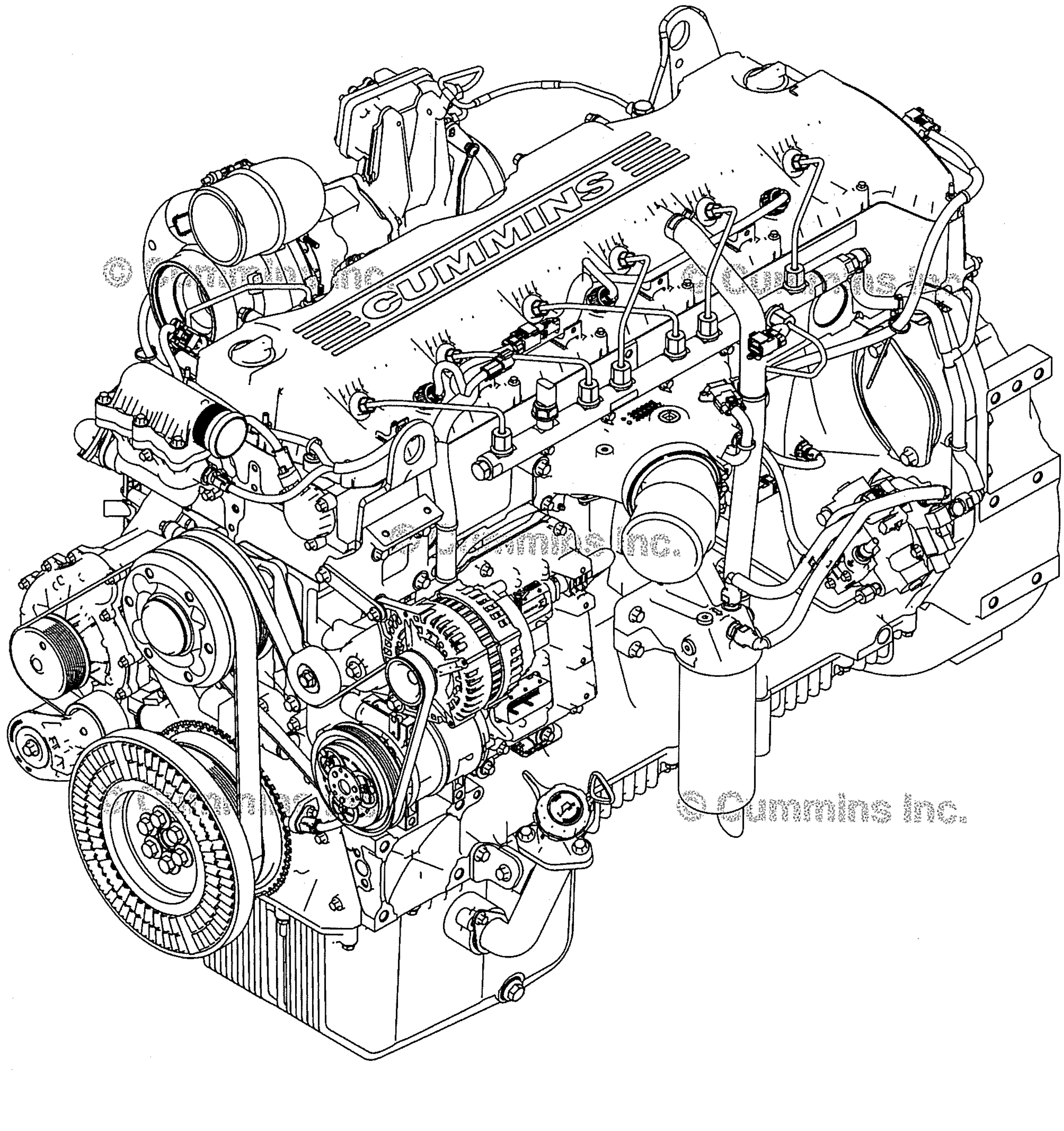
Service Manual
QSG12 CM2350 G110
Volume 2



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Foreword

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

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

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

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

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

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

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

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

The latest technology and the highest quality components are used to manufacture Cummins engines. When replacement parts are needed, we recommend using only genuine Cummins or ReCon® exchange parts.

Table of Contents

Section

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About the Manual

General Information

Cummins Inc. manuals are created to support Cummins® products. For information on components or fault codes not supplied by Cummins Inc., contact the original equipment manufacturer or supplier.

The content of this manual is based on the information in effect at the time of publish. 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.

About

Cummins® manuals are divided into sections. Each section consists of procedures which are associated with the title of the section.

When viewing a manual online, the sections of the manual are displayed to the left of the procedure display. If a section is clicked, it will expand to show the procedures within that section. to view a procedure, click on the procedure title.

When viewing a printed manual, the table of contents provides the list of sections and their subsequent procedures, with page numbers located to the right.

How to Use the Manual

General Information

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

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

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

Each section contains the following in sequence:

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

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

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

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

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

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

Symbols

General Information

The 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.

NOTE: It is possible to have four symbols for each text and graphic combination.

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, and assembly, or the engine can be damaged if the caution instructions are not followed.

Indicates a **REMOVAL** or **Dissassembly** 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**.

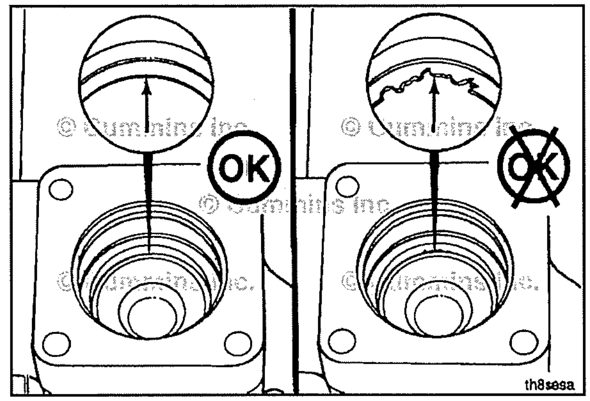
Refer to another location in this manual or another publication for additional information.

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

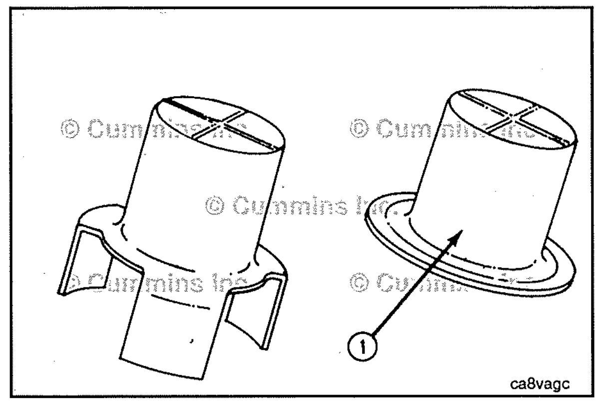
Illustrations

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

Read and understand the safety information and precautions before performing any repair or operating equipment. This procedure contains general safety precautions that **must** be followed to provide personal safety. **Always** follow procedures to mitigate safety concerns.

Work Environment

Follow these recommended practices when servicing products.

- **Always** follow on-site safety requirements.
- **Always** follow local training, certification, authorization, and specific customer requirements. Do **not** work on products unless proper training has been completed to allow safe repair completion. Do **not** operate equipment unless proper training has been completed to allow safe operation..
- Work in a well-ventilated area away from ignition sources.
- If adverse weather conditions are present, take appropriate safety precautions when performing work.
- **Always** be aware of hazardous conditions that may exist in the work environment.

Best Practices

Follow these recommended practices when servicing or operating equipment.

- **Always** wear protective glasses and protective shoes.
- Remove rings, watches, long jewelry, or metallic items.
- Do **not** wear loose fitting or torn clothing, jewelry, long hair, etc.. These increase the risk for personal injury.
- Do **not** perform any repairs, or operate equipment, when fatigued or impaired due to drugs or alcohol.
- **Always** use tools that are in good condition.
- Do **not** work on equipment that is running unless otherwise directed by troubleshooting procedures.
- If any work **must** be performed while the unit is running, use extreme caution around hot components, moving parts, etc..
- Exercise caution when working on products that have just been turned off. Hot parts may cause burns or ignite or melt common materials.
- Do **not** bleed the fuel system of a hot engine. Contact with hot manifolds or other components can cause a fire.
- Do **not** attempt to rotate the crankshaft by pulling or prying on the fan. **Only** use proper engine barring techniques.
- Do **not** lift components that weigh 23 kg [50 lb] or more. Use mechanical help or seek assistance.
- Exercise caution when working around rotating parts. Rotating parts can cause cuts, mutilation, or strangulation.
- Exercise caution when working on electrical components. High voltages can cause serious injury or death.
- Relieve system pressure as instructed before removing or disconnecting lines, fittings, or related items.
- **Always** test for pressure leaks as instructed.
- **Always** torque fittings and connections to the required specifications. Over or under tightening can damage threads and create leaks.
- **Always** use the same fastener part number, or equivalent, when replacing fasteners.

Perform the following prior to beginning work on any products.

- Shutdown the equipment unless otherwise directed by troubleshooting procedures.
- **Always** allow the product to cool.
- **Always** ensure the product is properly supported by blocks or stands. Do **not** work on a product supported **only** by lifting jacks or hoists.
- Disconnect the battery unless otherwise directed by troubleshooting procedures.
- Disconnect the starting motor, if equipped, unless otherwise directed by troubleshooting procedures.
- Place a "Do NOT Operate" tag in the operator area or near the product controls.
- Become familiar with the tools required for performing the task at hand and how to use those tools correctly.

- Use only genuine Cummins or Cummins Recon replacement parts as instructed.

Personal Protective Equipment (PPE)

To reduce the possibility of personal injury, personal protective equipment (PPE) should be utilized. Various types of PPE are listed below. Use proper judgment to determine which types of PPE are required for a given task. **Always** meet on-site safety regulations for required PPE. Proper maintenance of safety equipment **must** be practiced. Integrity of safety equipment **must** be checked to ensure equipment functionality is maintained.

Eye Protection

Eye protection **must always** be worn. Wear appropriate eye protection based on the task being completed. Types of eye protection to consider are listed below.

- Safety glasses. Exposure to flying particles or debris, chemicals or caustic liquids, gases or vapors.
- Polarized safety glasses. Working in outdoor or bright lighting environments.
- Over-the-glass safety glasses. Add protection to prescription glasses.
- Safety goggles. Handling caustic liquids or chemicals.
- Shade or arc rated eyewear. Exposure to welding. Use appropriate filter ratings.

Foot Protection

Protective shoes **must always**be worn. Wear appropriate foot protection based on the task being completed. Types of protective footwear to consider are listed below.

- Steel toed shoes. Exposure to falling or rolling objects. Working with or around parts, tools, and equipment.
- Chemical resistant. Exposure to chemicals and other fluids.
- Overshoes and overboots. Add protection to everyday work shoes.
- Foot, toe, and metatarsal guards. Add protection to everyday work shoes.
- Electrical hazard safety toe shoes. Exposure to electrical hazards.
- Leather footwear or shoe protectors. Exposure to welding or arc flash.
- Cold protection. Exposure to cold weather.

Head and Face Protection

Wear appropriate face protection based on the task being completed. Types of head and face protection to consider are listed below.

- Hard hats. Exposure varies. Consider welding, heat, or arc-rated.
- Visors. Exposure varies. Consider welding, heat, or arc-rated.
- Face liners. Exposure to cold weather.
- Face shields. Exposure to liquid splash. Handling caustic liquids or chemicals.

Hand Protection

Wear appropriate type and fit of gloves based on the task being completed. Types of protective gloves to consider are listed below.

- Heat resistant or insulated. Exposure to hot items.
- Flame resistant. Exposure to welding or arc flash.
- Impact resistant. Performing repetitive impact and vibration work. Using pneumatic tools.
- Impervious. Exposure to high pressure fluids.
- Chemical resistant. Exposure to chemicals, fluids, or batteries.
- Cut resistant. Handling sharp objects or tools.
- Cold weather. Exposure to cold weather.

Hearing Protection

When working around operating equipment, appropriately rated hearing protection should be worn. Types of hearing protection to consider are listed below.

- Single use ear plugs.

- Pre-formed ear plugs.
- Ear muffs.

Protective Clothing

Wear appropriate protective clothing based on the task being completed. Types of protective clothing to consider are listed below.

- Flame resistant. Exposure to electrical hazards. Exposure to oil and gas or generator set applications. Performing welding.
- Chemical resistant. Exposure to chemicals.
- High visibility. Exposure to reduced visibility working environments. Working on mining, oil and gas, or sites with large equipment.

Respiratory Protection

Wear appropriate respiratory protection based on the task being completed. Types of respiratory protection to consider are listed below.

- Disposable respirators. Exposure to dust and particles, welding fumes, nuisance odors, nuisance level acid gas.
- Reusable respirators. Exposure to cleaning, machining, welding, sanding, grinding, etc.

Fall Protection

Utilize fall protection if a task is being completed more than 1.2 m [4 ft] above a solid surface. Types of fall protection to consider are listed below.

- Fall harness and lanyard combinations.
- Safety nets.
- Guardrails.

Fuels

Follow these recommended practices when interacting with equipment that uses different fuel types. For information regarding proper handling of various substances, refer to the manufacturer's safety data sheet.

Diesel Fuel

- Protect eyes.
- Protect skin.
- **Always** test for fuel leaks as instructed.
- Do **not** dilute.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.
- Provide extra ventilation to the work area.
- Do **not** troubleshoot or repair fuel leaks while the engine is running.
- If material is spilled, avoid contact and dispersal with runoff, soil, waterways, drains, and sewers. Absorb with sand, clay, or commercial absorbent. Transfer to containers and neutralize the material. Flush spill area with soap and excess water.
- Report spills effecting water source contamination to local authorities immediately.
- Proper disposal is required. Dispose of in accordance with local and environmental regulations.
- **Always** torque fittings and connections to the required specifications. over or under tightening can damage threads and create leaks.

Gasoline

- Protect eyes.
- Protect skin.
- **Always** be alert for the smell of gas.
- **Always** test for fuel leaks as instructed.
- Do **not** dilute.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.

- Vapors accumulate near the floor. Check the work floor, sumps, and low lying areas for ignition sources before servicing equipment..
- Provide extra ventilation to the work area.
- Do **not** troubleshoot or repair fuel leaks while the engine is running.
- If material is spilled, avoid contact and dispersal with runoff, soil, waterways, drains, and sewers. Absorb with sand, clay, or commercial absorbent. Transfer to containers and neutralize the material. Flush spill area with soap and excess water.
- Report spills effecting water source contamination to local authorities immediately.
- Proper disposal is required. Dispose of in accordance with local and environmental regulations.
- **Always** torque fittings and connections to the required specifications. over or under tightening can damage threads and create leaks.

Biodiesel

- Protect eyes.
- Protect skin.
- **Always** test for fuel leaks as instructed.
- Do **not** dilute.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.
- Vapors accumulate near the floor. Check the work floor, sumps, and low lying areas for ignition sources before servicing equipment..
- Provide extra ventilation to the work area.
- Do **not** troubleshoot or repair fuel leaks while the engine is running.
- If material is spilled, avoid contact and dispersal with runoff, soil, waterways, drains, and sewers. Absorb with sand, clay, or commercial absorbent. Transfer to containers and neutralize the material. Flush spill area with soap and excess water.
- Report spills effecting water source contamination to local authorities immediately.
- Proper disposal is required. Dispose of in accordance with local and environmental regulations.
- **Always** torque fittings and connections to the required specifications. over or under tightening can damage threads and create leaks.

Compressed Natural Gas

- Protect eyes.
- Protect skin.
- **Always** be alert for the smell of gas. Compressed natural gas is typically treated with an odor producing chemical for leak detection. Non-refined sources of natural gas (landfill gas, biogas, coal bed gas, wellhead gas, etc.) can **not always** be detected by smell.
- **Always** test for fuel leaks as instructed. Odorant can fade.
- Upon entering a room or approaching a vehicle where the smell of gas is present, immediately shutoff all engines and ignition sources.
- Natural gas ignites when there is a 5% - 15% mixture in the air. Asphyxiation can occur when concentration reaches 21% or more.
- Do **not** start equipment or nearby equipment until a suspected gas leak is corrected and the area is ventilated.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.
- Work in areas that do **not** share common ventilation with areas containing ignition sources.
- Store and service natural gas fueled equipment in large, well-ventilated areas, or outside.
- Provide extra ventilation to the work area.
- Natural gas accumulates near the ceiling. Check the ceiling of the work area for ignition sources before servicing equipment.
- **Only** disconnect gas lines in a well-ventilated area.
- Do **not** troubleshoot or repair gas leaks while the engine is running.

- Natural gas ignition systems produce high voltage during operation. Do **not** touch ignition wiring or components while the engine is operating. If necessary, use **only** insulated tools.
- Natural gas exhaust systems operate at higher temperatures than similar diesel exhaust systems. Do **not** touch exhaust components. Do **not** route lines or hoses which deteriorate from heat exposure near exhaust components or in the flow path of the exhaust.
- **Always** torque fittings and connections to the required specifications. over or under tightening can damage threads and create leaks.

Liquefied Natural Gas

- Protect eyes.
- Protect skin.
- **Always** be alert for the smell of gas. Liquefied natural gas may **not** have an odor. Non-refined sources of natural gas (landfill gas, biogas, coal bed gas, wellhead gas, etc.) can **not always** be detected by smell.
- **Always** test for fuel leaks as instructed. Odorant can fade.
- Upon entering a room or approaching a vehicle where the smell of gas is present, immediately shutoff all engines and ignition sources.
- Natural gas ignites when there is a 5% - 15% mixture in the air. Asphyxiation can occur when concentration reaches 21% or more.
- Do **not** start equipment or nearby equipment until a suspected gas leak is corrected and the area is ventilated.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.
- Work in areas that do **not** share common ventilation with areas containing ignition sources.
- Store and service natural gas fueled equipment in large, well-ventilated areas, or outside.
- Provide extra ventilation to the work area.
- Natural gas accumulates near the ceiling. Check the ceiling of the work area for ignition sources before servicing equipment.
- **Only** disconnect gas lines in a well-ventilated area.
- Do **not** troubleshoot or repair gas leaks while the engine is running.
- Natural gas ignition systems produce high voltage during operation. Do **not** touch ignition wiring or components while the engine is operating. If necessary, use **only** insulated tools.
- Natural gas exhaust systems operate at higher temperatures than similar diesel exhaust systems. Do **not** touch exhaust components. Do **not** route lines or hoses which deteriorate from heat exposure near exhaust components or in the flow path of the exhaust..
- Liquefied natural gas is stored in vehicle tanks at extremely cold temperatures. If there is a liquefied natural gas spill, evacuate the area immediately and do not attempt to make contact with the liquid.
- **Always** torque fittings and connections to the required specifications. over or under tightening can damage threads and create leaks.
- Vapors accumulate near the floor. Check the work floor, sumps, and low lying areas for ignition sources before servicing equipment.

Liquefied Petroleum Gas

- Protect eyes.
- Protect skin.
- **Always** be alert for the smell of gas. Liquefied petroleum gas is typically treated with an odor producing chemical for leak detection.
- **Always** test for fuel leaks as instructed. Odorant can fade.
- Upon entering a room or approaching a vehicle where the smell of gas is present, immediately shutoff all engines and ignition sources.
- Do **not** start equipment or nearby equipment until a suspected gas leak is corrected and the area is ventilated.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.
- Work in areas that do **not** share common ventilation with areas containing ignition sources.
- Store and service natural gas fueled equipment in large, well-ventilated areas, or outside.

- Provide extra ventilation to the work area.
- Liquefied petroluem gas accumulates near the floor. Check the work floor, sumps, and low lying areas for ignition sources before servicing equipment.
- **Only** disconnect gas lines in a well-ventilated area.
- Do **not** troubleshoot or repair gas leaks while the engine is running.
- Liquefied petroleum gas ignition systems produce high voltage during operation. Do **not** touch ignition wiring or components while the engine is operating. If necessary, use **only** insulated tools.
- Liquefied petroleum gas exhaust systems operate at higher temperatures than similar diesel exhaust systems. Do **not** touch exhaust components. Do **not** route lines or hoses which deteriorate from heat exposure near exhaust components or in the flow path of the exhaust..
- Liquefied natural gas is stored in vehicle tanks at extremely cold temperatures. If there is a liquefied natural gas spill, evacuate the area immediately and do not attempt to make contact with the liquid.
- **Always** torque fittings and connections to the required specifications. over or under tightening can damage threads and create leaks.

Power Generation Applications

Follow these recommended practices when interacting with equipment in generator set applications.

Power generation applications produce high voltage during operation. When servicing a generator set, the following safety precautions **must** be taken.

- Remove any debris from the generator set.
- Keep the floor clean and dry throughout servicing
- Service access doors **must** be secured in the "open" position before working on enclosed generator sets.
- Use insulated or non-conducting tools.
- Prevent accidental or remote starting. Disconnect the starting battery cables. Disconnect the negative (-) terminal first.
- Isolate all auxiliary supplies.
- Switch the generator set control panel "off."
- Place a "Do **Not** Operate" tag on the control panel.
- Lock the generator set circuit breaker in the "Open" position.
- Activate the manual "Emergency Stop" device.
- Do **not** step on the generator set when servicing, entering, or leaving the generator room.

Aftertreatment

Follow these recommended practices when interacting with equipment that utilize aftertreatment systems. For information regarding proper handling of various substances, refer to the manufacturer's safety data sheet.

Diesel Exhaust Fluid

- Avoid breathing vapor or mist.
- Protect eyes. In case of contact with eyes, flush with water for a minimum of 15 minutes.
- Protect skin. In case of contact with skin, wash with soap and water.
- Do **not** ingest. If ingested, contact a physician immediately.

Diesel Particulate Filter

- Protect eyes.
- Protect skin.
- Avoid stirring up exhaust particulate dust.
- Avoid inhalation of exhaust particulate dust. Wear a dust mask. If respiratory irritation or discomfort occurs, leave the dusty area. Utilize breathing assistance or oxygen if necessary.
- Elevated concentrations of metals in the form of dust, soot, and contaminants are contained in these filters. Health regulations may exist for the materials found in these filters such as Zinc, Molybdenum, polynuclear aromatic

hydrocarbons. Potentially toxic materials found in these filters are oxides of calcium, zinc, phosphorous, silicon, sulfur, and iron.

- Proper disposal of the exhaust dust and filter are required. Dispose of in accordance with local and environmental regulations.
- Diesel particulate filter maintenance **must** be completed by appropriately trained personnel.

Selective Catalytic Reduction (SCR) Catalyst

- Protect eyes.
- Protect skin.
- Avoid stirring up exhaust catalyst dust.
- Avoid inhalation of exhaust catalyst dust. Wear a dust mask. If respiratory irritation or discomfort occurs, leave the dusty area. Utilize breathing assistance or oxygen if necessary.
- Do **not** cut open exhaust catalyst assemblies.
- Proper disposal of the exhaust catalyst is required. Dispose of in accordance with local and environmental regulations.

Oxidation Catalysts

Types of Oxidation Catalysts may include, but are not limited to the following.

- Diesel Oxidation Catalyst (DOC)
- 3-way Oxidation Catalyst

When working with oxidation catalysts, perform the following.

- Protect eyes.
- Protect skin.
- Avoid stirring up exhaust catalyst dust.
- Avoid inhalation of exhaust catalyst dust. Wear a dust mask. If respiratory irritation or discomfort occurs, leave the dusty area. Utilize breathing assistance or oxygen if necessary.
- Do **not** cut open exhaust catalyst assemblies.

Common Substances

Follow these recommended practices when interacting with the following substances. For information regarding proper handling of various substances, refer to the manufacturer's safety data sheet.

Coolant

- Coolant is also referred to as antifreeze.
- Protect eyes. In case of contact with eyes, flush with water for a minimum of 15 minutes. Receive medical attention immediately.
- Protect skin. In case of contact with skin, wash with soap and water. Remove contaminated clothing. If injection occurs, it is a medical emergency. Receive medical attention immediately.
- Do **not** ingest. If ingested, drink excess water for dilution and seek medical attention.
- Do **not** pour used antifreeze into containers that have been used to store other chemicals or products, such as oil or gasoline, unless they have been thoroughly cleaned.
- If material is spilled, avoid contact and dispersal with runoff, soil, waterways, drains, and sewers. Provide adequate ventilation to the area. Absorb with sand, clay, or commercial absorbent. Transfer to containers and neutralize the material. Flush spill area with soap and excess water.
- Report spills effecting water source contamination to local authorities immediately.
- Proper disposal is required. Dispose of in accordance with local and environmental regulations.

Liquid Nitrogen

- Work in a well-ventilated area.
- Protect eyes. In case of contact with eyes, flush with water for a minimum of 15 minutes. Receive medical attention immediately.
- Protect skin. In case of contact with skin, receive medical attention immediately.

- Wear protective clothing and gloves that insulate.
- Handle items with tongs or wire hooks.
- Avoid prolonged breathing of liquid nitrogen vapors. Utilize breathing assistance or oxygen if necessary.

Lubricating Oil

See Lubricating Oil in the "Hazardous Substances" step.

Refrigerant

- Protect eyes. In case of contact with eyes, flush with water for a minimum of 15 minutes. In case of frostbite, use lukewarm water, not hot. Seek medical attention if irritation continues.
- Protect skin. Wear leather or insulated gloves. In case of contact with skin, wash with soap and water. Seek medical attention if irritation continues.
- Proper disposal is required. Dispose of in accordance with local and environmental regulations.
- **Only** disconnect liquid refrigerant lines in a well-ventilated area. 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 refrigerant in the United States of America.

Solvents

- Follow the manufacturer's instructions for safe handling practices.
- Follow the manufacturer's recommendations for use.
- Some solvents are flammable and toxic..
- Protect eyes. In case of contact with eyes, follow manufacturer's recommendations.
- Protect skin. In case of contact with skin, follow manufacturer's recommendations.
- Dispose of in accordance with manufacturer's recommendations.

Starting Aids (Starting Fluid)

- Do **not** use starting fluid if the intake air heater option is used.
- Do **not** use volatile cold starting aids in underground mine or tunnel operations. The local United States Bureau of Mines inspector can provide more information and instructions.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.
- Work in a well-ventilated area.
- Avoid inhalation.

Hazardous Substances

Hazardous substances are known to some state and federal agencies to be carcinogenic and cause reproductive harm. Hazardous substances that may be encountered during service events are listed below.

Diesel Engine Exhaust

- Protect eyes. In case of contact with eyes, flush with water for a minimum of 15 minutes.
- Protect skin. In case of contact with skin, wash with soap and water.
- Avoid inhalation.

Lubricating Oil

- Protect eyes. In case of contact with eyes, flush with water for a minimum of 15 minutes.
- Protect skin. In case of contact with skin, wash with soap and water.
- Do **not** ingest. If ingested, contact a physician immediately..
- Proper disposal is required. Dispose of in accordance with local and environmental regulations.
- Do **not** allow water droplets to enter a container of hot oil. A violent reaction can result.

Mercury

- Protect eyes. In case of contact with eyes, flush with water for a minimum of 15 minutes.
- Protect skin. In case of contact with skin, wash with soap and water.
- Do **not** ingest. If ingested, contact a physician immediately.

- Proper disposal is required. Dispose of in accordance with local and environmental regulations.

Vanadium Pentoxide

- Can be found in some selective catalytic reduction (SCR) catalysts.
- Protect eyes. In case of contact with eyes, flush with water for a minimum of 15 minutes.
- Protect skin. In case of contact with skin, wash with soap and water.
- Do **not** ingest. If ingested, contact a physician immediately.
- Avoid inhalation of vapors or airborne particles.
- Proper disposal is required. Dispose of in accordance with local and environmental regulations.

Electrical Components

Follow these recommended practices when interacting with electrical components.

Batteries

- Protect eyes. Wear safety glasses or goggles. In case of battery acid contact with eyes, flush with water for a minimum of 15 minutes. Receive medical attention immediately.
- Protect skin. Wear rubber gloves and a chemical apron. In case of battery acid contact with skin or clothing, rinse with water for several minutes. Avoid spreading the acid. Receive medical attention immediately.
- Do **not** open the battery caps with your face over or near the battery.
- Remove rings, watches, long jewelry, or metallic items when working with or near batteries.
- Ventilate the battery compartment before servicing the battery.
- Work in a well-ventilated area.
- Avoid sparks, arcing switches and equipment, cigarettes, pilot lights, flames, and other sources of ignition.
- Use insulated or non-conducting tools.
- Neutralize static buildup by contacting the nearest ground surface before working on a battery.
- Do **not** lift batteries by the posts.
- Do **not** touch both battery terminals with your bare hands at the same time.
- Disconnect the negative (-) battery cable first.
- Attach the negative (-) battery cable last.

Common Hazards

Follow these recommended practices when interacting with equipment as the following hazards may exist.

High Temperature Area

Be alert for high temperature areas which may cause severe burns. High temperature areas may be encountered in the following situations.

- On products that have just been turned off.
- On or around exhaust related components (turbocharger, aftertreatment systems, etc).
- In exhaust gas flow paths.
- Contacting hot fluid lines, tubes, or compartments.

Recommended Practices:

- Allow components to cool before servicing. Verify the temperature of the component. Utilize an infrared gun, temperature sensor, temperature gauge, or other reliable method to determine component temperature. Take appropriate precautions before starting work.
- Protect eyes.
- Protect skin. Wear insulated gloves.
- Ensure surrounding items do not come in contact with hot components or exhaust. Contact may ignite or melt those materials.

Heavy Objects

Be alert when working with heavy objects.

- Do **not** lift components that weigh 23 kg [50 lb] or more. Use mechanical help or seek assistance.
- Use mechanical help to move items whenever possible. Make sure the load is securely fastened to the equipment.
- Make sure lifting devices, like chains, hooks, slings, etc., are in good condition and are rated for the correct capacity before use.
- Make sure lifting devices are positioned correctly before use.
- Use a spreader bar when necessary.
- If the item can be lifted manually, squat to lift and lower the item. Do **not** bend at the waist.
- Maintain balance when lifting items by keeping feet apart or staggered if possible.
- If the item must be carried, make sure the path is clear when carrying the item to, and placing the item in, the desired location.

Pressurized Areas

Be alert for pressurized areas. Pressurized areas may be encountered in the following situations.

- Air, Oil, Fuel, and Cooling systems.
- When disconnecting or removing lines, fittings, or related items.
- When disconnecting a device from a pressurized system.
- When removing or loosening caps on tanks or pressurized systems.

Injuries that may result when interacting with pressurized areas are listed below.

- High pressure spray can penetrate the skin. Serious injury or death may result.
- Hot fluid spray can cause burns. See "High Temperature Area."

Recommended Practices:

- Protect skin. Wear impervious gloves. If skin penetration from high pressure spray occurs, it is a medical emergency. Receive medical attention immediately.
- Check for pressure leaks as instructed. **Never** check for pressure leaks with your hand.
- Allow product to cool before accessing pressurized areas.
- Relieve system pressure as instructed.
- Slowly loosen fill caps to relieve pressure before servicing.

Job Safety Assessment

Completing a Job Safety Assessment (JSA) prior to performing work helps identify job safety hazards and prevent incidents. Use the guidelines below to assess if a situation is safe or at risk prior to performing designated work. If deteremined to be at risk, take appropriate precautions to prepare for, or eliminate, the hazard. If the risks are uncontrollable, consult a knowledgeable resource to find a safe practice solution. A knowledgeable resource may include, but is not limited to, one of the following:

- Site supervisor
- Customer
- Work supervisor

Always check with the site where work is being performed to determine if safety assessment documentation is required.

Work Practices

Job Safety Analysis.

- Assess the job to identify safety hazards that may occur during the repair event.

Ascending or Descending

- Maintain 3 points of contact when using steps, ladders, or entering and exiting a unit.

Communication

- When working with others, make sure you understand what each other is doing to safely complete the task.

Eyes On Hands and Work.

- Confirm if you will be able to maintain an unobstructed view of your hands at all times while performing the task.

Eyes On Path

- Watch for hazards in your path to avoid trip or slip hazards. Examples are pits, platform edges, etc.

Line Of Fire

- Position yourself so that you avoid striking against, or being struck by, anything that can swing, fall, or roll.

Pinch Point

- Prevent exposure of all parts of your body to a nip hazard or pinch point.

Rushing

- Take adequate time to safely perform the job. Do **not** rush or take short cuts.

Follow Procedures

- Utilize QuickServe® Online or other standard procedures when available.
- Make sure the procedures are correct and safe.

Ergonomics

Back-Bending and Twisting

- Avoid bending forward more than 45 at your waist.
- Avoid working with your back twisted with loads over 23 kg [50 lb].

Knee

- Avoid bending your knee more than 90.
- Avoid kneeling for more than 4 hours per day.

Lifting and Lowering

- Squat to pick up parts.
- Keep loads close to the body when lifting or carrying.
- Use a team lift or a lifting device if the object is more than 23 kg [50 lb].

Pulling or Pushing

- Pull with your arms.
- Push with your legs.
- Avoid exerting more force than necessary.
- Avoid moving heavy load(s) too quickly.

Tools and Equipment

Selection

- Select the correct tool or equipment to perform the task.

Condition

- Confirm the tool or equipment is free of defects before use.
- Confirm that safety devices are in place before use.

Use

- Use the tool or equipment as directed.
- Follow the manufacturer's instructions.

Personal Protective Equipment (PPE)

Eye, Face, and Head Protection

- Confirm the eye, face, or head protection you plan to use are adequate for performing the task at hand.

Foot Protection

- Confirm the foot protection you plan to use is adequate for performing the task at hand in the current environment.

Fall Protection

- Fall protection should be used if you are working more than 1.2 m [4 ft] above the floor.
- Use fall protection if you have been properly trained to do so. If you are not trained to use fall protection, allow someone who has received proper training to perform the task.

Hand Protection

- Avoid exposing hands to cuts or burns while completing the task.
- Confirm the proper glove type is being used for the task at hand. Examples are cut-resistant, chemical-resistant, electric shock-resistant, electric arc flash, welding, etc.

Hearing Protection

- Hearing protection should be worn when required or recommended.

Body Protection

- Body parts should be protected from work hazards.
- Avoid contact with sharp edges, hot surfaces, etc.

Work Prcedures

Training

- Confirm if you have received task and safety training for the job being performed.

Working Alone

- Avoid working alone.
- Avoid working where you are **not** able to be seen or heard by another person.
- If you **must** work alone, notify others of your location and schedule check-in times.

Lockout and Tagout

- Lock out or tag out energy sources before work. Examples are electrical, mechanical, hydraulic, and pneumatic.

Barricades and Warnings

- Mark overhead work areas with barricade tape or signs.
- Mark open floor hazards with barricade tape, signs, or cones.

Confined Space

- Confirm if a confined space entry permit is required.
- If required, confirm the permit is posted, signed, and dated correctly.

Hot Work

- Confirm a functional fire extinguisher is readily available.
- Maintain separation between ignition sources and fuel sources.

Place Wheel Chocks

- Place wheel chocks at either the front or back tire of the unit prior to starting the task.

Spotter

- Use a spotter when moving a customer's unit.
- Confirm the driver can see and hear the spotter when moving.

Housekeeping (The 5 S's - Scrap or Segregate, Set to Order, Spotless, Standardize, and Sustain)

- Remove parts, extension cords, air hoses, and liquids from the work area that may cause trip, slip, or fall hazards.

General Repair Instructions

General Information

This system incorporates the latest technology at the time it was manufactured; yet, it is designed to be repaired using normal repair practices performed to quality standards.

⚠WARNING⚠

Cummins Inc. does not recommend or authorize any modifications or repairs to components except for those detailed in Cummins Service Information. In particular, unauthorized repair to safety-related components can cause personal injury or death. Below is a partial listing of components classified as safety-related:

1 Air Compressor
2 Air Controls
3 Air Shutoff Assemblies
4 Balance Weights
5 Cooling Fan
6 Fan Hub Assembly
7 Fan Mounting Bracket(s)
8 Fan Mounting Capscrews
9 Fan Hub Spindle
10 Flywheel
11 Flywheel Crankshaft Adapter
12 Flywheel Mounting Capscrews
13 Fuel Shutoff Assemblies
14 Fuel Supply Tubes
15 Lifting Brackets
16 Throttle Controls
17 Turbocharger Compressor Casing
18 Turbocharger Oil Drain Line(s)
19 Turbocharger Oil Supply Line(s)
20 Turbocharger Turbine Casing
21 Vibration Damper Mounting Capscrews
22 Manual Service Disconnect
23 High Voltage Interlock Loop
24 High Voltage Connectors/Connections and Harnesses
25 High Voltage Battery System
26 Power Inverter
27 Generator Motor
28 Clutch Pressure Plate

- Follow all safety instructions noted in the procedures
- Follow the manufacturer's recommendations for cleaning solvents and other substances used during repairs. Some solvents have been identified by government agencies as toxic or carcinogenic. Avoid excessive breathing, ingestion and contact with such substances. **Always** use good safety practices with tools and equipment
- Provide a clean environment and follow the cleaning instructions specified in the procedures
- All components **must** be kept clean during any repair. Contamination of the components will cause premature wear.
- Perform the inspections specified in the procedures
- Replace all components or assemblies which are damaged or worn beyond the specifications

- Use genuine Cummins new or ReCon® service parts and assemblies

- The assembly instructions have been written to use again as many components and assemblies as possible. When it is necessary to replace a component or assembly, the procedure is based on the use of new Cummins or Cummins ReCon® components. All of the repair services described in this manual are available from all Cummins Distributors and most Dealer locations.

- Follow the specified disassembly and assembly procedures to reduce the possibility of damage to the components

Welding on a Vehicle with an Electronic Controlled Fuel System

△CAUTION△

Disconnect both the positive (+) and negative (-) battery cables from the battery before welding on the vehicle. Attach the welder ground cable no more than 0.61 meters [2 feet] from the part being welded. Do not connect the ground clamp of the welder to any of the sensors, wiring harness, electronic control units or the components. Direct welding of any electronic components must not be attempted. Sensors, wiring harness, and electronic control unit should be removed if nearby welding will expose these components to temperatures beyond normal operation. Additionally, all electronic control unit connectors must be disconnected

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
bhp	Brake Horsepower
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
CES	Cummins Engineering Standard
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
ESN	Engine Serial Number
°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
JSA	Job Safety Assessment
km/l	Kilometers per Liter
kPa	Kilopascal
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
LTA	Low Temperature Aftercooler
MCRS	Modular Common Rail System
MIL	Malfunction Indicator Lamp

MPa	Megapascal
mph	Miles Per Hour
mpq	Miles Per Quart
N•m	Newton-meter
NOx	Nitrogen Oxides
NG	Natural Gas
O2	Oxygen
OAT	Organic Acid Technology
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PID	Parameter Identification Descriptions
PPE	Personal Protective Equipment
ppm	Parts Per Million
psi	Pounds Per Square Inch
PTO	Power Takeoff
QSOL	QuickServe® Online
REPTO	Rear Engine Power Takeoff
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
TSB	Technical Service Bulletin
ULSD	Ultra Low Sulfur Diesel
VDC	Volts of Direct Current
VGT	Variable Geometry Turbocharger
VS	Variable Speed
VSS	Vehicle Speed Sensor

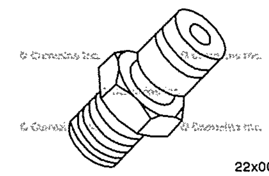
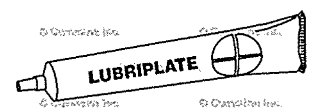
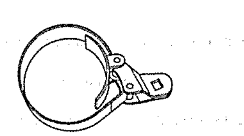
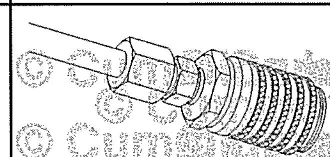
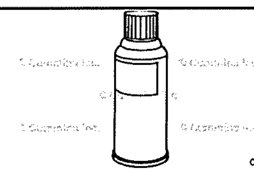
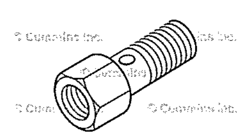
Section 6 - Injectors and Fuel Lines - Group 06

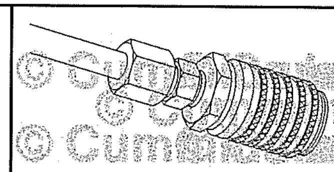
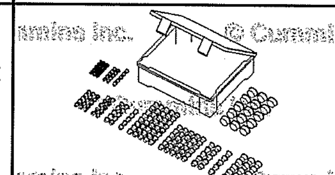
Section Contents

Service Tools

Injectors and Fuel Lines

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3042618	**Compuchek Fitting** Used to connect a fuel pressure gauge to the fuel filter head.	 22x00005
3163087	**Lubricant** Lubriplate™ 105 lubricant, used to improve assembly of various fuel system components.	 12x00041
3400157	**Filter Wrench** Used to remove and install fuel and oil filters.	 3400157
3824844	**Diagnostic Fuel Hose** Used in combination with other fuel system tools to isolate fuel drain flow from the fuel pump and injector drain.	 22c00253
3824510	**QD Contact Cleaner** Use this non-petroleum cleaner to clean electrical connections and fuel pump internal parts.	 oi8togt
4918413	**M12 Banjo Fitting Adapter** A banjo-style pressure gauge adapter that can be used to measure pressure or vacuum at any point in the low-pressure fuel system where a 12-mm banjo bolt exists at a fuel line.	

Tool No.	Tool Description	Tool Illustration
3164621	**Fuel Line with 1.09 mm [0.043 in] Orifice** Used to create rated fuel flows through the low-pressure fuel system without loading the engine.	 22c00253
4919073	**Fuel System Clean Care Kit** Used to cap or plug the fuel system fittings during service to prevent debris from entering the fuel system.	 22c00376

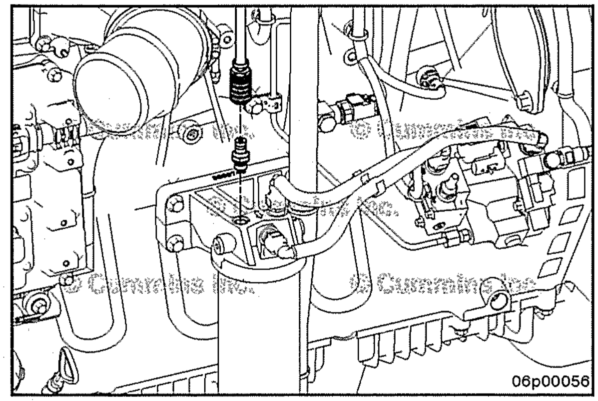
Air in Fuel (006-003)

Setup

Install a Compuchek™ fitting, Part Number 3824844, at the outlet to the fuel filter head.

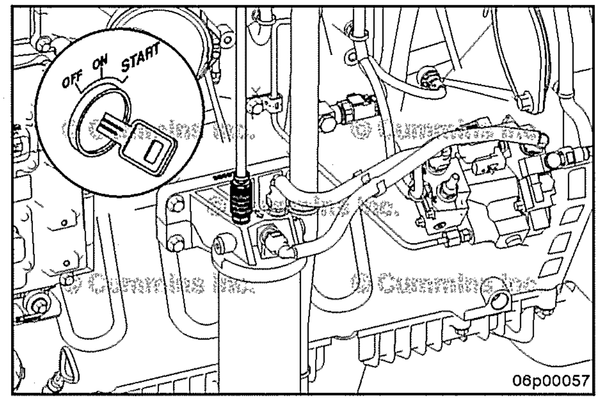
Install orificed diagnostic fuel line, Part Number 3164621, onto the Compuchek™ fitting at the inlet to the pressure side fuel filter.

The orificed diagnostic fitting is used in procedures to create rated flow through the low pressure fuel system without the need to operate the engine under load.



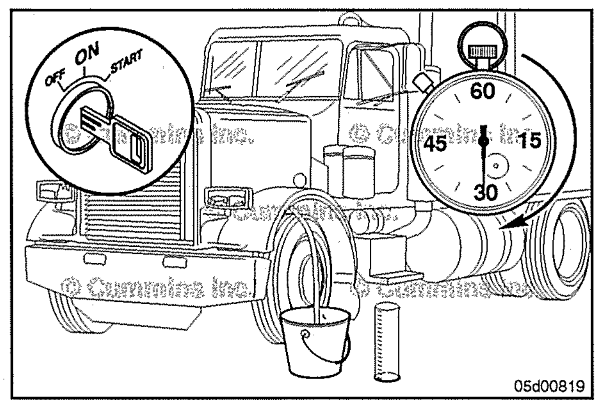
Measure

NOTE: A symptom of air-in-fuel for the engines equipped with a common rail fuel system is an audible surge associated with fuel system pressure fluctuations, due to air in the fuel supply.



Use a quick-connect to route the fuel that exits the orificed diagnostic fitting into a container suitable for collection of fuel, such as a 19 liter [5 gal] bucket.

Start the engine and run the engine speed from idle to high idle several times to purge the air induced while installing the diagnostic fuel line.

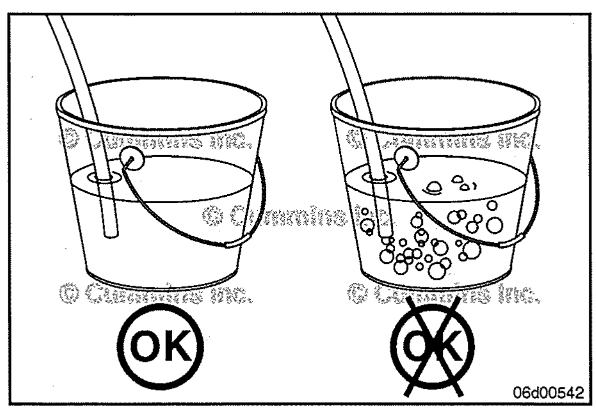


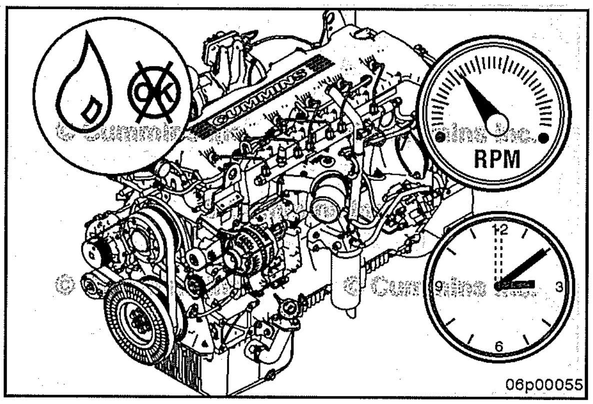
Observe the fuel flow exiting the diagnostic fuel line while the engine runs at idle speed. No air should be present in the fuel.

Air in the fuel is an indication of a leak that allows air to enter, a severe inlet restriction that causes cavitation, or a system that is **not** yet primed. Use the following procedure to check inlet restriction. Refer to Procedure 006-020 in Section 6.

If fuel inlet restriction is **not** excessive, the source of air entry should be isolated to one of the following:

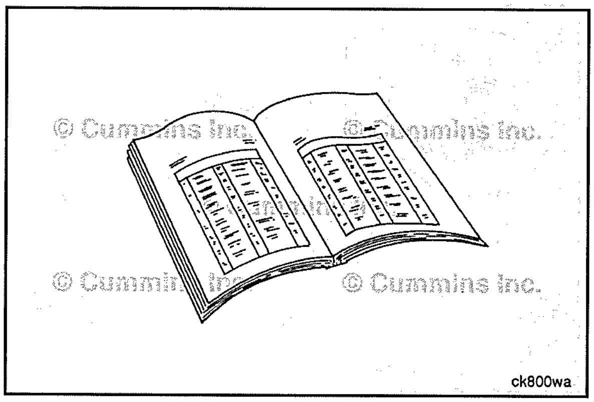
- Suction fuel lines
- OEM fuel lines
- Suction-side fuel filter assemblies
- Stand-pipe(s) in the fuel tank(s).





Finishing Steps

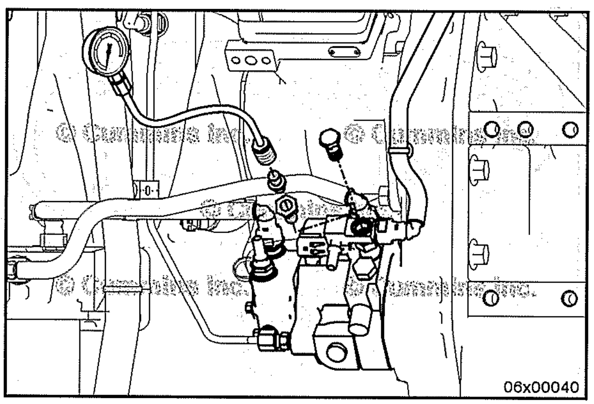
- Remove all test fuel lines.
- Operate the engine and check for leaks.



Fuel Drain Line Restriction (006-012)

General Information

The fuel drain line restriction is measured near the point at which the OEM connects the vehicle fuel drain line. The injector return, fuel rail pressure relief valve, and fuel pump return connect to a single fitting between the fuel drain line and high-pressure fuel pump.



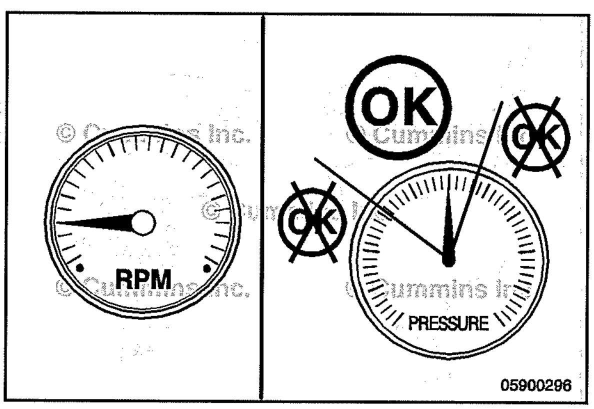
Setup

Remove the banjo bolt from the fuel drain line at the fuel drain fitting connection at the fuel pump.

Install the banjo bolt gauge tool, Part Number 4918413, in place of the banjo bolt.

Install Compuchek™ fitting, Part Number 3042618, into the banjo bolt.

Attach a fuel pressure gauge to the Compuchek™ fitting.



Measure

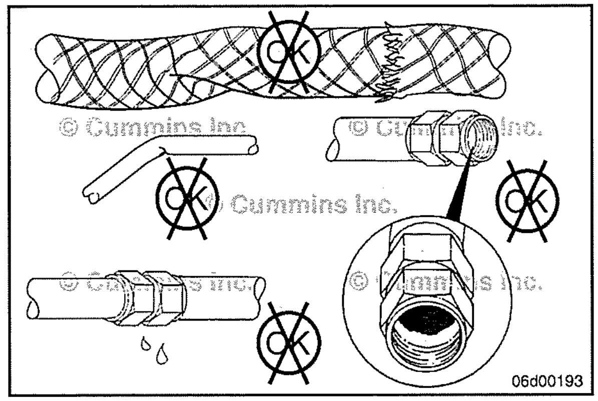
Operate the engine at cranking or high idle and measure the fuel pressure.

Observe the reading on the gauge.

Fuel Drain Line Restriction		
kPa		**in Hg**
13.5	MAX	4

If the fuel drain line restriction is too high:

- Check the OEM fuel lines to the tank for proper size, leaks, bends, or clogs.
- Check the fuel tank vents for plugging.

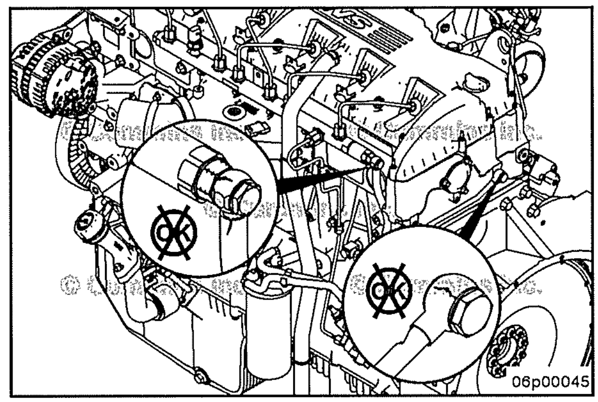


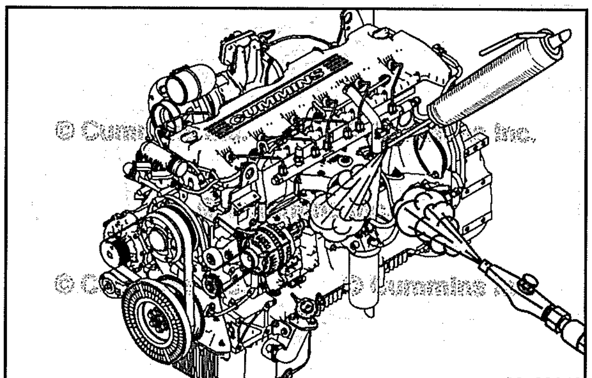
Fuel Drain Lines (006-013)

Initial Check

Inspect the fuel drain lines for any signs of leaks, cracks, chafing, and loose or broken brackets.

Repair or replace any damaged parts.




06p00046

Preparatory Steps

⚠WARNING⚠

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

⚠WARNING⚠

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

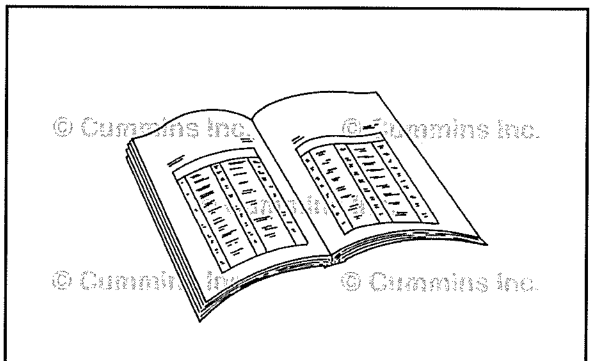
⚠CAUTION⚠

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. Refer to Procedure 000-009 in Section 0.

Clean the fuel drain line and mating components with electrical contact cleaner, Part Number 3824510, or equivalent.

To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.

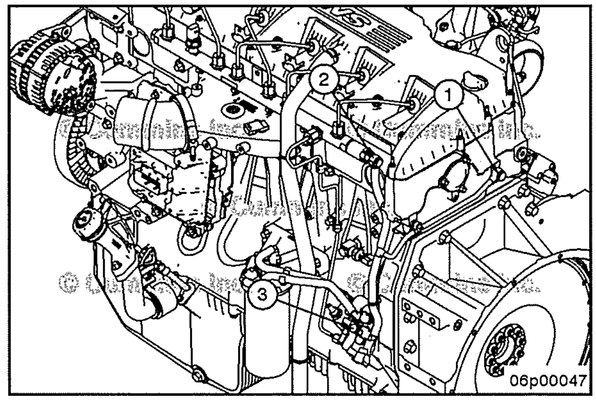

ck800wa

⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.

Remove



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

⚠WARNING⚠
Do not bleed the fuel system of a hot engine; this can result in fuel spilling onto a hot exhaust manifold, which can cause a fire.

The injector drain connects at the back of the cylinder head (1) with an M12 banjo bolt style check valve.

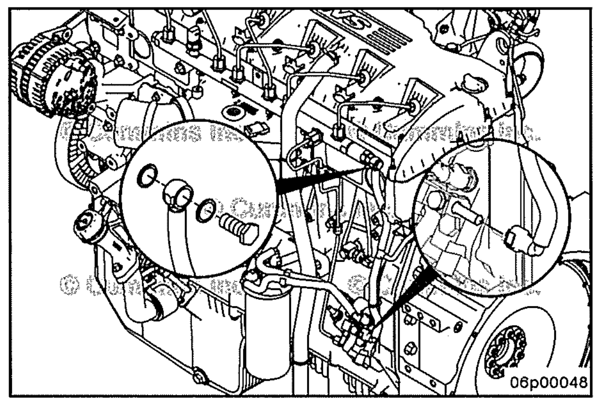
The fuel rail pressure relief valve (2) connects to the fuel rail with an M14 banjo bolt.

The fuel pump drain (3) connects to the fuel pump head with an M12 banjo bolt.

Remove p-clip capscrews, stud, banjo bolts, check valve, and sealing washers.

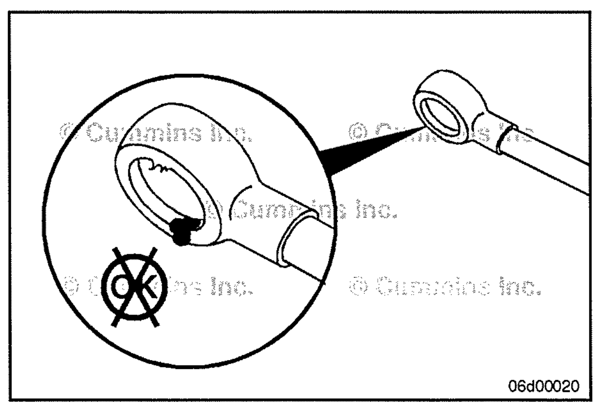
Discard sealing washers.

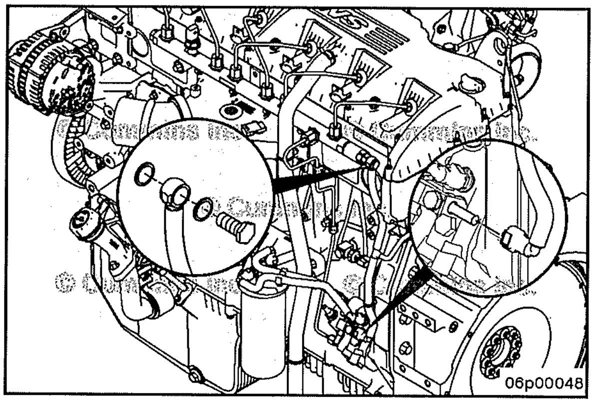
Remove fuel drain lines.



Inspect for Reuse

Inspect p-clips, drain lines, and banjo fittings for damage.





Install

Install the drain lines.

Loosely install the p-clip capscrews, stud, banjo fittings, banjo style check valve, and new sealing washers for each drain line.

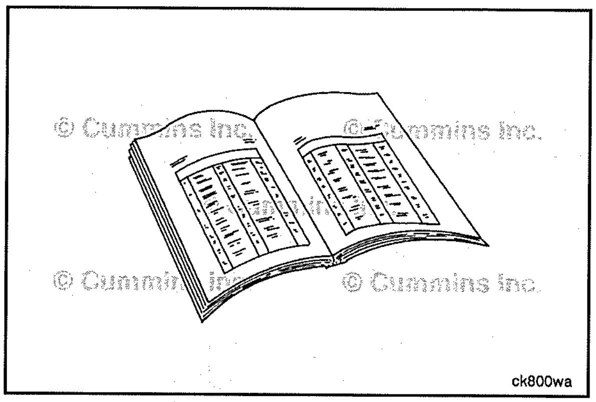
Tighten the p-clip capscrews, banjo bolts, and banjo style check valve.

Torque Value:
M12 Banjo Bolts and Check Valve 24 N•m [212 in-lb]

Torque Value:
M14 Banjo Bolts 34 N•m [25 ft-lb]

Torque Value:
P-Clip Capscrew 20 N•m [177 in-lb]

Torque Value:
P-Clip Stud 46 N•m [34 ft-lb]



Finishing Steps

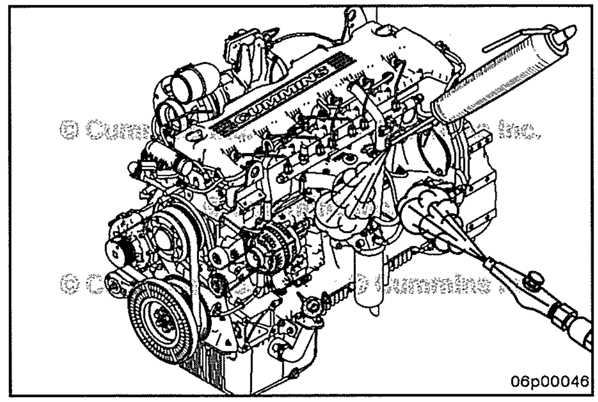
WARNING

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

Fuel Filter Head (006-017)

Preparatory Steps



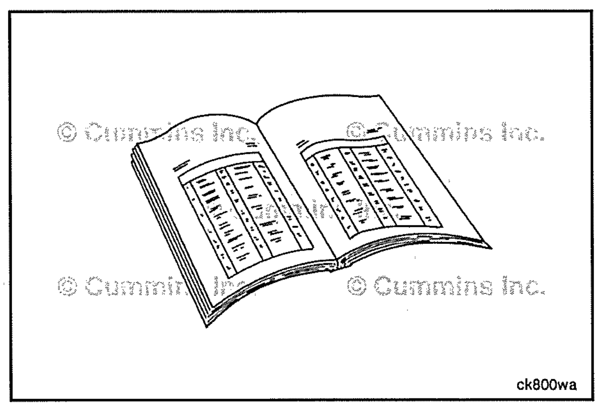
WARNING
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

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

CAUTION
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 components 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. Refer to Procedure 000-009 in Section 0.

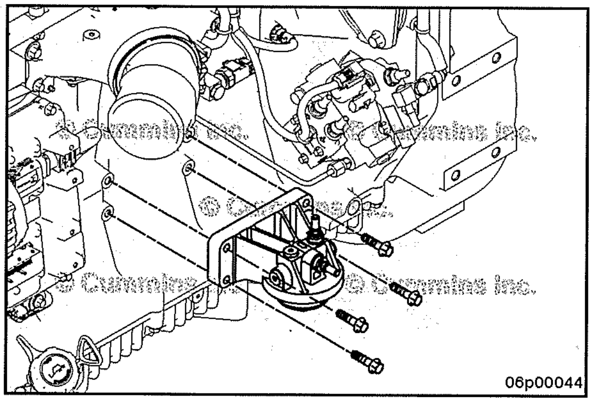
It is important to cover, cap, or plug any openings as soon as possible when servicing the fuel system in order to prevent engine damage. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.



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.

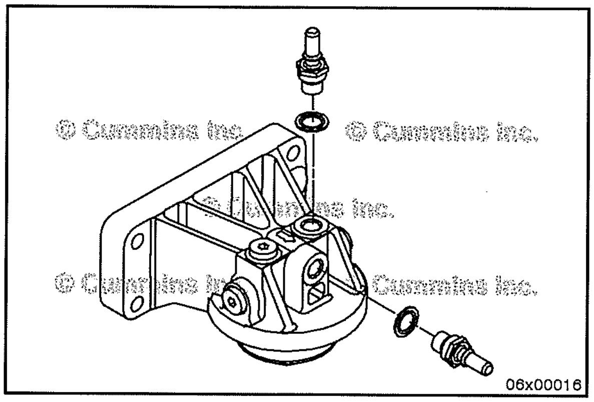
- Disconnect the batteries. See equipment manufacturer service information.
- Disconnect the crankcase breather tube. Refer to Procedure 003-018 in Section 3.
- Remove the pressure side fuel filter. Refer to Procedure 006-065 in Section 6.
- Disconnect the fuel supply and return line connections. Refer to Procedure 006-024 in Section 6.



Remove

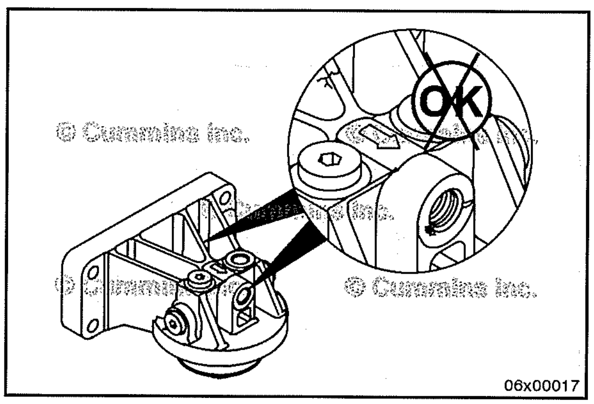
Remove fuel filter head mounting capscrews.

Remove fuel filter head.



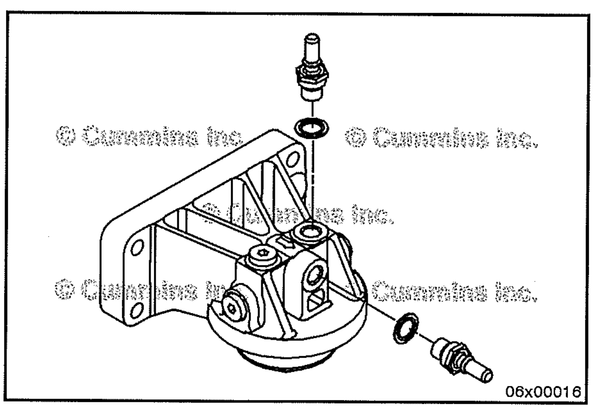
Disassemble

If damaged, remove quick connect fittings from the fuel filter head.



Inspect for Reuse

Inspect fuel filter head and quick connect fittings for cracks, passage blockage, and material or debris on the sealing surfaces.

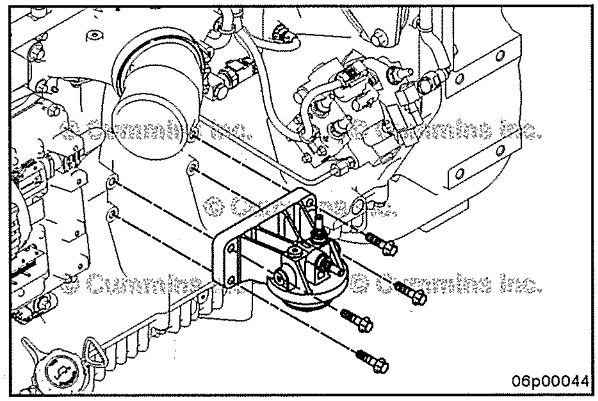


Assemble

If removed, install quick connect fittings.

Torque Value: 27 N•m [239 in-lb]

Install

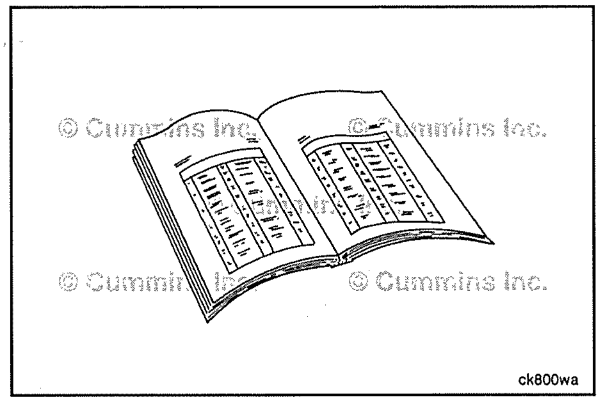


Install fuel filter head.

Tighten capscrews in a crisscross pattern.

Torque Value: 46 N•m [34 ft-lb]

Finishing Steps

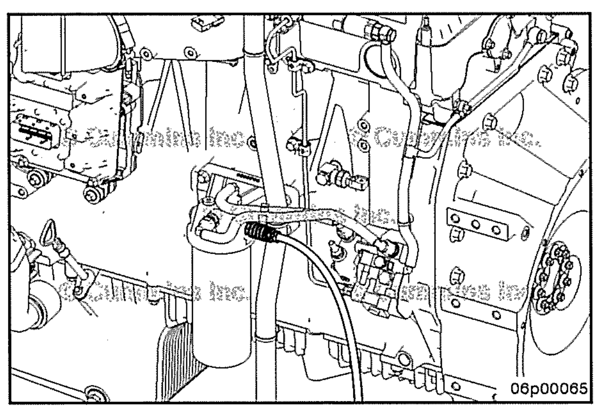


⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Install the fuel supply and return line connections. Refer to Procedure 006-024 in Section 6.
- Install the pressure side fuel filter. Refer to Procedure 006-065 in Section 6.
- Connect the crankcase breather tube. Refer to Procedure 003-018 in Section 3.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks.

Fuel Inlet Restriction (006-020)

Setup

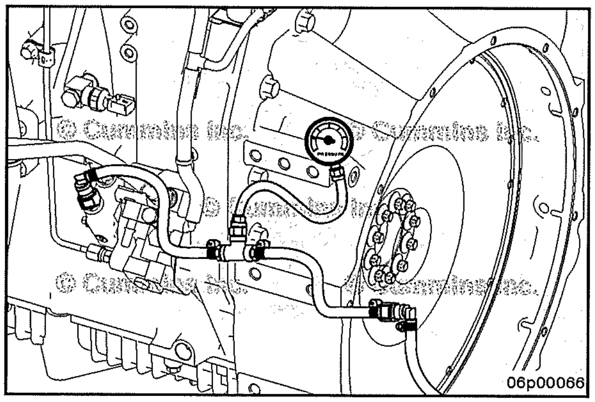


Install Compuchek™ fitting, Part Number 3824844, at the inlet to the pressure side fuel filter.

Install orificed diagnostic fuel line, Part Number 3164621, onto the Compuchek™ fitting at the inlet to the pressure side fuel filter.

A 1.09-mm [0.043-in] orificed diagnostic fuel line is used to create rated flow through the low pressure fuel system without the need to operate the engine under load.

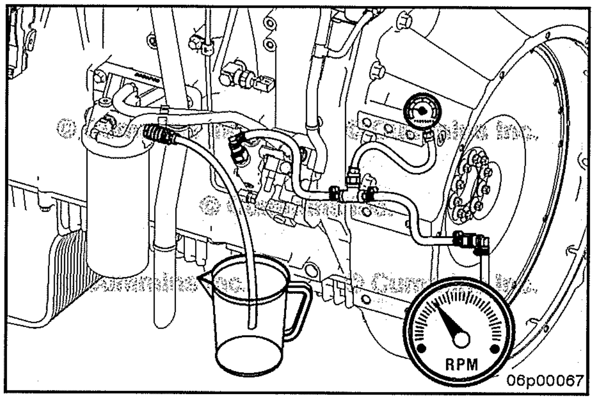
Route the hose from this adapter to a suitable container.



If equipped with a quick disconnect inlet, install Part Number 4918696 in line with fuel gear pump inlet and OEM fuel supply line.

If equipped with a threaded inlet, install Part Number ST-434-2 in line with fuel gear pump inlet and OEM fuel supply line.

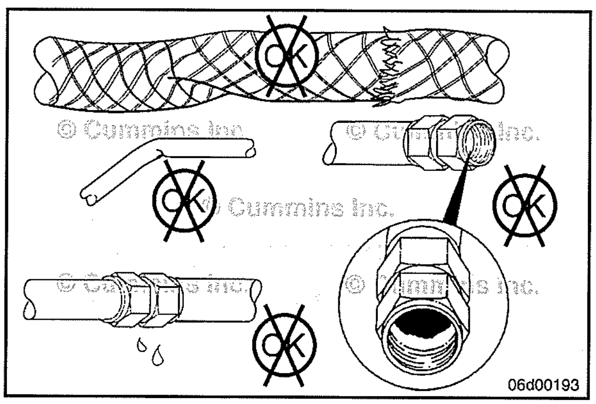
Attach a 0 to 762 mm-Hg [0 to 30 in-Hg] vacuum gauge, found in kit part number 3400162, to the Compuchek™ test fitting Part Number 3376920 at the gear pump inlet.



Measure

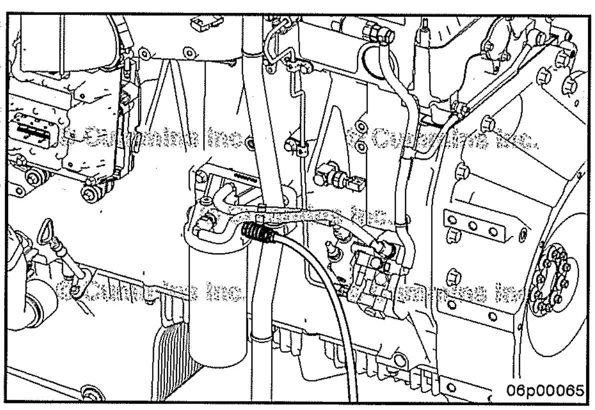
Operate the engine at high idle and measure the inlet restriction.

Fuel Inlet Restriction		
mm Hg		in Hg
254	MAX	10



If the inlet restriction is excessive, look for the root cause:

- Suction side fuel filter plugged
- Fuel heater valves are restricted
- OEM fuel lines pinched or restricted
- Fuel tank stand pipes restricted.



Finishing Steps

Disconnect all diagnostic test fittings and install all components removed during testing.

Fuel Supply Lines (006-024)

General Information

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.

WARNING

Normal engine operation creates highly pressurized fuel in the fuel line which will remain in the fuel line after engine shutdown. Never open the fuel system when the engine is operating. Before servicing the fuel system, always loosen the pump to rail fuel line at the rail to vent the pressure. Keep hands clear of the line when loosening. High pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

WARNING

Fuel can be returned at highly elevated temperatures. Wear safety glasses and protective gloves and clothing when performing this test. Avoid any contact with returned fuel.

CAUTION

Be sure the fuel inlet and return valves are returned to the open position before cranking engine. Engine damage can result if valves are in the wrong position when engine is cranked or started. Environmental damage can also occur. Refer to Procedure 005-999 in Section F for further information.

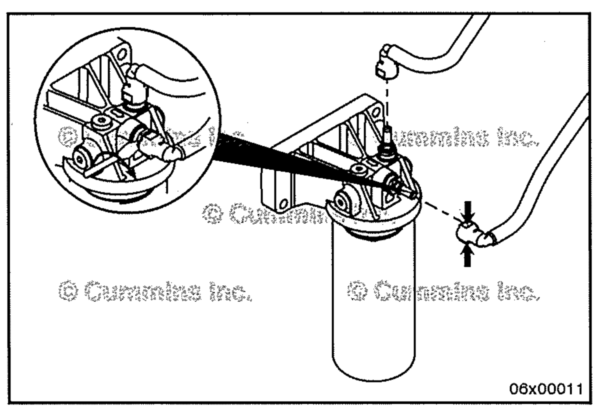
Due to the number of different fuel supply line routings and connector styles, the steps in this procedure have been written to be generic. Some of the illustrations can **not** represent the parts being removed or installed.

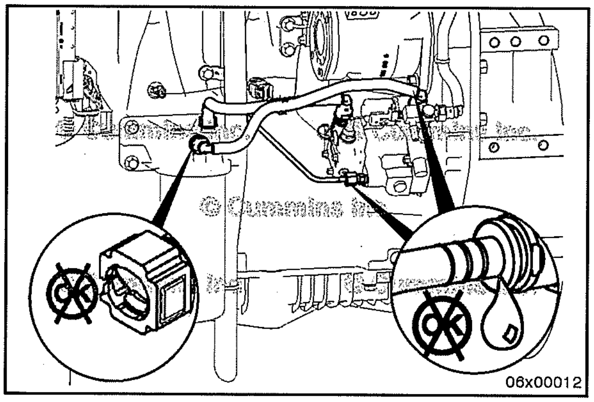
Directions for service of a two-button quick-disconnect fitting:

To remove the quick disconnect style fuel lines, press in the locking tangs on both sides of the quick disconnect fitting.

To aid removal, a screwdriver can be inserted between the fuel line end and quick disconnect male union. After pressing the opposing locking tangs, twisting the flat blade of the screwdriver helps to remove the fuel line.

Install the quick-disconnect style fuel lines by pushing the quick-disconnect fitting onto the male union until it clicks.



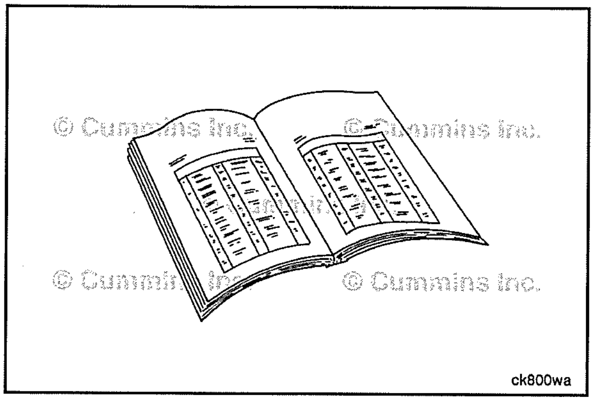

06x00012

Initial Check

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

Inspect all fuel supply line fittings and lines. Look for cracks in the lines or leaks in the fittings.

Check for loose or broken brackets.


ck800wa

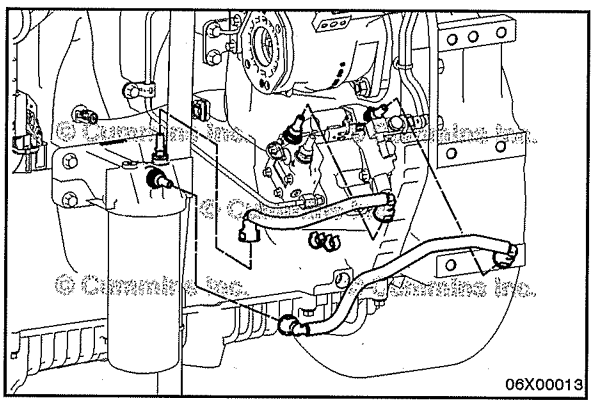
Preparatory Steps

CAUTION

Use caution when disconnecting or removing fuel lines, replacing filters and priming the fuel system, that fuel is not spilled or drained into the bilge area. Do not drop or throw filter elements into the bilge area. The fuel and fuel filters must be discarded in accordance with local environmental regulations.

NOTE: Clean all fittings before disassembly. Dirt or contaminants can damage the fuel system.

Shut off the fuel supply to the engine.

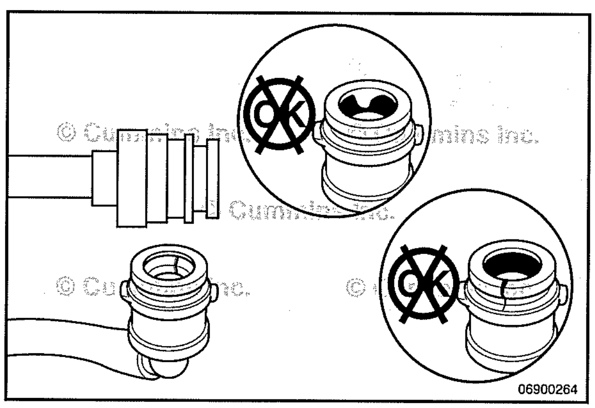

06X00013

Remove

Mark the location of all p-clips and routing of fuel supply lines to make sure that they are replaced in the correct location during assembly.

Remove the fuel supply line connecting the gear pump to the fuel filter head.

Remove the fuel supply line connecting the fuel filter head to the inlet of the high pressure fuel pump.


06900264

Clean and Inspect for Reuse

Inspect for burrs or debris on metal connectors that can cause leaks.

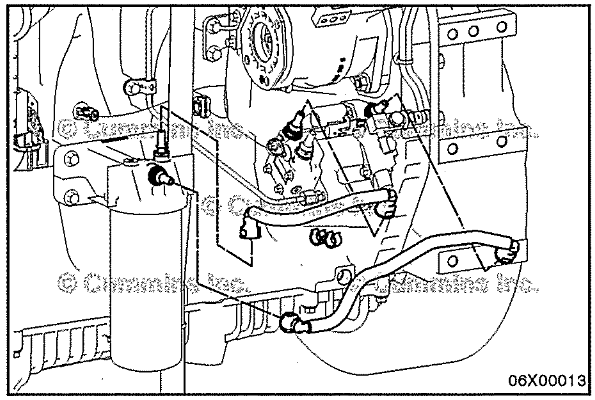
On quick-disconnect fittings, be certain that the o-rings are **not** frayed or cut, and that the lock tangs are **not** damaged.

Install

Install the fuel supply line connecting the gear pump to the fuel filter head.

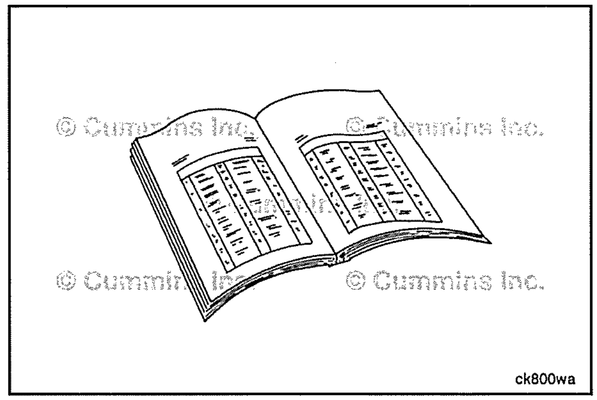
Install the fuel supply line connecting the fuel filter head to the inlet to the high pressure pump.

Install the p-clips and p-clip mounting capscrews in locations noted during removal.



Finishing Steps

⚠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.



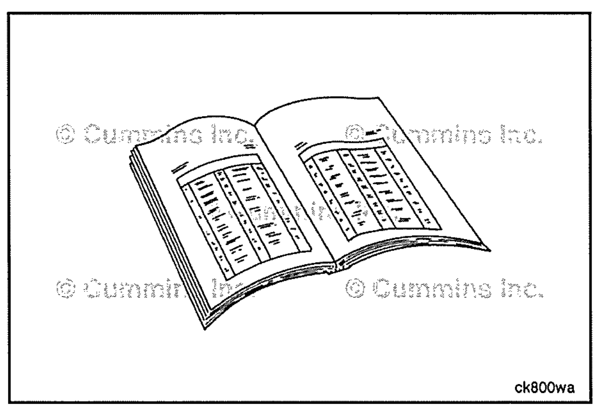
⚠CAUTION⚠
Use caution when disconnecting or removing fuel lines, replacing filters and priming the fuel system that fuel is not spilled or drained into the bilge area. Do not drop or throw filter elements into the bilge area. The fuel and fuel filters must be discarded in accordance with local environmental regulations.

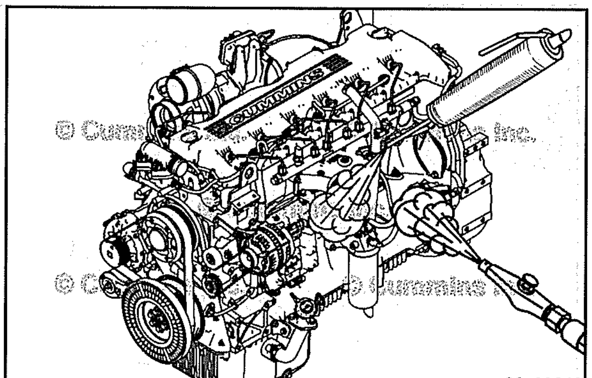
- Open the fuel supply valve.
- Prime the fuel system. Refer to Procedure 005-016 in Section 5.
- Operate the engine and check for leaks.

Injector (006-026)

Initial Check

Use the following procedure for details on injector drain and leakage measurements. Refer to Procedure 005-236 in Section 5.





06p00046

Preparatory Steps

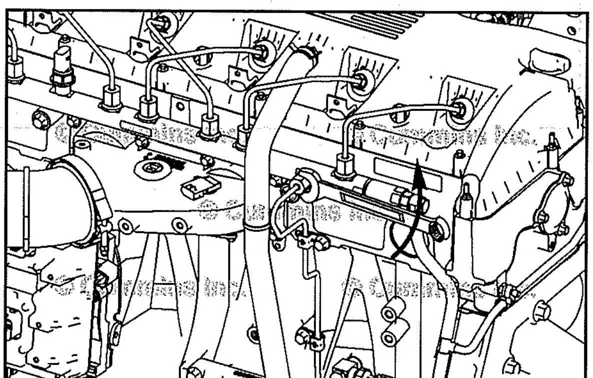
⚠CAUTION⚠

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 components 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 injector supply line connections and mating components with contact cleaner, Part Number 3824510 or equivalent.

To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.



06p00042

⚠WARNING⚠

Normal engine operation creates highly pressurized fuel in the fuel line which will remain in the fuel line after engine shutdown. Never open the fuel system when the engine is operating. Before servicing the fuel system, always loosen the pump to rail fuel line at the rail to vent the pressure. Keep hands clear of the line when loosening. High pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

⚠WARNING⚠

When servicing the engine, do not use the starting motor to rotate the 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.

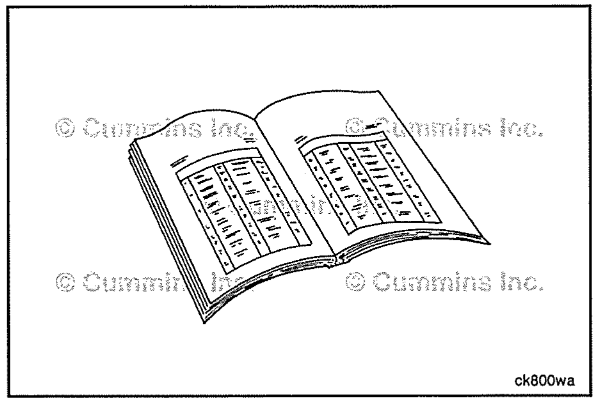
Before servicing the fuel system, loosen the pump to rail line at the rail to vent the fuel pressure.

Keep hands clear of the line when loosening the fuel rail nut.

Tighten the fuel rail nut.

Torque Value: 25 N•m [221 in-lb]

NOTE: A machined slot in this fitting directs the fuel spray toward the inboard side of the fuel rail.

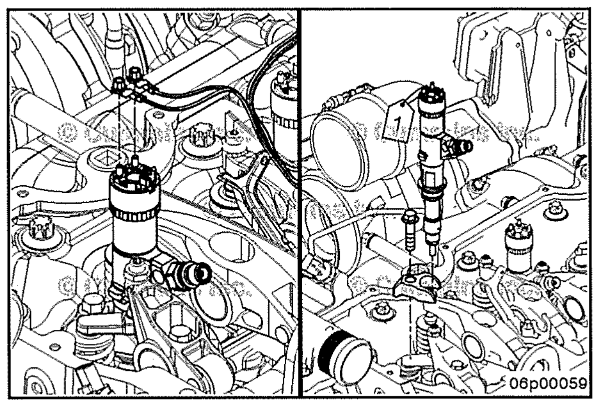


⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

⚠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 sever personal injury or death when working on the fuel system.

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Disconnect the high-pressure fuel lines. Refer to Procedure 006-051 in Section 6.
- Any open fuel connectors **must** be closed immediately with clean protection caps.
- Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3.

Remove



⚠CAUTION⚠
When removing the injector, care must be taken not to damage the injector tip.

NOTE: If possible, provide a work area that will **not** have flying debris or dust. Gently place the removed injector(s) on a clean work table or container that has been cleaned of debris and oils. Immediately cover each injector to prevent contamination. Cover the engine if it will be left unattended to prevent contamination.

NOTE: Neighboring work areas may inadvertently contaminate the work area with debris from compressed air, air tools, or cleaning.

Remove the injector actuator wire nuts and wires from the injector.

Loosen and remove the injector hold-down capscrew.

A small heel pry bar can also be used to pry up the injector. Pry up the injector hold-down flange (part of the injector body just above the cylinder head casting).

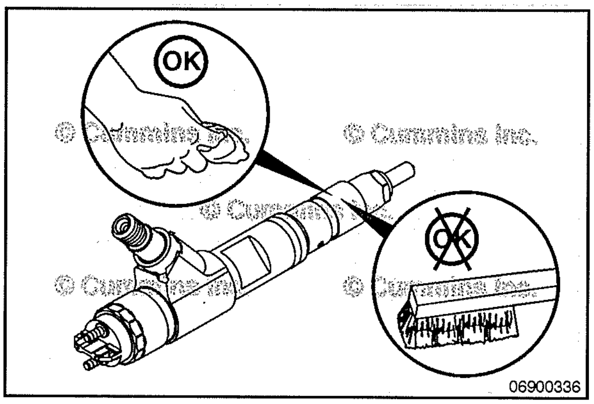
Remove the injector hold-down clamp from the injector.

Remove the injector from the cylinder head.

Apply a protective cap to the injector nozzle.

Insert a blind plug to prevent dust or debris from entering the engine through the cylinder head.

Reused injectors **must** be installed with the same cylinder each time the injector is removed. Mark or tag the fuel injector with the cylinder number to keep track of the correct position of each fuel injector.



Clean and Inspect for Reuse

WARNING

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

CAUTION

Overheating will cause the nozzle to turn a dark yellow/tan or blue color resulting in injector damage, depending on the degree of overheating.

CAUTION

Do not use any abrasives (such as glass beading, sand paper, emery cloth, Scotch-Brite™ pads, etc) or metallic items (including wire brushes made of any metallic material) to clean the injectors. The use of any cleaning method other than safety solvent and a soft, clean, lint-free cloth will damage the nozzle holes and cause performance issues.

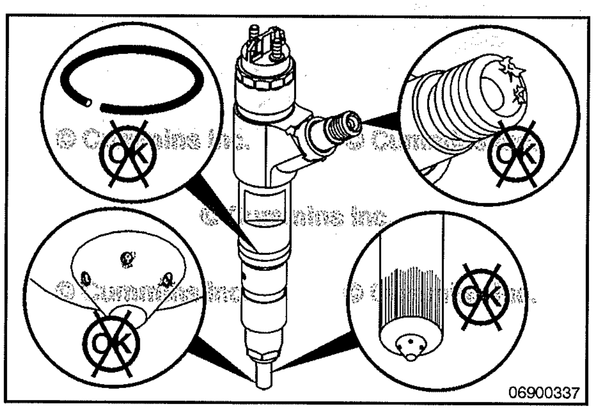
The injector shaft and nozzle should be cleaned in an ultrasonic bath with a safe, aqueous cleaning agent.

Remove the protective cap from the injector nozzle.

Place the injector in the ultrasonic bath in the vertical position. The high pressure fuel connector and electrical connection **must not** contact the cleaning solution.

A new fine lint free cleaning cloth may also be used to remove any dirt residue.

Do **not** remove the protection caps from the fuel inlet and drain connectors during cleaning.



Inspect the injector tip for carbonization or corrosion.

Check for terminal damage to the solenoid.

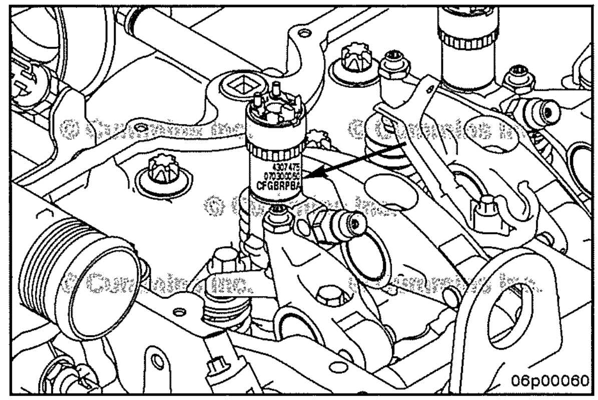
Inspect the injector inlet and high-pressure connector tip for damage.

Overheating will cause the nozzle to turn a dark yellow/tan or blue color, depending on the degree of overheating.

Inspect the injector o-rings for damage and replace if necessary.

Resistance between the terminals **must** be less than 3 ohms.

Install



⚠CAUTION⚠

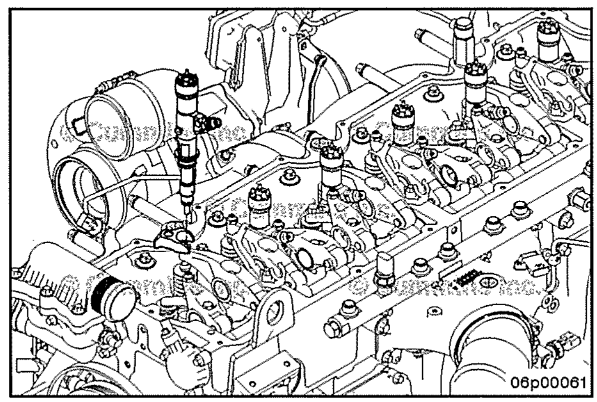
When installing the injector, care must be taken not to damage the injector tip.

NOTE: If the injector solenoid shipping cap is **not** used to install the injector, be careful that pressure is **not** placed on the wire terminals. Wire terminals can break off if they are used to push on the injector.

Record the injector trim codes that are listed on each injector.

Record the cylinder location where each injector will be installed.

NOTE: The injector trim codes are nine-character alphanumeric codes, located on the solenoid at the top of the injector.



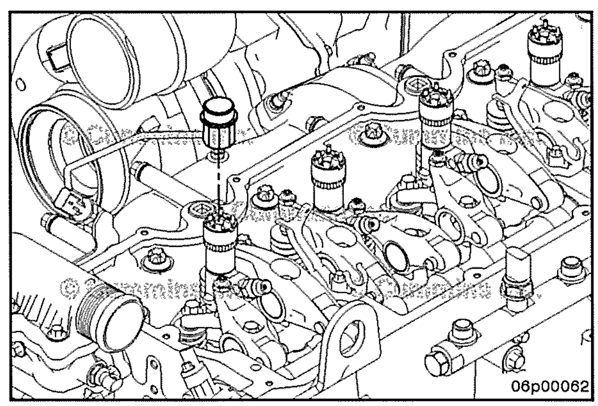
Remove the blind plug installed to prevent dust or debris from entering the engine.

Make sure the injector bore is clean.

Ensure o-ring and injector seal are properly installed.

Lubricate injector o-ring with clean engine oil.

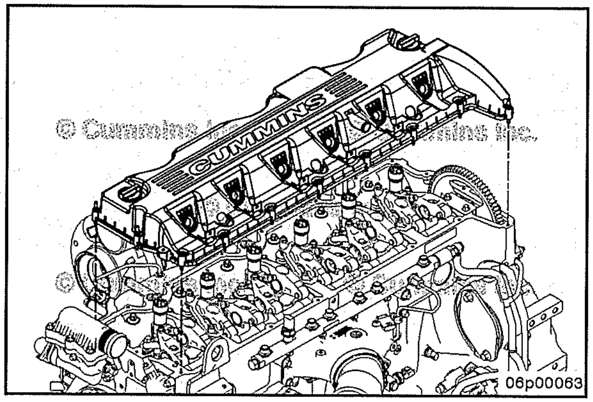
Install injector hold-down clamp on injector before installing injector into the bore.



Use injector solenoid shipping cap to ensure injector is seated in the injector bore.

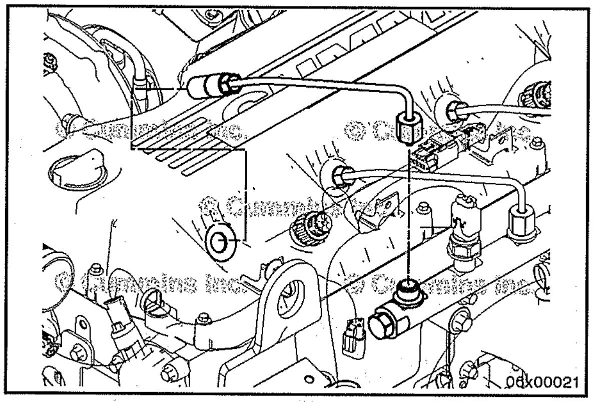
Install injector hold-down capscrew. Do **not** tighten beyond hand-tight at this time.

Repeat process to loosely install the other five injectors.



Install rocker lever cover without the oil seal. Tighten one mounting capscrew on each side of the cover. Refer to Procedure 003-011 in Section 3.

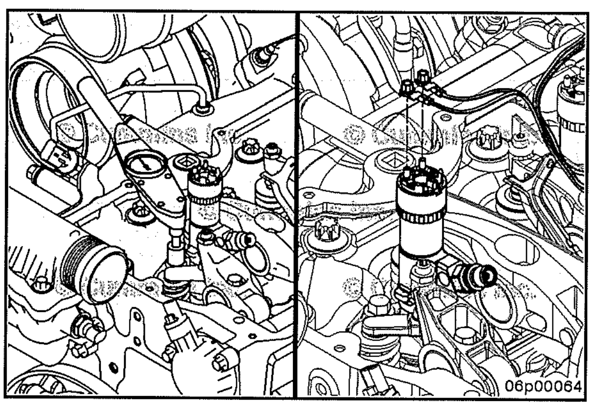
NOTE: The rocker lever cover **must** be installed without the oil seal. If this procedure is performed with the oil seal installed on the rocker lever cover the injectors may **not** align properly, causing oil and/or fuel leaks.



Connect injector end of one of the high-pressure fuel lines to injector. Use injector end nut as a guide and center injector in the grommet.

Remove high-pressure fuel line from injector and repeat process for all six injectors.

Remove rocker lever cover and install the oil seal. Refer to Procedure 003-011 in Section 3.



Tighten the injector hold-down clamp capscrew.

Torque Value:
Injector Hold-down Clamp Capscrews 65 N•m [48 ft-lb]

Install the injector actuator wires and nuts onto the injector.

NOTE: Align the injector wires so they will **not** interfere with each other or the rocker levers. If a rocker lever is able to come into contact with the injector harness, it will rub through the wire insulation and cause injector circuit fault codes.

Tighten the nuts.

Torque Value:
Injector Actuator Wire Nuts 2 N•m [18 in-lb]

Repeat the process to install the other five injectors.

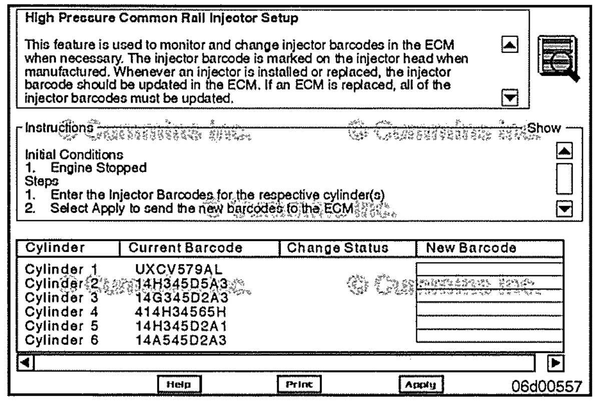
Finishing Steps

WARNING

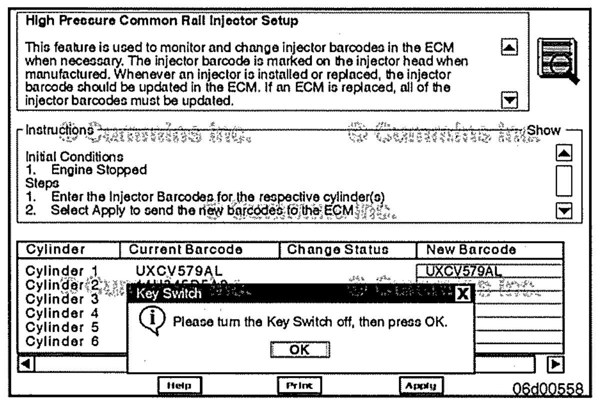
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Trim Code Installation Instructions: INSITE™ 7.3 Feature Pack 1 and Newer

1. Connect the batteries. See equipment manufacturer service information.
2. Connect INSITE™ electronic service tool to the ECM.
3. Select "Advanced ECM Data".
4. Select "High-Pressure Common Rail Injector Setup"
5. Read the information listed under the "High-Pressure Common Rail Injector Setup" and "Instructions" headings.



1. Click on the "New Bar Code" section for the respective cylinder and enter the new bar code.
2. After all the injector trim information is entered, select "Apply". Turn the keyswitch OFF, then press the "OK" button to send the new barcode(s) to the ECM.

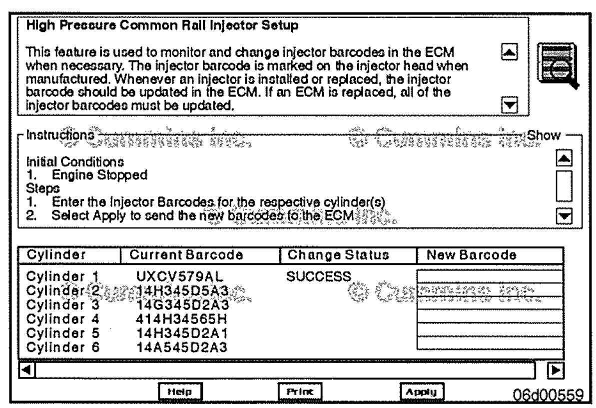


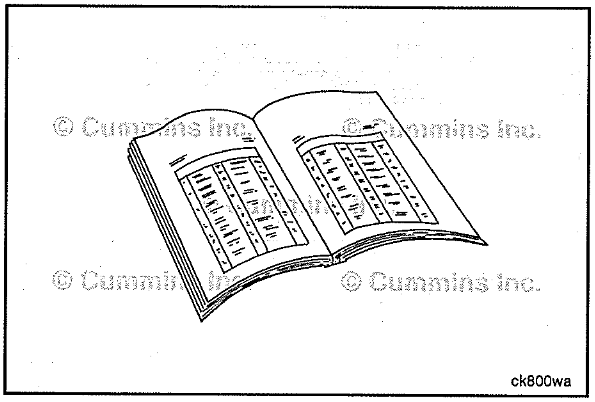
After INSITE™ electronic service tool reconnects with the ECM, verify that the "Change Status" = "Success".

If "Change Status" = "Error Occurred", "Invalid Barcode", Invalid Cylinder Number", or "Duplicate Barcode", check for the following:

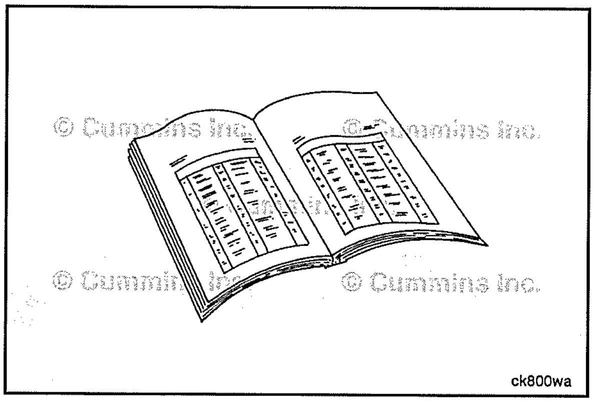
- Verify the correct injector trim code was recorded from the injector.
- Re-enter the trim codes.

Clear all inactive faults.





- Install the rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Install the high-pressure fuel lines. Refer to Procedure 006-051 in Section 6.
- Operate the engine and check for leaks.

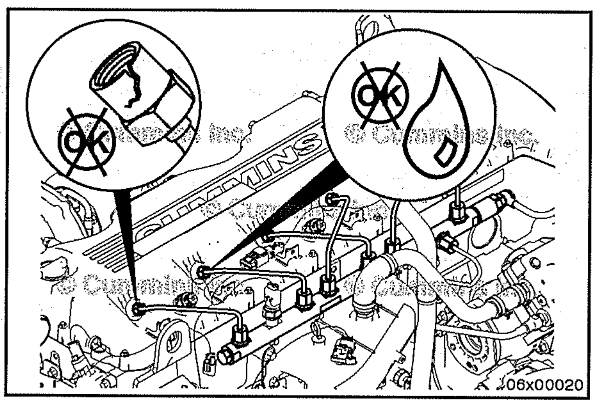


Injector Supply Lines (High Pressure) (006-051)

General Information

CAUTION

Be sure that the fuel inlet and return valves are returned to the open position before cranking engine. Engine damage can result if valves are in the wrong position when engine is cranked or started. Environmental damage can also occur. Refer to Procedure 005-999 in Section F for further information.



Initial Check

WARNING

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

WARNING

Normal engine operation creates highly pressurized fuel in the fuel line which will remain in the fuel line after engine shutdown. Never open the fuel system when the engine is operating. Before servicing the fuel system, always loosen the pump to rail fuel line at the rail to vent the pressure. Keep hands clear of the line when loosening. High-pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

Inspect the injector high-pressure supply lines for cracks, chafing, leaks, and loose or broken brackets.

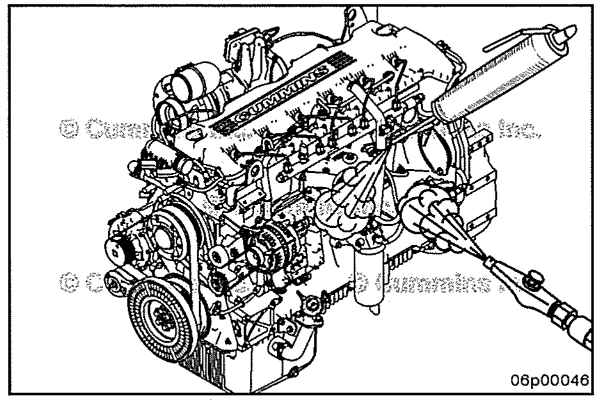
Preparatory Steps

⚠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 components 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 injector supply line connections and mating components with contact cleaner, Part Number 3824510 or equivalent.

To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.



⚠WARNING⚠
When servicing the engine, do not use the starting motor to rotate the 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.

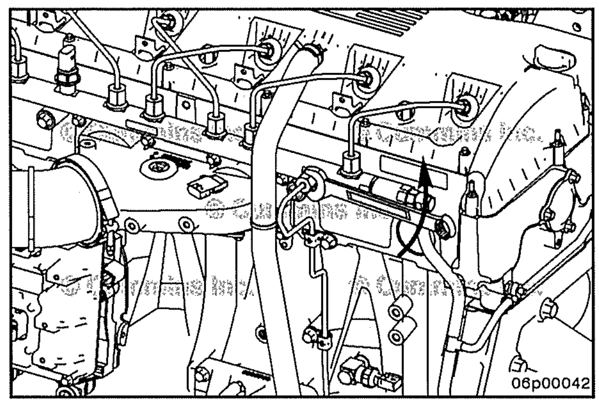
Before servicing the fuel system, loosen the pump to rail line at the rail to vent the fuel pressure.

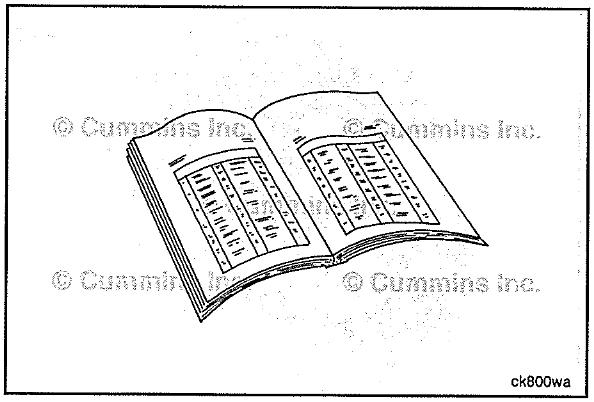
Keep hands clear of the line when loosening the fuel rail nut.

Tighten the fuel rail nut.

Torque Value: 25 N•m [221 in-lb]

NOTE: A machined slot in this fitting directs the fuel spray toward the inboard side of the fuel rail.





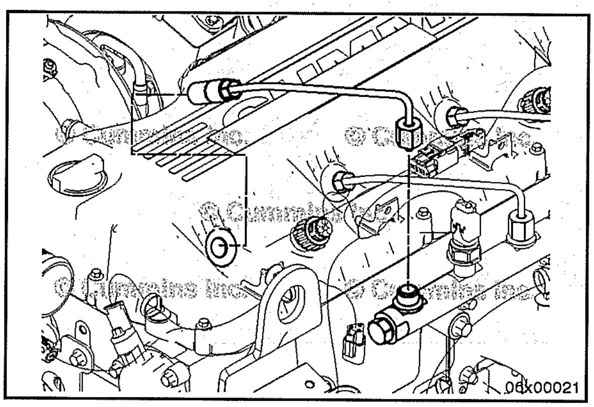
WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) 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 sever personal injury or death when working on the fuel system.

- Disconnect the batteries. See equipment manufacturer service information.
- Before removing any of the high-pressure fuel lines, be sure to have clean caps to cover the ends of the high-pressure fuel lines and the connection on the injectors. This will help to prevent any dirt from entering the fuel lines and the injectors.
- Clean the top of the rocker lever cover and the area around each injector supply line.

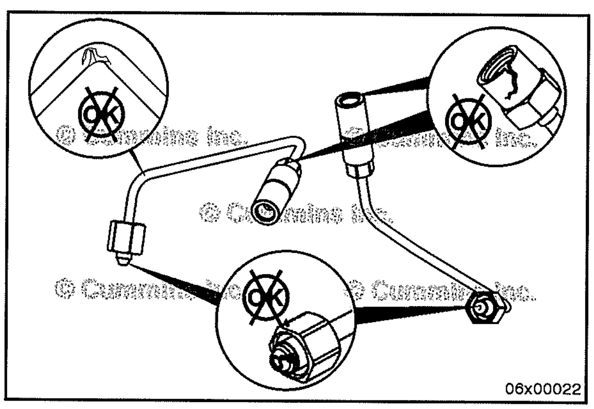


Remove

Disconnect the high-pressure fuel line from the rail end of injector Number 1. Cover the end of the line and the rail connection immediately.

Disconnect the line from the number 1 injector. Cover the end of the line and the injector connection immediately.

Repeat the steps for all six injectors, removing and capping the connections one at a time.



Inspect for Reuse

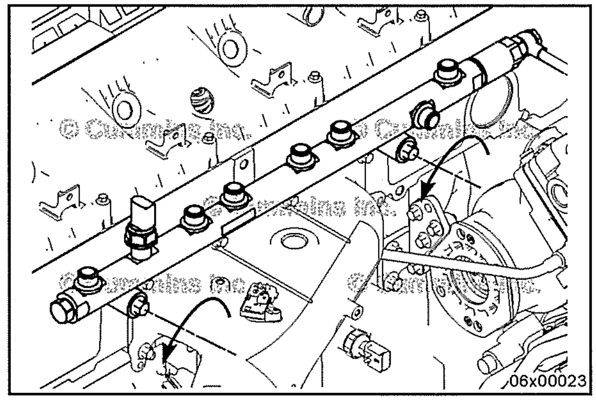
Inspect the high-pressure fuel supply line ferrules for any signs of burrs, foreign material, rounding, or cracking. Replace, if necessary.

Check for cracks, wear, or pinched areas. Replace, if necessary.

Inspect the ends of the high-pressure lines for damaged sealing surfaces.

Install

Loosen the capscrews for the fuel rail. Do **not** remove the fuel rail. The capscrews are loosened to allow proper alignment of the fuel rail after installing the new fuel line.



Using clean 15W-40 engine oil, lubricate the six injector fuel line seals in the rocker cover before fitting the injector fuel lines.

The fuel lines **must** be aligned correctly. The process below should be followed to avoid any problems.

Hand-tighten the injector fuel line union at the injector. Make sure the line is central within the union.

Hand-tighten fuel line union at the rail. Make sure the line is central within the union.

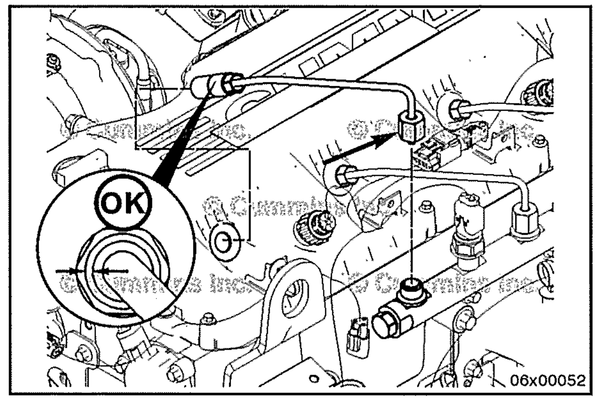
Tighten the injector end, making sure there is no contact between the line and the union at either end.

Torque Value: 25 N•m [221 in-lb]

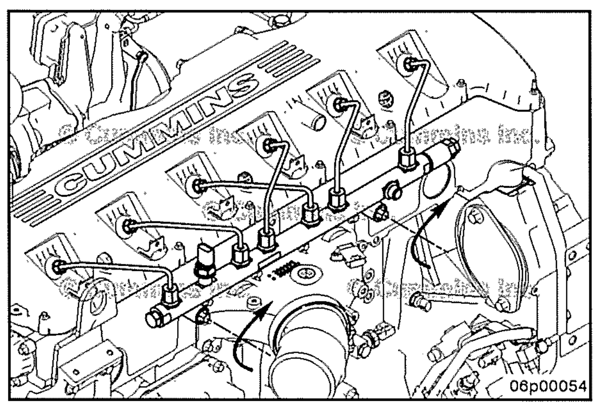
Tighten the injector fuel line union.

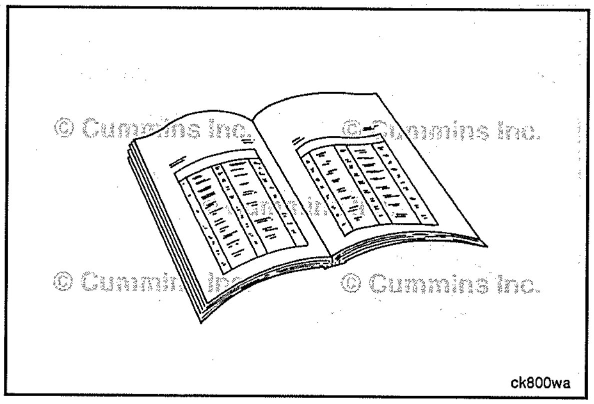
Torque Value: 25 N•m [221 in-lb]

Repeat this process for the other five lines.



Tighten the capscrews for the fuel rail. Refer to Procedure 006-060 in Section 6.





Finishing Steps

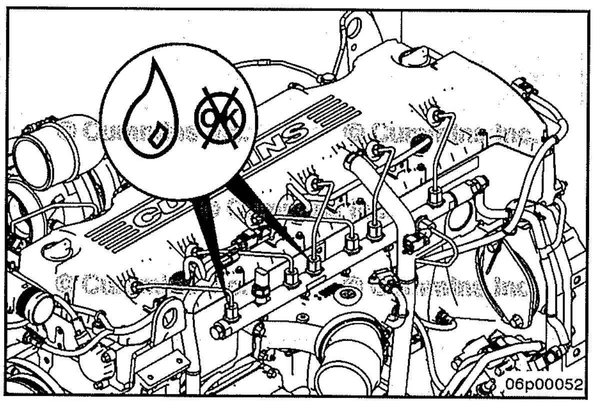
⚠WARNING⚠

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

⚠WARNING⚠

The fuel pump, high-pressure fuel lines, and fuel rail contain very high-pressure fuel. To reduce the possibility of personal injury, never loosen any fittings while the engine is running.

- It is **not** necessary to vent air from the high-pressure fuel system before starting the engine. Cranking the engine will prime the fuel system.
- Connect the battery. See equipment manufacturer service information.
- Operate engine and check for leaks.



Fuel Rail (006-060)

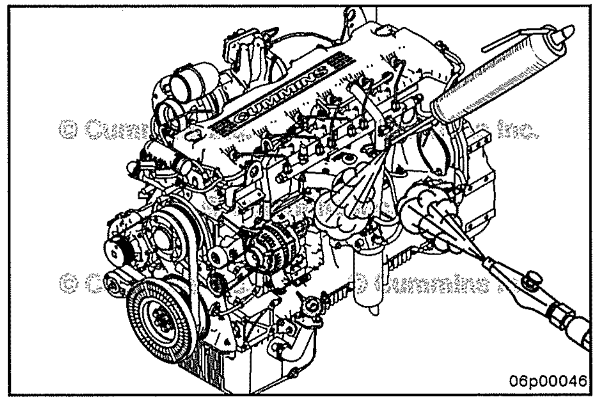
Initial Check

⚠WARNING⚠

Normal engine operation creates highly pressurized fuel in the fuel line which will remain in the fuel line after engine shutdown. Never open the fuel system when the engine is operating. Before servicing the fuel system, always loosen the pump to rail fuel line at the rail to vent the pressure. Keep hands clear of the line when loosening. High-pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

Inspect the fuel pressure sensor, injector supply line connections, and male unions for leaks.

Preparatory Steps



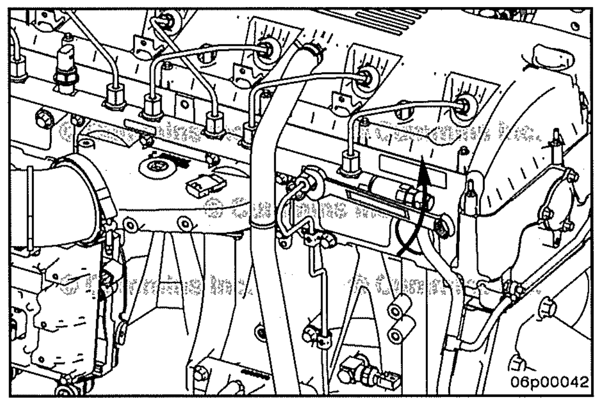
⚠CAUTION⚠

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 components 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 injector supply line connections and mating components with contact cleaner, Part Number 3824510 or equivalent.

To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.



⚠WARNING⚠

When servicing the engine, do not use the starting motor to rotate the 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.

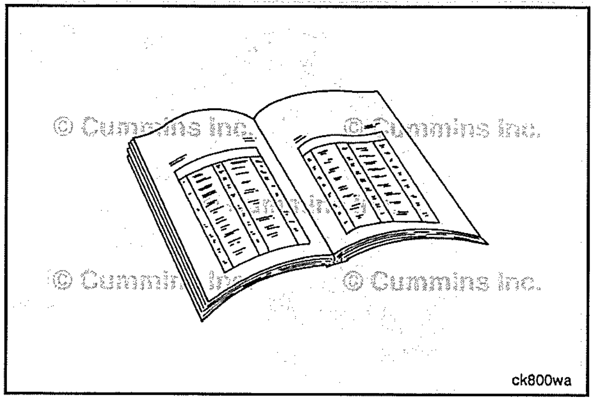
Before servicing the fuel system, loosen the pump to rail line at the rail to vent the fuel pressure.

Keep hands clear of the line when loosening the fuel rail nut.

Tighten the fuel rail nut.

Torque Value: 25 N•m [221 in-lb]

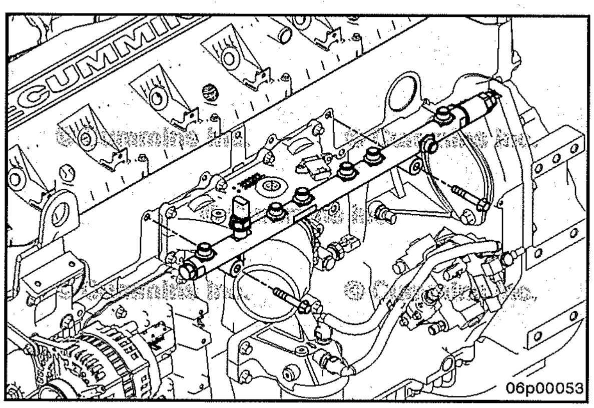
NOTE: A machined slot in this fitting directs the fuel spray toward the inboard side of the fuel rail.



⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) 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 batteries. See equipment manufacturer service information.
- Disconnect the fuel pressure sensor from the engine wiring harness. Refer to Procedure 019-115 in Section 19.
- Remove the high-pressure fuel lines from the fuel rail. Refer to Procedure 006-051 in Section 6.
- Disconnect the fuel drain line from the fuel pressure relief valve. Refer to Procedure 006-013 in Section 6.

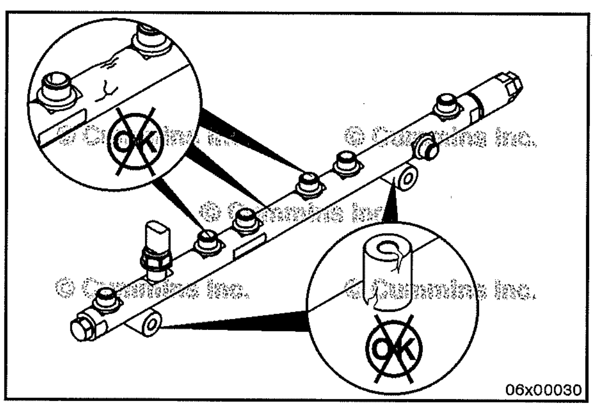


Remove

Remove the two capscrews that secure the fuel rail to the cylinder head.

Remove the fuel rail.

To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.



Clean and Inspect for Reuse

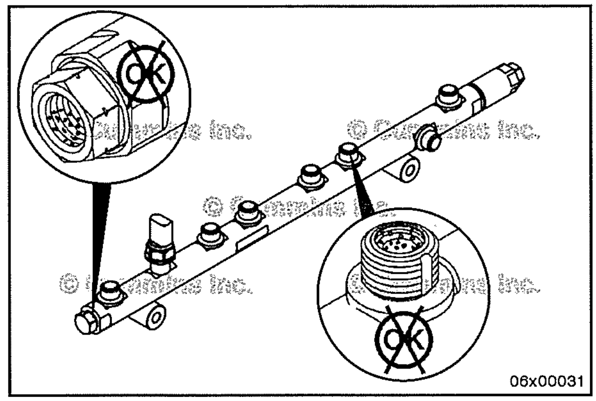
Inspect the fuel rail fittings for dings or damage.

Inspect the fuel rail mounting pads for cracks or other damage.

Inspect the fuel rail body for damage.

Replace the fuel rail if damage is found.

Inspect the fuel rail connection bores for dirt or debris.



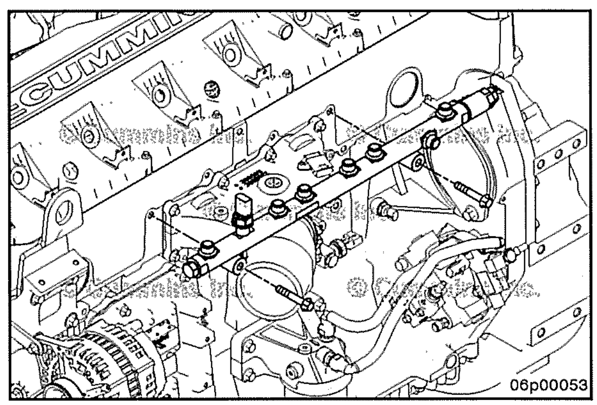
Clean the fuel rail and mating components with contact cleaner, Part Number 3824510, or equivalent.

Install any caps or plugs removed during cleaning.

Install

Install the fuel rail assembly.

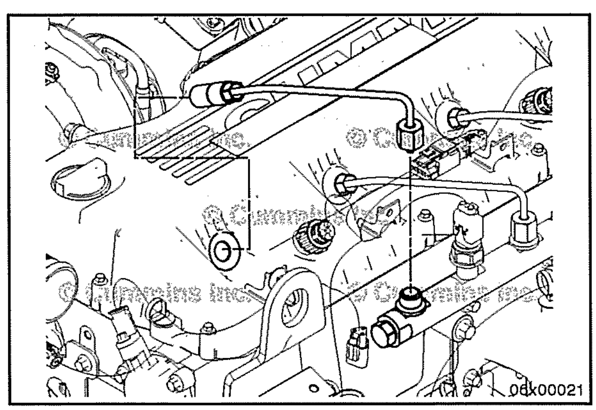
Hand-tighten the fuel rail capscrews.

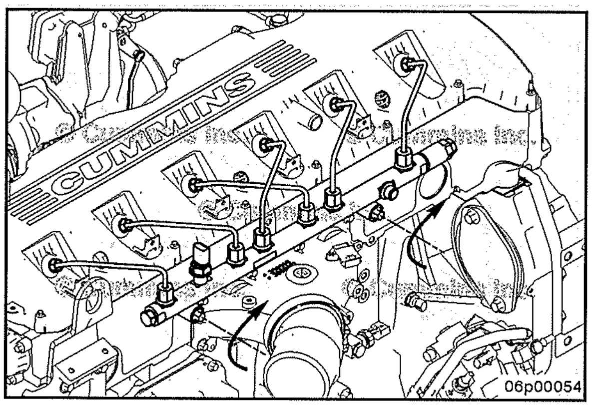


⚠CAUTION⚠

Injector supply lines and the high-pressure supply line must be torqued prior to tightening the fuel rail cap screws.

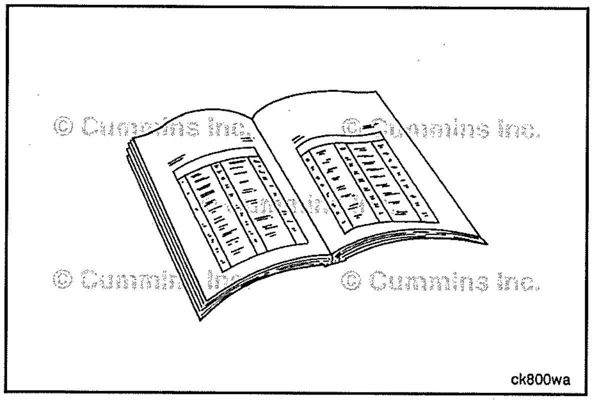
Install the injector supply line(s) that connect the fuel rail to the fuel injectors. Refer to Procedure 006-051 in Section 6.





Tighten the fuel rail capscrews.

Torque Value: 46 N•m [36 ft-lb]

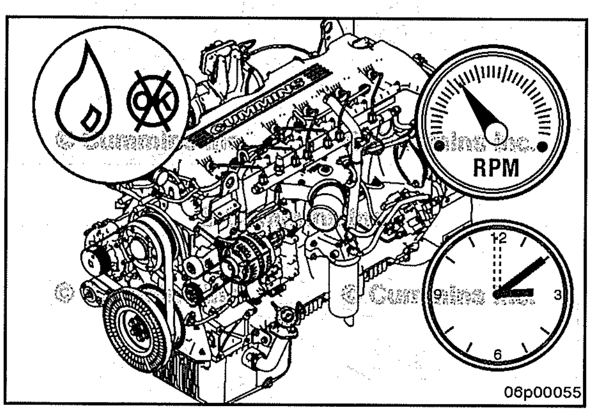


Finishing Steps

WARNING

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

- Connect the fuel rail supply line. Refer to Procedure 006-071 in Section 6.
- Connect the fuel drain line to the fuel pressure relief valve. Refer to Procedure 006-013 in Section 6.
- Connect the fuel pressure sensor to the engine wiring harness. Refer to Procedure 019-115 in Section 19.
- Connect the battery. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks.



Fuel Pressure Relief Valve (006-061)

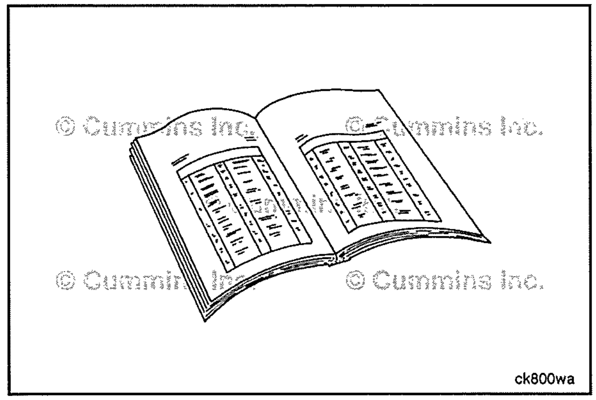
Initial Check

WARNING

The fuel pump, high-pressure fuel lines, and fuel rail contain very high-pressure fuel. To reduce the possibility of personal injury, never loosen any fittings while the engine is running.

Operate the engine and check for external fuel leaks.

Use the following procedure for details on testing the fuel pressure relief valve for excessive leakage. Refer to Procedure 005-236 in Section 5.



Preparatory Steps

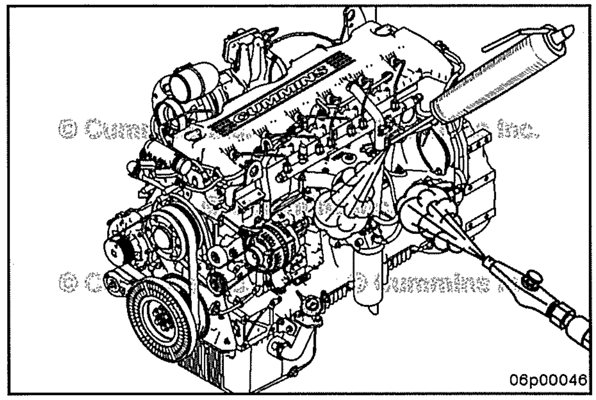
CAUTION

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 fuel pressure relief valve and surrounding area with contact cleaner, Part Number 3824510 or equivalent.

To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.



WARNING

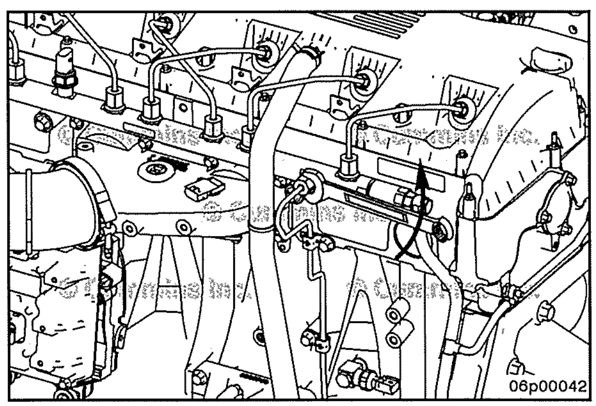
Normal engine operation creates highly pressurized fuel in the fuel line which will remain in the fuel line after engine shutdown. Never open the fuel system when the engine is operating. Before servicing the fuel system, always loosen the pump to rail fuel line at the rail to vent the pressure. Keep hands clear of the line when loosening. High-pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

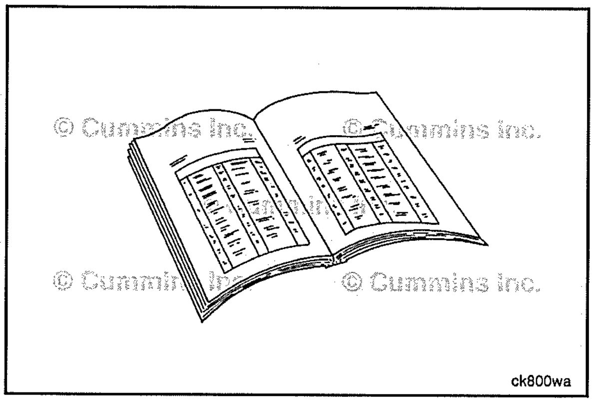
- Before servicing the fuel system, loosen the pump to rail line at the rail to vent the pressure.
- Keep hands clear of the line when loosening.
- Tighten pump to rail line nut.

Torque Value: 25 N•m [221 in-lb]

NOTE: A machined slot in this fitting directs the fuel spray toward the cylinder block.

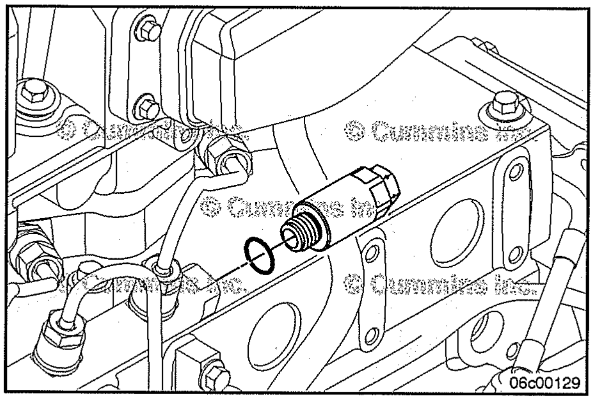
- Remove the fuel drain line from the fuel rail pressure relief valve. Refer to Procedure 006-013 in Section 6.





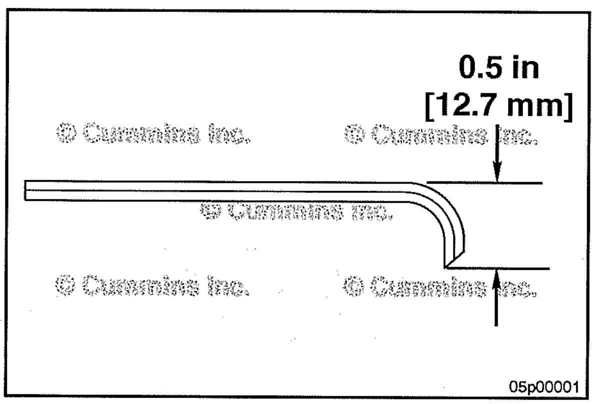
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries. See equipment manufacturer service information.



Remove

Remove the fuel pressure relief valve.

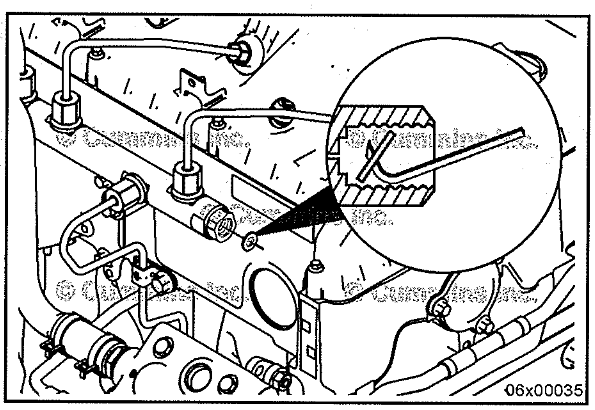


Removal of a "flat washer"

The flat sealing washer is swaged into the inlet fitting bore during installation.

A special tool can be created to aid in its removal by grinding a 45 degree angle on the short leg of a 1/8-inch or 3/16-inch Allen wrench, so that the wrench is no longer than 13-mm [1/2-in] long (measured from the outside of the long leg).

This tool acts as a mini heel bar to pry out the sealing washer without damaging the back of the hole.



Pry out the old sealing washer from the threaded hole in the back of the high-pressure pump head using the modified Allen wrench.

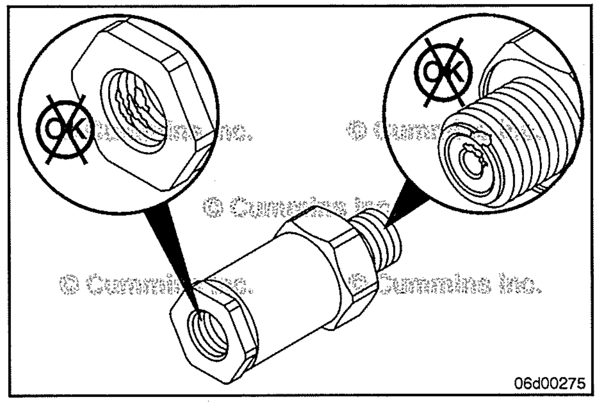
NOTE: Considerable force is required to remove the sealing washer.

Inspect for Reuse

If the fuel pressure relief valve exhibits leakage to drain, it **must not** be reused.

Inspect the high-pressure seal surface on the fuel pressure relief valve and in the fuel rail for damage. Do **not** reuse components if the high-pressure seal joint is damaged.

Inspect the copper seal washer and adapter fitting for damage.

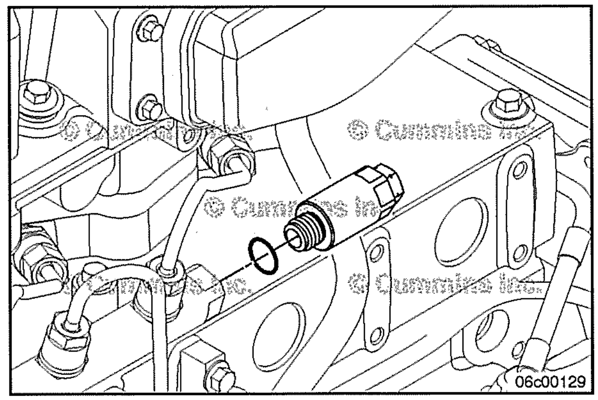


Install

Install the fuel pressure relief valve, with a new sealing washer, using assembly lubricant, Part Number 3163087 or equivalent, on the threads.

Torque Value:

Step 1	27 N•m	[239 in-lb]
Step 2	Rotate 90 degrees	

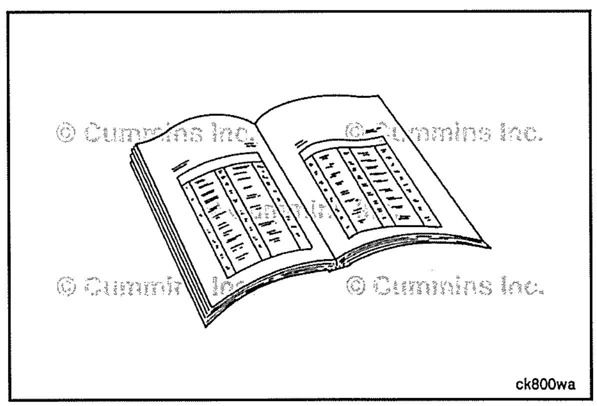


Finishing Steps

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 fuel drain line to the fuel pressure relief valve. Refer to Procedure 006-013 in Section 6.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

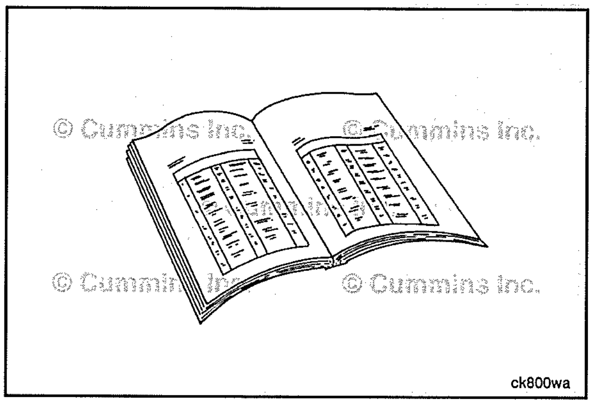


Pressure Fuel Filter (006-065)

General Information

Use **only** the Cummins Inc. recommended fuel filter of the correct part number for this application.

- Use the following procedure in the QSG12 CM2350 G110 Operation and Maintenance Manual, Bulletin 4367322 for fuel filter recommendations. Refer to Procedure 018-024 in Section V.

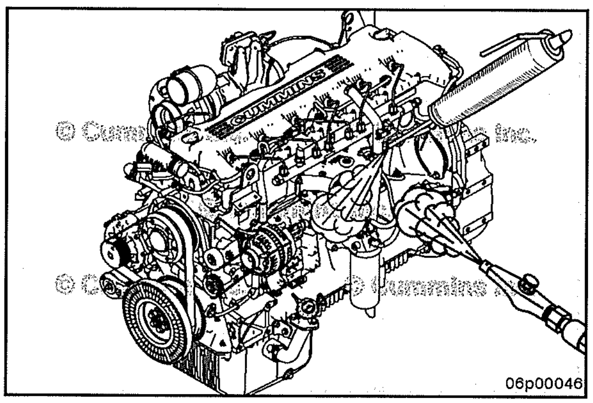


Preparatory Steps

⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.



⚠WARNING⚠

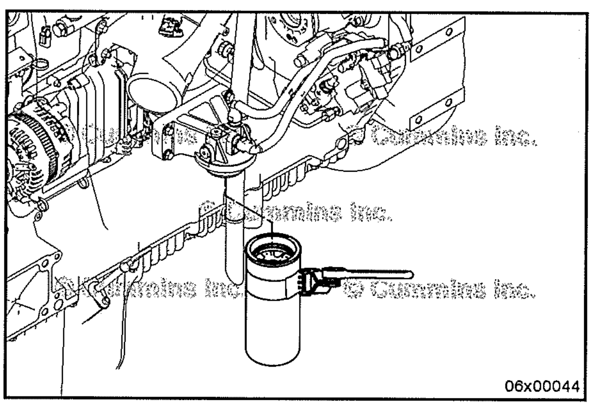
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

⚠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.

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 fuel filter head connections, fittings, and mating components with contact cleaner, Part Number 3824510, or equivalent.



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.

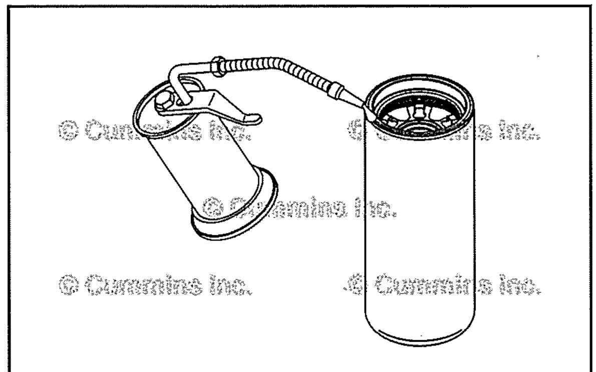
Remove fuel filter with filter wrench, Part Number 3400157.

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

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

Install

Apply a thin coating of clean engine oil to the filter gasket surface and the center seal.

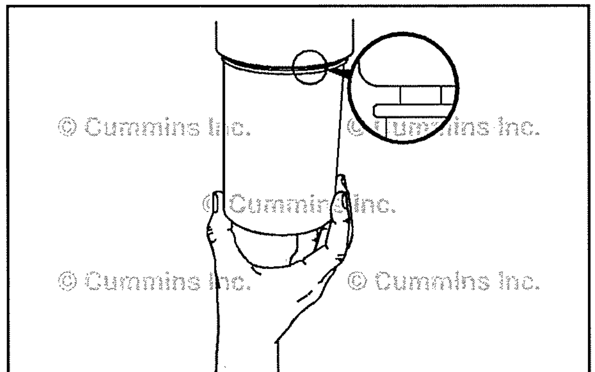


06c00219

CAUTION

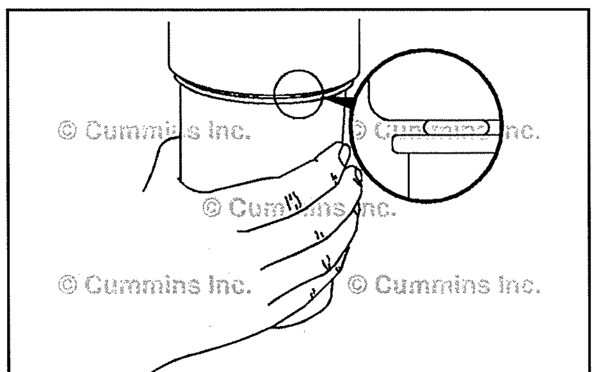
Mechanical over tightening of the filter can distort the threads and damage the fuel filter seal.

Install filter onto the filter head. Turn the filter until the gasket contacts the filter head surface.



07200039

Tighten filter an additional 3/4 of a turn after the gasket contacts the filter head surface, or as specified by the filter manufacturer.



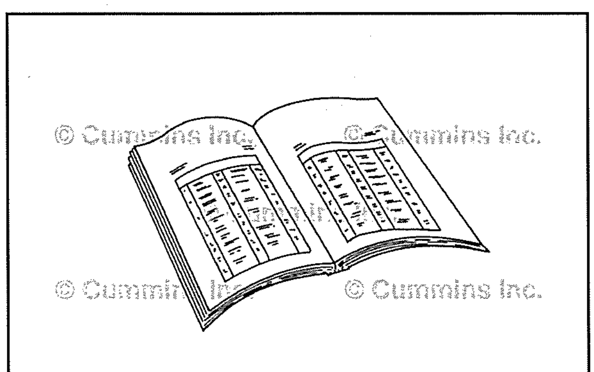
07200040

Finishing Steps

WARNING

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

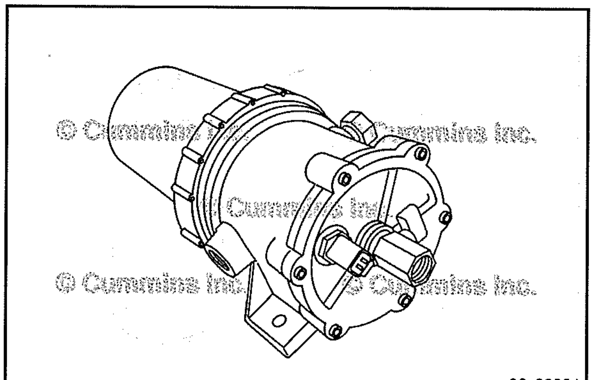
- Connect the batteries. See equipment manufacturer service information.
- Prime the fuel system. Refer to Procedure 005-234 in Section 5.
- Operate the engine and check for leaks.



ck800wa

Fuel Filter Suction (006-066)

General Information



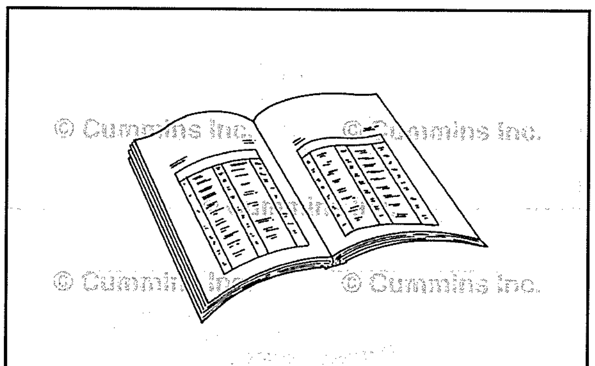
06c00324

The fuel system requires the use of two fuel filters. An equivalent suction fuel filter can be used, but it **must** meet or exceed the following characteristics:

- Remove a minimum of 95 percent of free and emulsified water
- NanoNet™ media with Beta Ratio (filtration efficiency) rating of ß5(C)=75, or equivalent, is recommended in order to extend fuel filter service intervals, but a minimum of 7-micron rating at 98.7 percent efficiency is required
- Water-in-fuel sensor with shunt resistor
- Water drain valve

See equipment manufacturer service information for more information on the suction side fuel filter.

Preparatory Steps

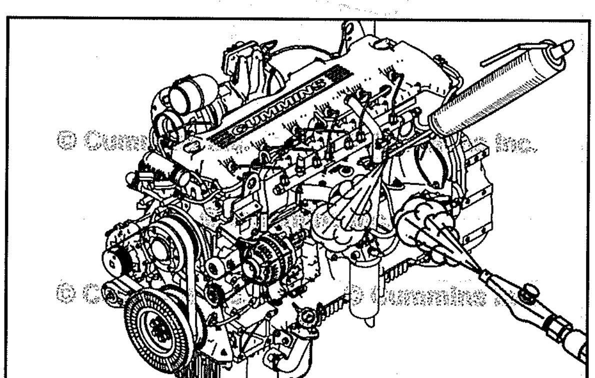


ck800wa

WARNING

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

- Disconnect the batteries. See equipment manufacturer service information.



06p00046

WARNING

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

WARNING

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

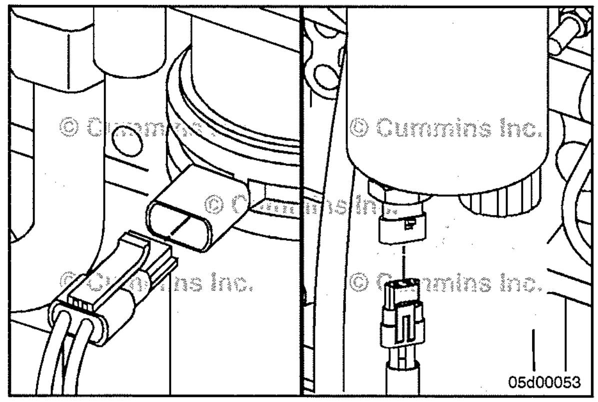
CAUTION

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 components 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 fuel filter head with Cummins® contact cleaner, Part Number 3824510, or equivalent.

Remove



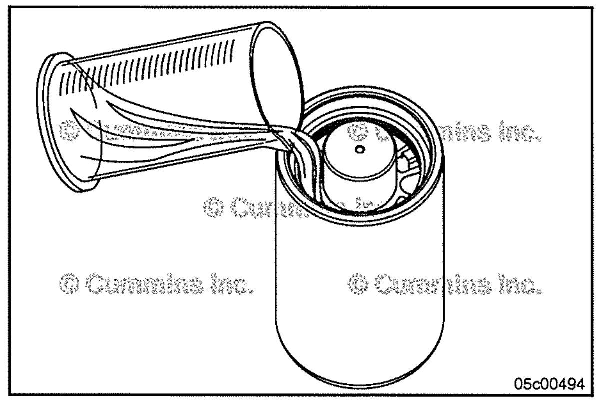
WARNING

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.

See equipment manufacturer service information for information regarding the removal of the suction side fuel filter.

NOTE: Suction-side fuel filters are OEM supplied. See equipment manufacturer service information for appropriate service intervals.

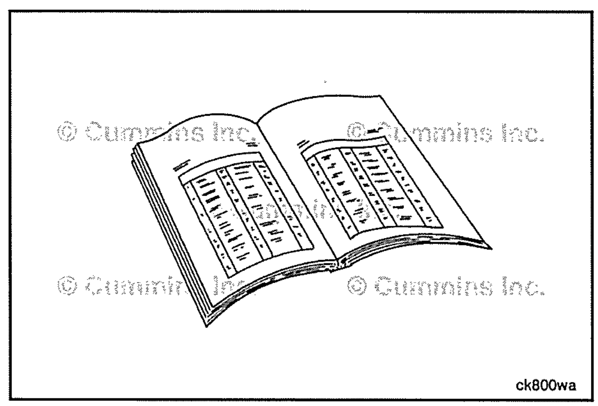
Install



Use the correct filter(s) for your engine. The suction side fuel filter **must** remove a minimum of 95 percent of free and emulsified water. It **must** also have a 5-micron particle removal efficiency.

See equipment manufacturer service information for information regarding proper installation of the suction-side fuel filter.

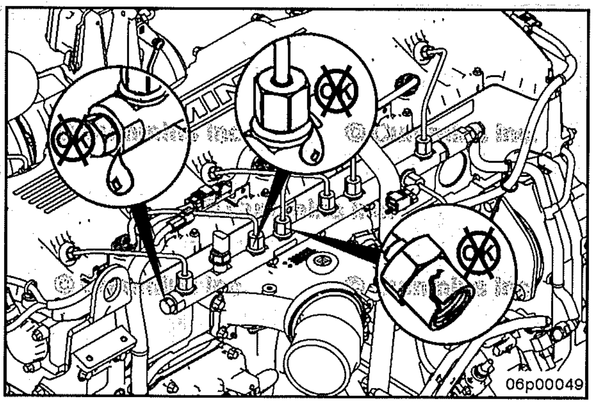
Finishing Steps



WARNING

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

- Connect the batteries. See equipment manufacturer service information.
- Prime the fuel system. Refer to Procedure 005-234 in Section 5.
- Operate the engine and check for leaks.

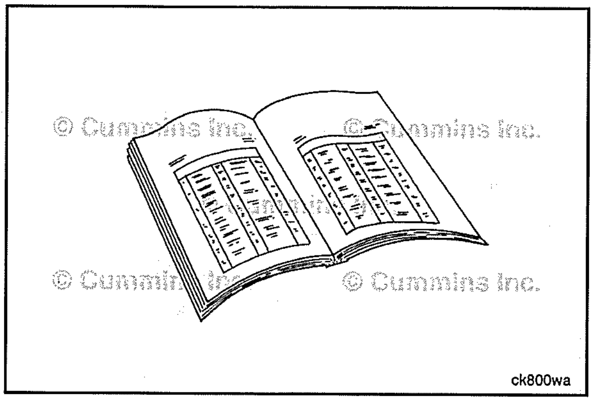


Fuel Rail Supply Line (High Pressure) (006-071)

Initial Check

Inspect the high-pressure supply lines for cracks, chafe, leaks, and loose or broken brackets.

NOTE: Make sure the fuel line is **not** rubbing on any other components.



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

Normal engine operation creates highly pressurized fuel in the fuel line which will remain in the fuel line after engine shutdown. Never open the fuel system when the engine is operating. Before servicing the fuel system, always loosen the pump to rail fuel line at the rail to vent the pressure. Keep hands clear of the line when loosening. High pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

WARNING

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

WARNING

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

WARNING

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

CAUTION

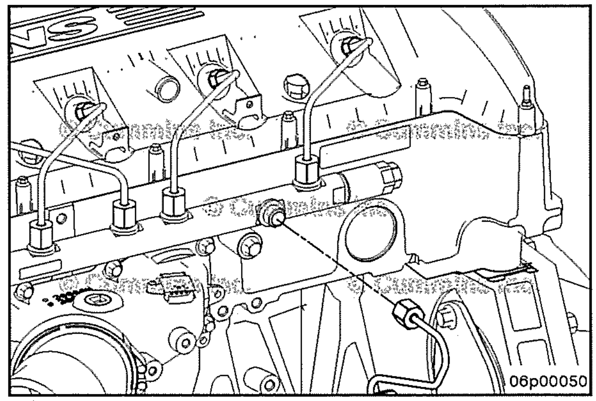
Clean all fittings before disassembly. Dirt or contaminants can damage the fuel system.

- Disconnect the batteries. See equipment manufacturer service information.
- Steam clean the area around the fuel rail supply line and fittings.
- Dry with compressed air.

Remove

NOTE: A counter-torque **must** be applied to the fitting on the high-pressure pump. This is to prevent the fitting from being loosened and to reduce the possibility of a leak.

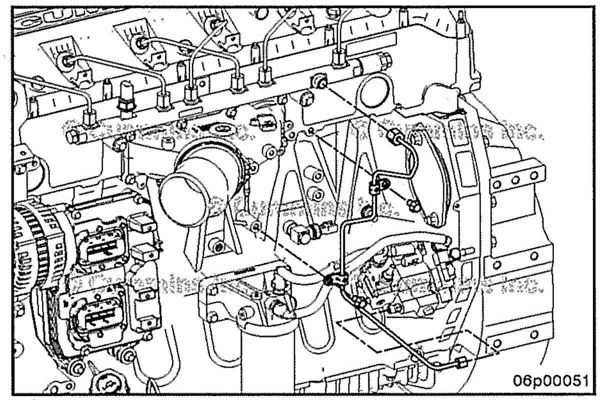
Disconnect the high-pressure fuel rail supply line.



Remove the fuel rail supply line clamps.

NOTE: Do **not** bend, pry, or kink the fuel rail supply line during removal.

Remove the fuel rail supply line.

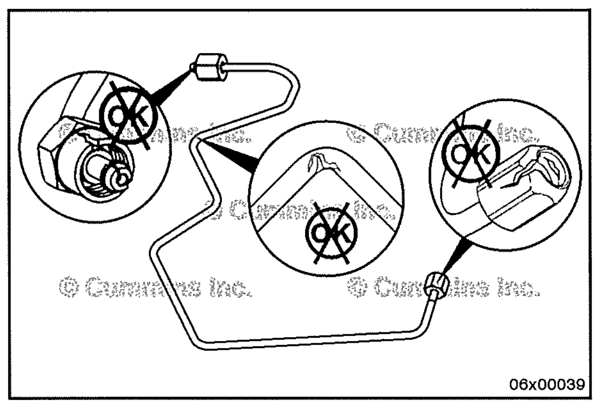


Clean and Inspect for Reuse

Inspect the high-pressure fuel rail supply line ferrules for any sign of burrs, or foreign material, rounding, or cracking. Replace if necessary.

Check for cracks, wear, or pinched areas along the fuel rail supply line and clamps. Replace if necessary.

Inspect the ends of the high-pressure lines for damaged sealing surfaces. Replace any other damaged component.



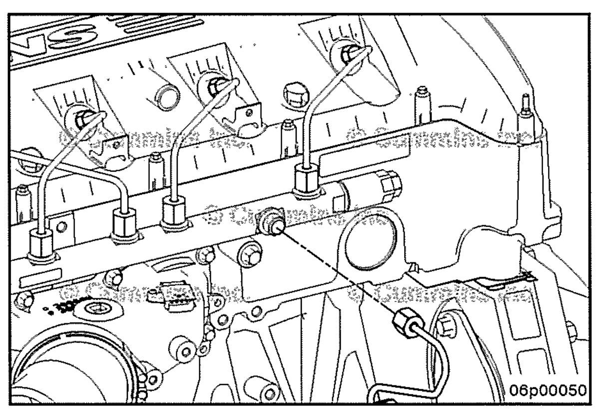
Install

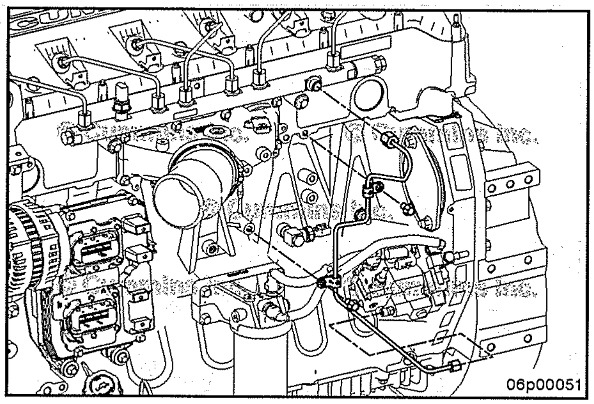
⚠CAUTION⚠

Make sure that no dirt or debris enters the fuel rail supply line to prevent the passing of contaminants to the high-pressure fuel rail and injectors. Small amounts dirt or debris can cause a malfunction of these components.

Install and tighten the fuel rail supply line.

Torque Value: 25 N•m [221 in-lb]



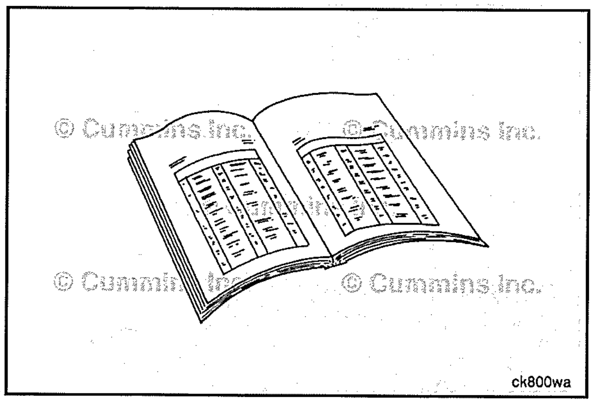


Install the fuel rail supply line clamps.

Tighten the clamps.

Torque Value: 46 N•m [34 ft-lb]

NOTE: Make sure that the fuel line is **not** rubbing on any other components.



Finishing Steps

WARNING

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

- Connect the batteries. See equipment manufacturer service information.

NOTE: It is **not** necessary to vent the air from the high-pressure fuel system before starting the engine. Cranking the engine will prime the fuel system.

- Operate the engine and check for leaks.

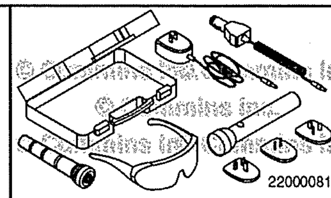
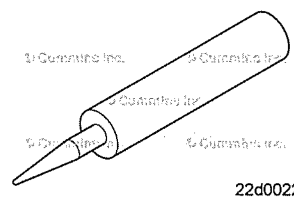
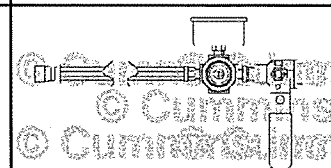
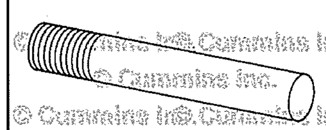
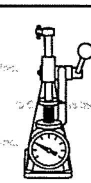
Section 7 - Lubricating Oil System - Group 07

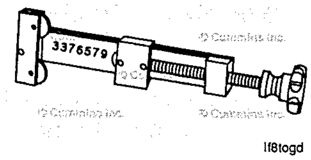
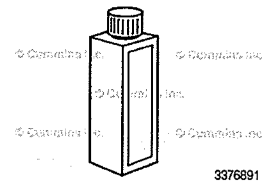
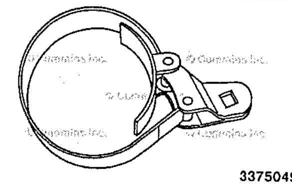
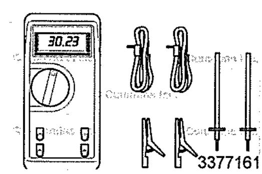
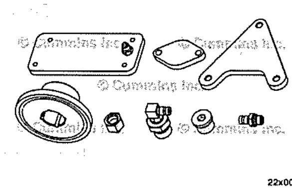
Section Contents

Service Tools

Lubricating Oil System

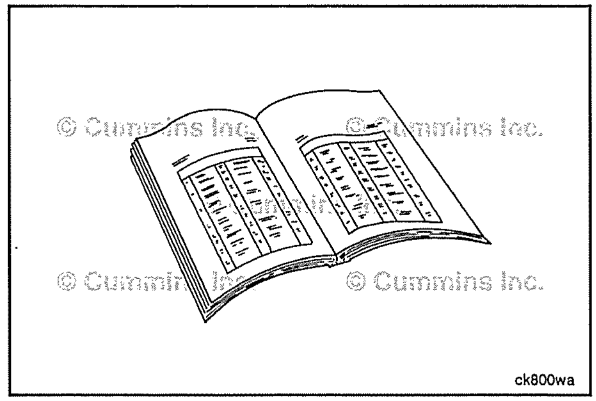
The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
2892320	**Leak Test Kit** Used to detect leaks in all engine fluid systems (lubrication, coolant, and fuel) using a cordless True-UV light that will detect the presence of fluorescent dye additive. The kit is also capable of detecting leaks in air conditioning systems using the appropriate dye.	 22000081
3164070	**RTV Sealant** Use to seal flywheel housing to gear housing joint.	 22d00220
3164231	**Air Pressure Regulator Kit** Used to regulate air pressure.	 22c00403
3164977	**Assembly Guide Pins** Used to guide components on engine for assembly (M8 x 1.25).	 3822784
3375068	**Threadlocker** Used to lock and seal while preventing parts from loosening due to vibration.	 bp8togk
3375182	**Spring Compression Tester** Measures spring force at a given spring height.	 kn8togs

Tool No.	Tool Description	Tool Illustration
3376579	**Tube Filter Cutter** Used for inspection of the filter element.	
3376891	**Fluorescent Tracer Dye** The dye is added to the lubricating oil and used with a black light to find leaks.	
3400157	**Oil Filter Wrench** Used to remove spin-on filters. Replaces oil filter wrench, Part Number 3397929.	
3400162	**Digital Multimeter Kit** Includes deluxe multimeter 3164489, pressure adapter 3164491, and immersion probe 3164492.	
5298873	**Lubrication Oil Cooler Pressure Test Kit** Used to seal and pressurize the lube oil cooler to test for leaks. Requires regulated pressure supply, Part Number 3164231, or equivalent (purchased separately).	

Engine Oil Heater (007-001)

Preparatory Steps



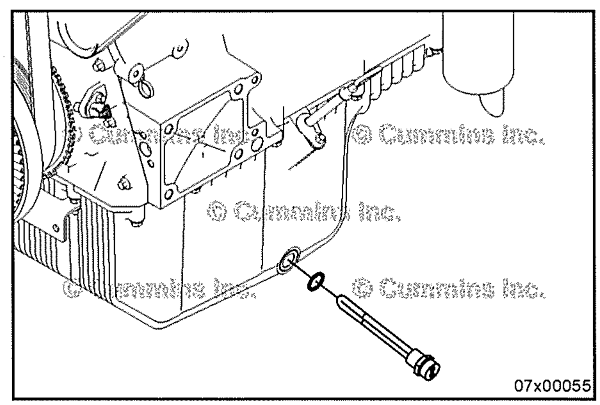
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

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

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

- Disconnect the battery cables. See equipment manufacturer service information.
- Drain the lubricating oil. Refer to Procedure 007-037 in Section 7.

Remove

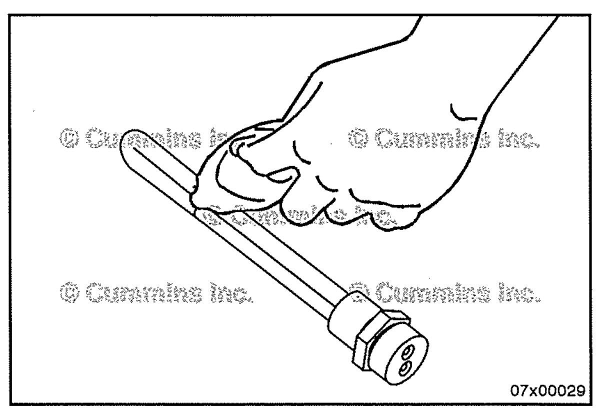


Disconnect the oil heater electrical cord.

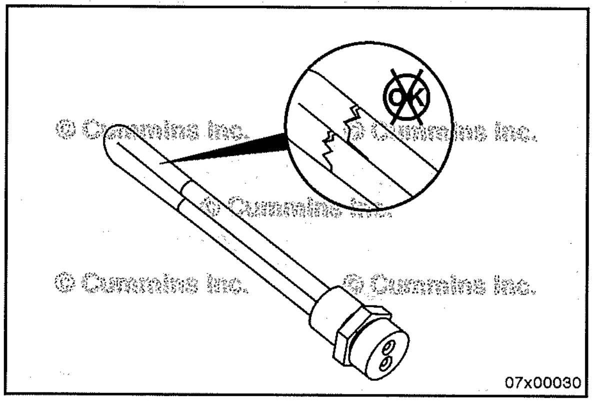
Remove the heater element.

Discard o-ring.

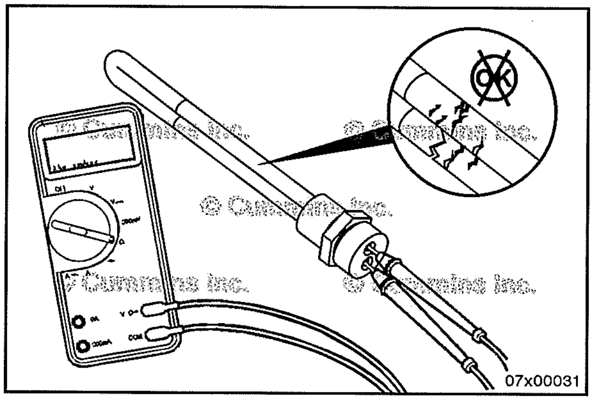
Clean and Inspect for Reuse



Clean the heater element with a dry, clean towel.


07x00030

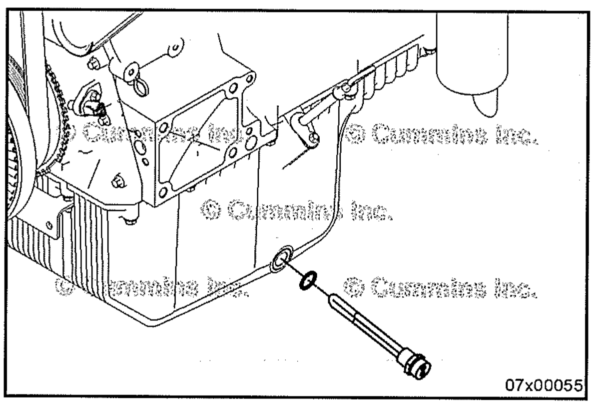
Check for cracks in the heating element.


07x00031

Test

Perform a resistance test on the engine lubricating oil heater element.

The readings **must** be a minimum of 187 ohms to a maximum of 197 ohms.

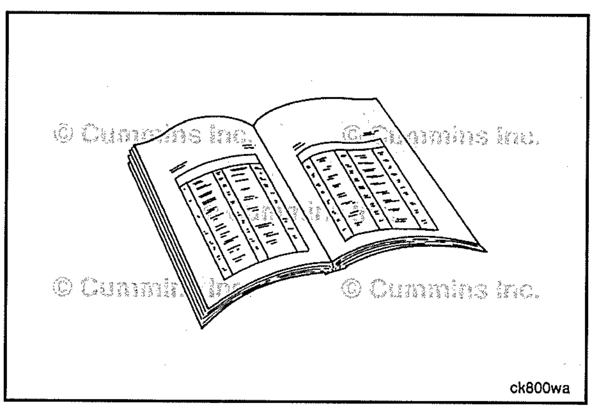

07x00055

Install

Install the heater element with new o-ring into the intake side of the engine.

Torque Value: 55 N•m [41 ft-lb]

Connect the oil heater electrical cord.


ck800wa

Finishing Steps

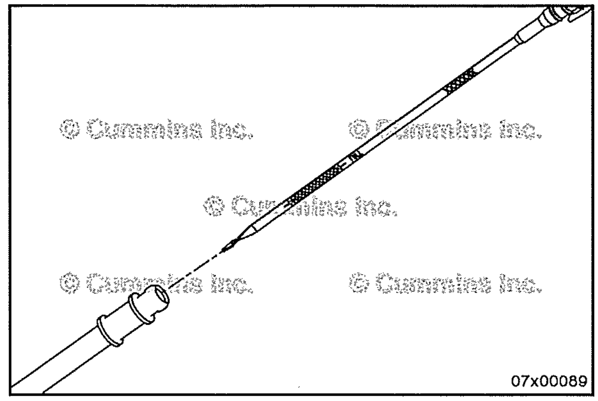
WARNING

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 engine with clean oil to the correct level. Refer to Procedure 007-037 in Section 7.
- Connect the battery cables. See equipment manufacturer service information.
- Operate the engine and check for leaks.

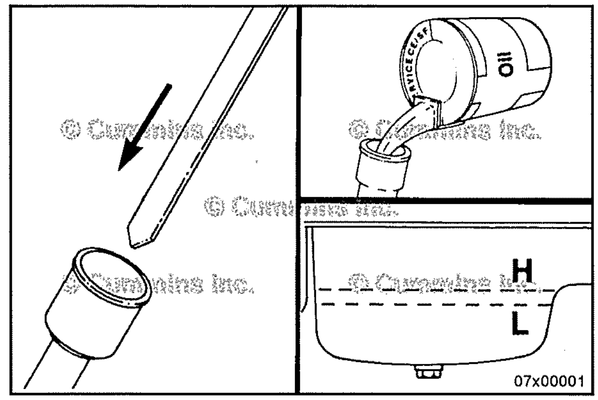
Lubricating Oil Dipstick (007-009)

General Information



The lubricating oil dipstick for this engine comes with a pre-printed fill range. A manual calibration of the dipstick, therefore, is **not** necessary. If the printed range is suspected to be incorrect, follow the Measurement steps in this procedure to verify. If the printed range is found to be incorrect, replace the lubricating oil dipstick.

Measure



WARNING

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

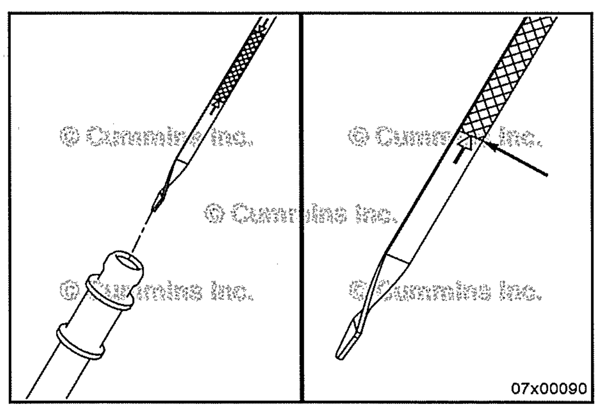
WARNING

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

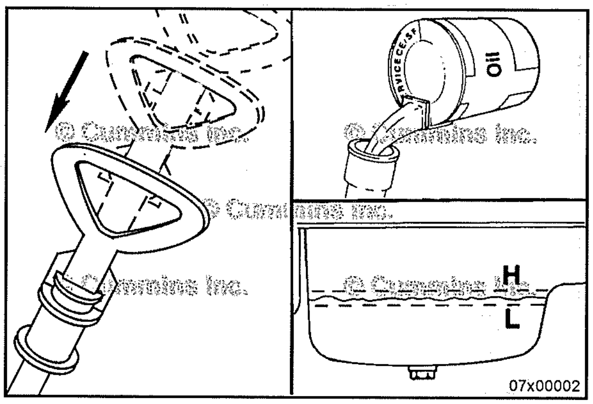
Drain the lubricating oil. Refer to Procedure 007-037 in Section 7.

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

Use clean oil to fill the oil pan to the specified low oil level. The low oil level can be found by looking up the oil pan option for the engine serial number on QuickServe™ Online.

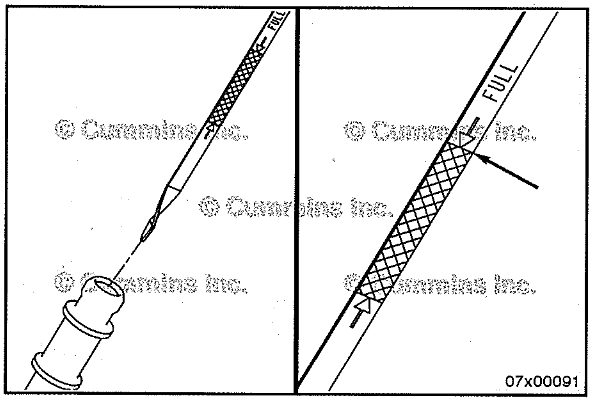


Remove the dipstick, and verify the low level mark is correct.



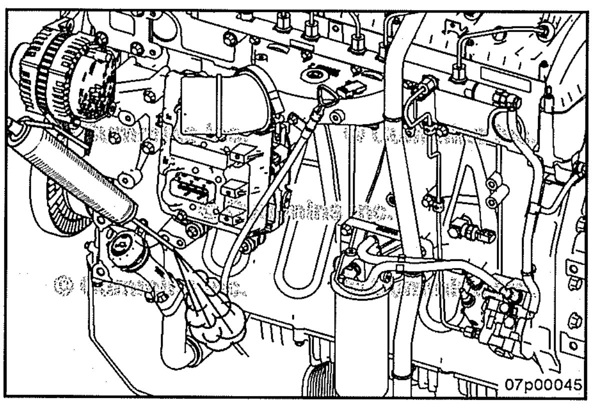
Wipe off the dipstick, and install it in the dipstick tube housing.

Fill the oil pan to the specified high oil level. The high oil level can be found by looking up the oil pan option for the engine serial number on QuickServe™ Online.



Remove the dipstick, and verify the high level mark is correct.

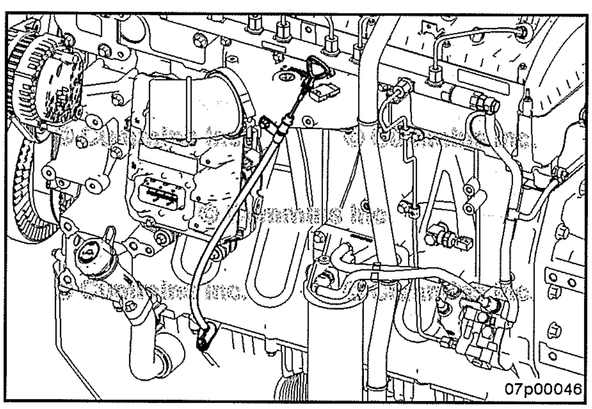
If either the low level or high level is found to be incorrect, replace the lubricating oil dipstick.



Lubricating Oil Dipstick Tube (007-011)

Preparatory Steps

Clean the area around the dipstick tube .

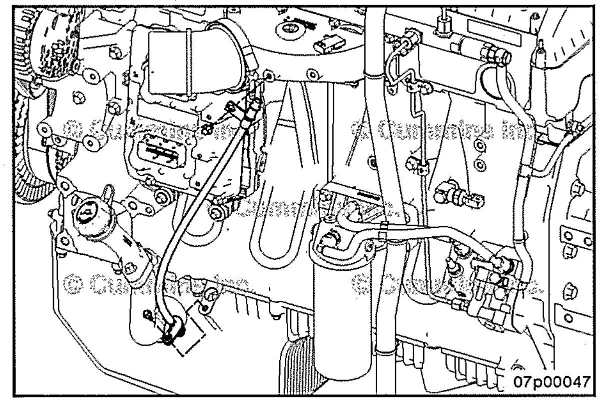


Remove

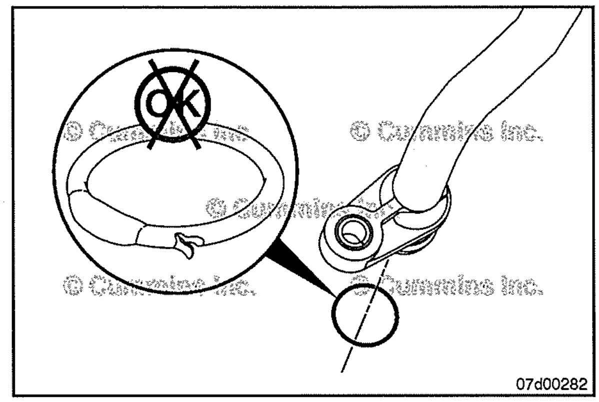
Remove the dipstick from the dipstick tube.

Remove the mounting capscrews that hold the dipstick tube to the oil pan and if necessary, the intake manifold.

Remove the dipstick tube.



Inspect the sealing o-ring for damage. Replace the o-ring if damage is found.



Install

Lubricate the o-ring with clean engine oil.

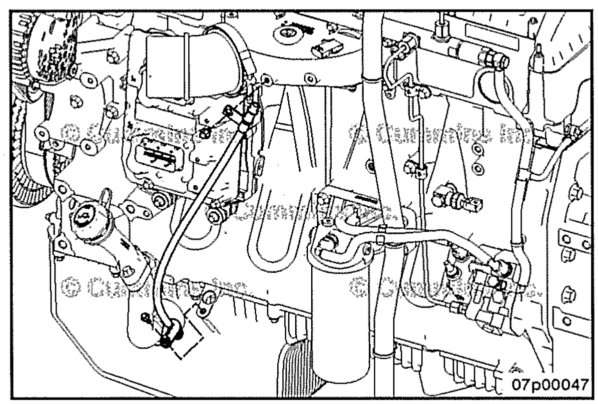
Install the oil dipstick tube into the oil pan.

Install the mounting capscrew that attaches the dipstick tube to the oil pan.

Torque Value: 7 N•m [62 in-lb]

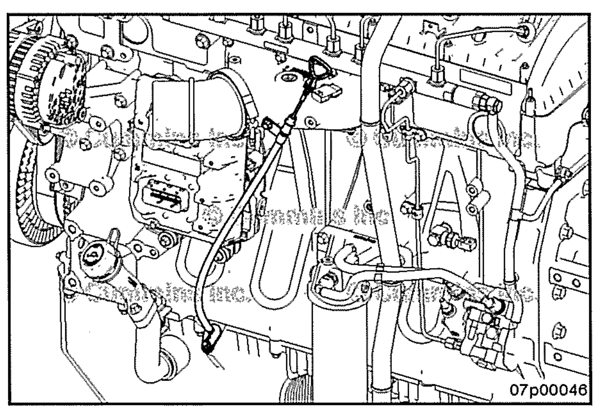
If necessary, install the mounting capscrew that attaches the oil dipstick tube to the intake manifold.

Torque Value: 18 N•m [159 in-lb]

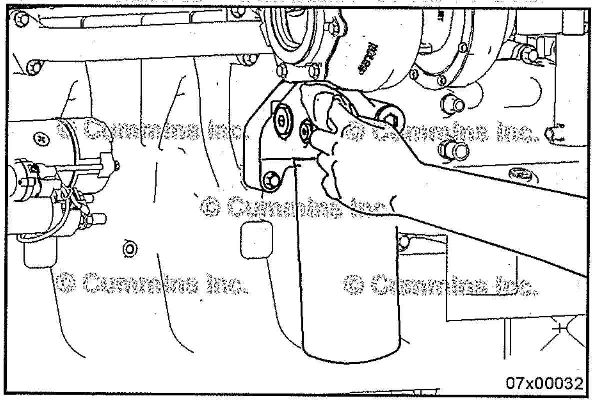


Finishing Steps

Install the dipstick.

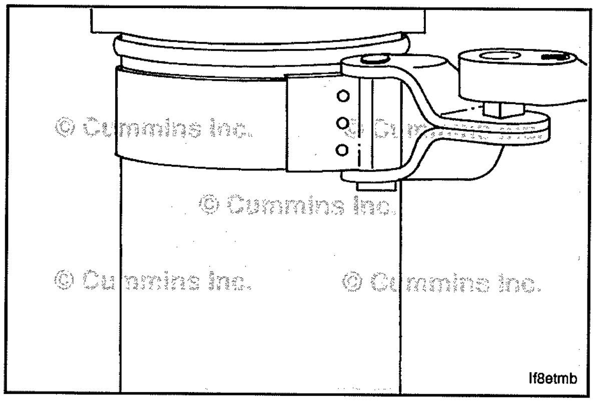


Lubricating Oil Filter (Spin-On) (007-013)



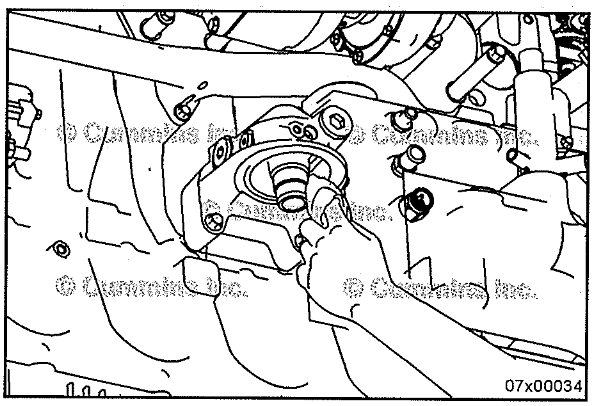
Preparatory Steps

Clean the area around the lubricating oil filter head.

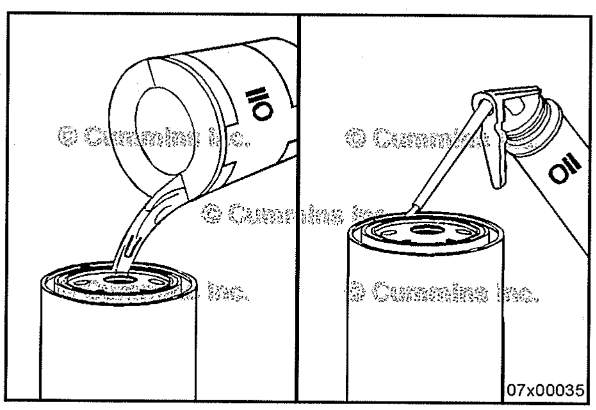


Remove

Use an oil filter wrench, Part Number 3400157, to remove the oil filter.



Clean the sealing surface of the filter head.



Install

⚠CAUTION⚠

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

Use clean engine oil to coat the gasket surface of the filter.

Fill the filter with clean engine oil.

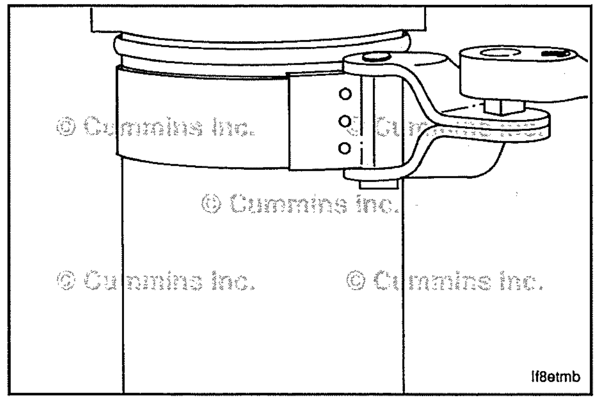
NOTE: Be careful that no debris is poured into the filter. If using an oil supply with a metallic or plastic seal under the cap, be careful to peel the seal back. Puncturing the seal with a knife or sharp object can create debris in the oil container.

⚠CAUTION⚠
Mechanical overtightening of 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.

NOTE: If a strap type oil filter wrench is used, keep the strap as close to the filter head as possible during installation in order to reduce the possibility of damage to the filter.

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

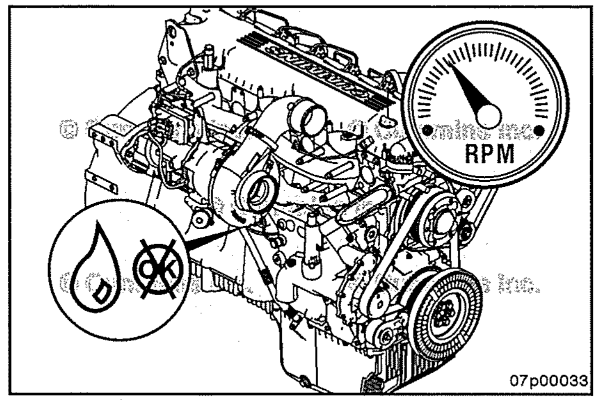


Finishing Steps

⚠CAUTION⚠
If the engine does not produce oil pressure in 15 seconds after starting the engine, shut off the engine to avoid component damage.

Operate the engine and check for leaks.

Shut down the engine and check the oil level. Refer to Procedure 007-037 in Section 7.



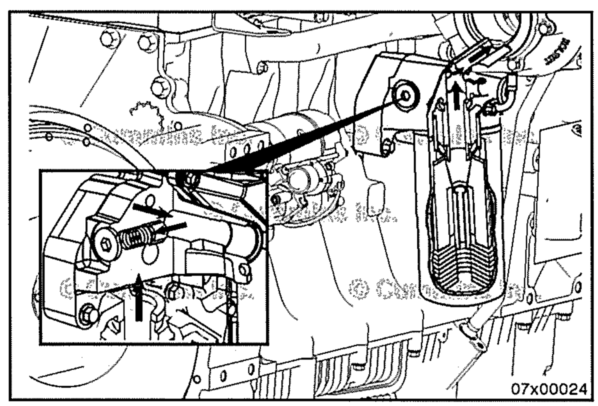
Lubricating Oil Filter Bypass Valve (007-014)

General Information

Whenever the pressure drop across the lubricating oil filter exceeds 758 kPa [110 psi], the oil filter bypass valve opens and allows lubricating oil to bypass the lubricating oil filter.

This condition can occur during cold ambient temperature (cold lubricating oil) engine start-ups.

The purpose of the bypass valve is to maintain lubricating oil flow to the engine and prevent an oil filter collapse.

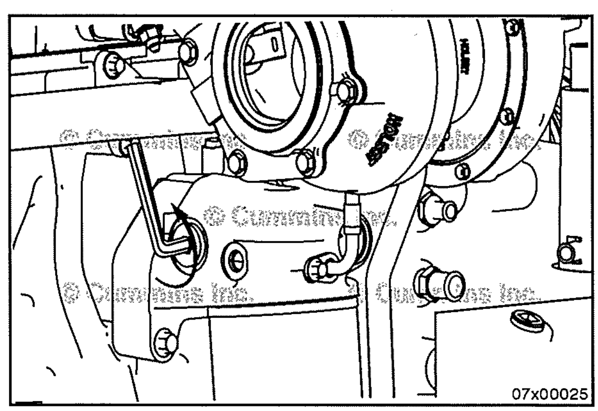


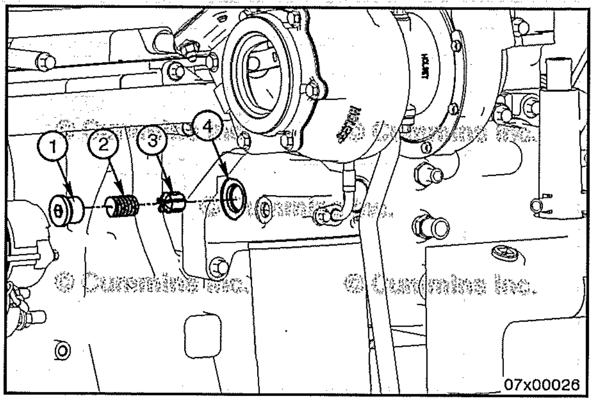
Remove

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

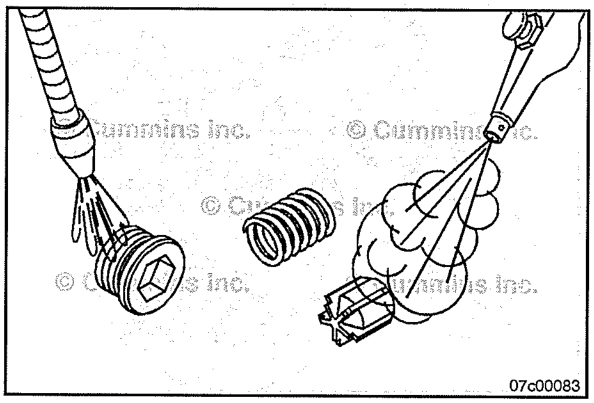
⚠WARNING⚠
Some state and federal agencies have determined that used engine oil can be carcinogenic and cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil. If not reused, dispose of in accordance with local environmental regulations.

Loosen the retaining plug.





Remove the retaining plug (1), spring (2), and plunger (3) from the lubricating oil cooler housing (4).



Clean and Inspect for Reuse

WARNING

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

WARNING

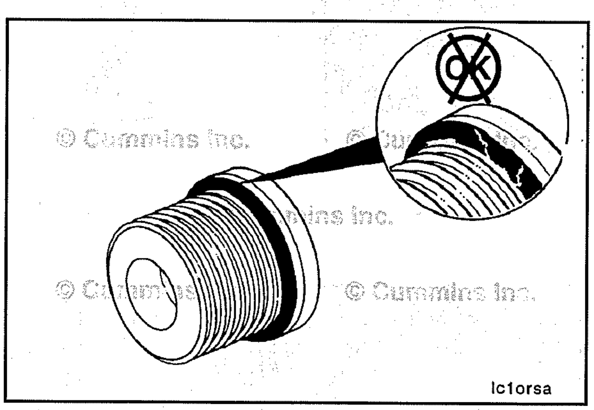
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

Clean the spring, plunger, and retaining plug with solvent.

Dry with compressed air.



Inspect the o-ring on the retaining plug for cuts or tears.

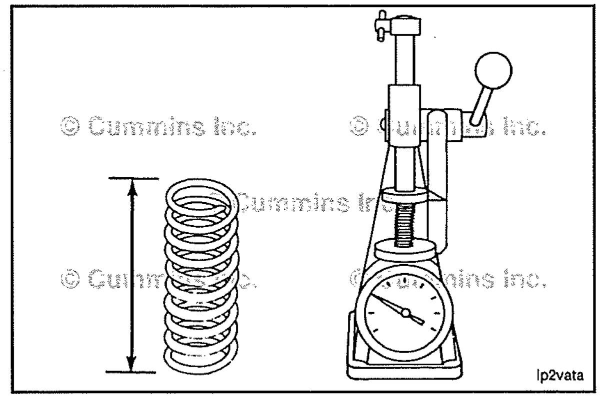
Replace the o-ring if it is damaged.

Use a spring compression tester, Part Number 3375182, to measure the relief valve spring tension.

Compress the spring to 29.65-mm [1.17-in] height. The force required to compress the spring **must** be:

Force Required to Compress Spring to 29.65 mm [1.17 in]		
N		lbf
115.7	NOM	26

If the spring does **not** meet this specification, it **must** be replaced.



Install

CAUTION

The notched end of the bypass valve (3) must be installed toward the spring (2). If the bypass valve is installed incorrectly, it will bypass the filter continuously which can cause engine damage.

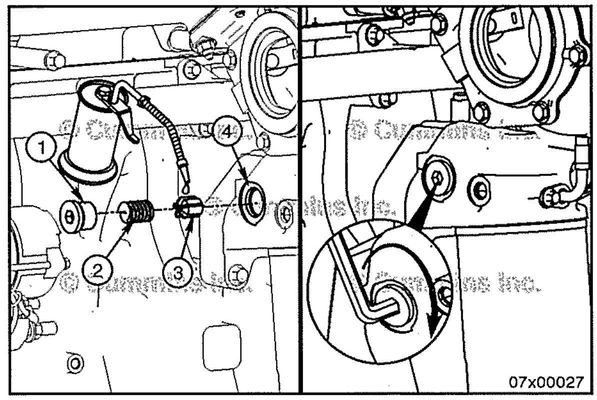
Lubricate all pieces and the o-ring seal.

Install the plunger (3) with the notched end toward the spring into the lubricating oil cooler housing (4).

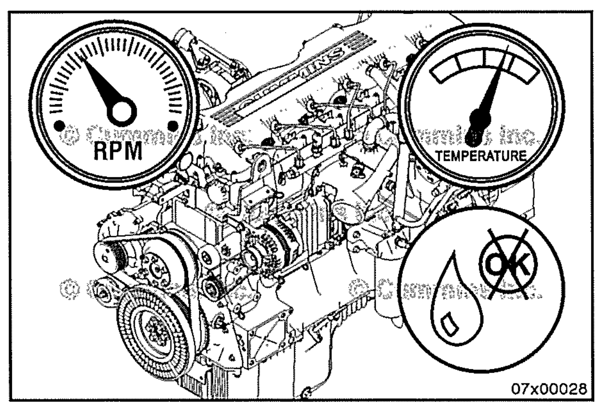
Install the spring (2), and retaining plug (1) into the lubricating oil cooler housing (4).

Tighten the retaining plug.

Torque Value: 68 N•m [50 ft-lb]



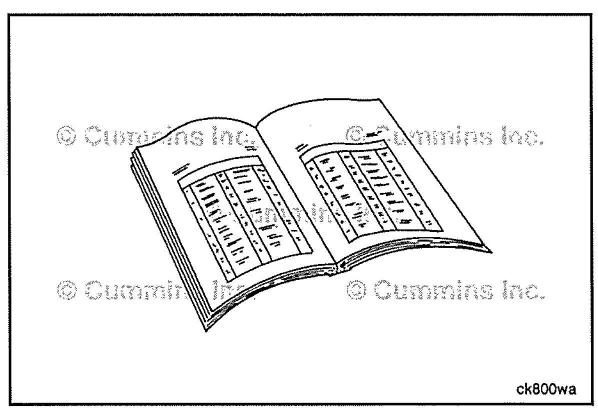
Operate the engine to normal operating temperature and check for leaks.

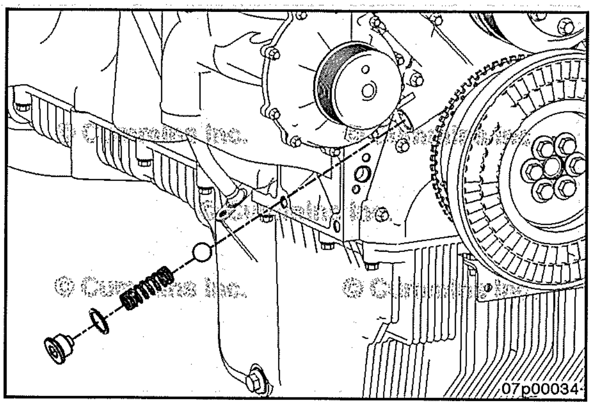


Lubricating Oil High Pressure Relief Valve (007-021)

Preparatory Steps

- Remove the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the cooling fan belt tensioner and tensioner bracket. Refer to Procedure 008-087 in Section 8.





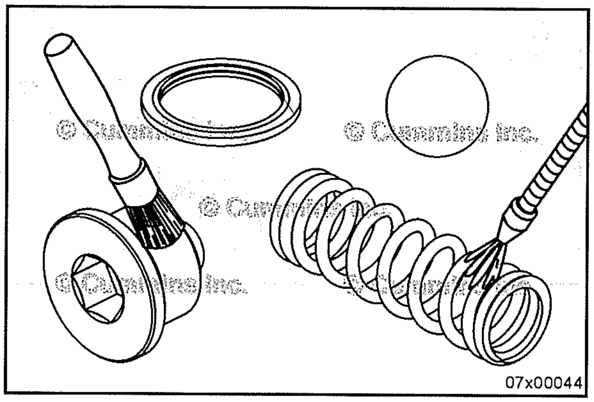
Remove

WARNING
To reduce the possibility of personal injury, wear the appropriate eye and face protection when removing the straight threaded o-ring plug holding in the oil pressure regulator. The spring is under pressure and can cause personal injury.

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

Remove the high-pressure relief valve and spring by removing the threaded retaining plug from the lubricating oil pump housing.

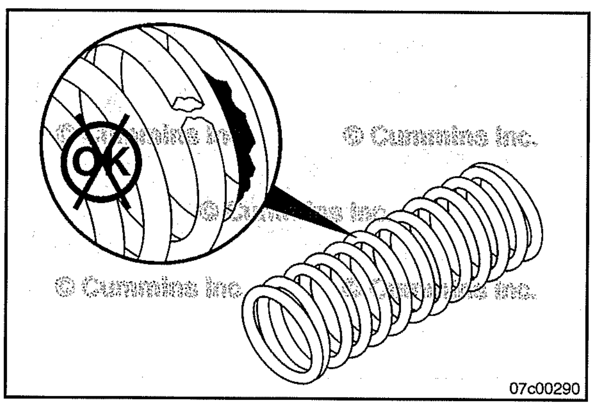
Discard the gasket.



Clean and Inspect for Reuse

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

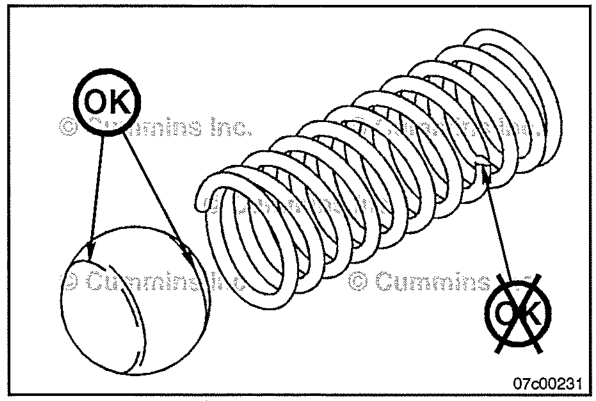
Clean the high-pressure relief valve and spring with solvent and a bristle brush.



Inspect the spring for broken coils or rust.

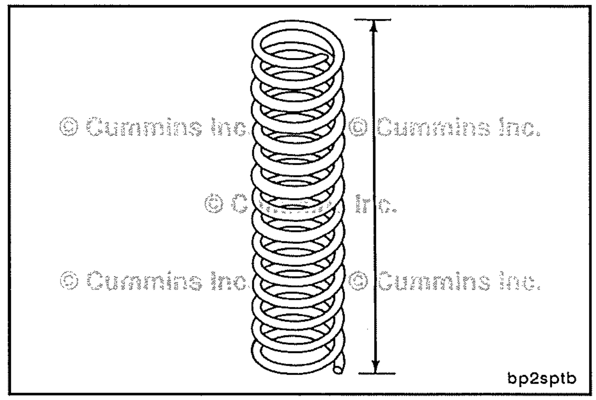
A damaged or rusty spring **must** be replaced.

Inspect the ball. A slight ring around the ball from contact with the pump body and spring is acceptable.



Measure the spring free length.

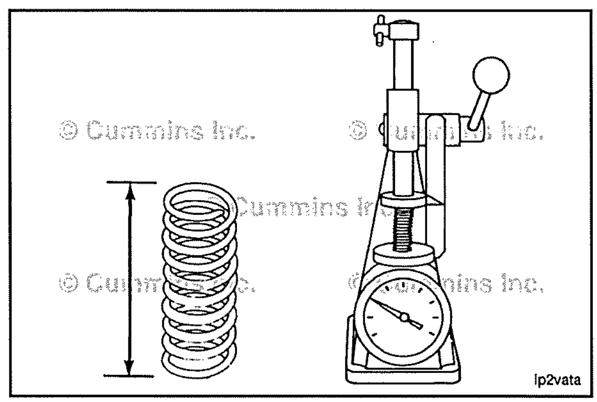
High Pressure Relief Valve Spring Free Length		
mm		in
67	NOM	2.638



Use a spring compression tester, Part Number 3375182, to measure the relief valve spring tension.

Compress the spring to 37 mm [1.457 in] height. The force required to compress the spring **must** meet these specifications.

Force Required to Compress Spring to 55.67 mm [2.19 in]		
N		lbf
311.2	MIN	70
344	MAX	77.3



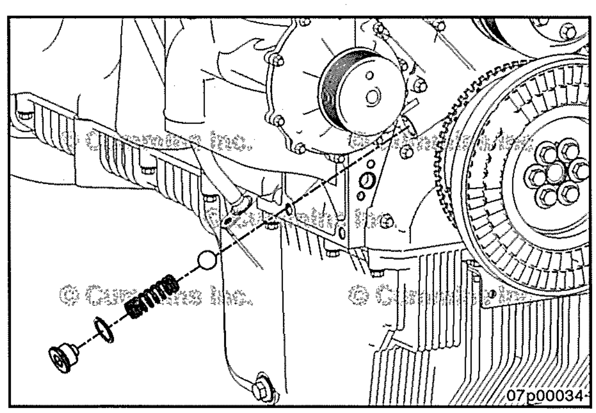
Install

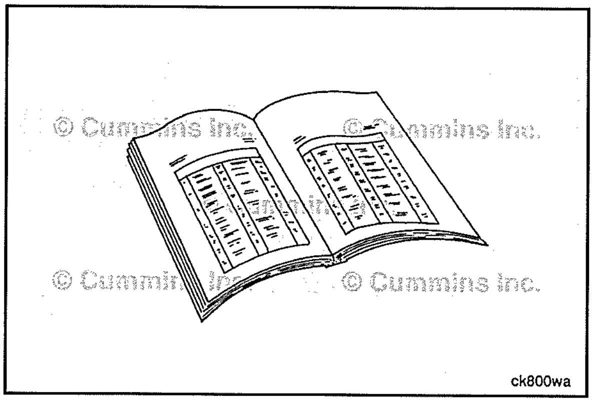
Install the high-pressure relief valve and spring into its bore in the lube pump housing.

Apply a small amount of threadlocker, Part Number 3375068, to the threads of the retaining plug.

Install the retaining plug and new gasket.

Torque Value: 70 N•m [52 ft-lb]



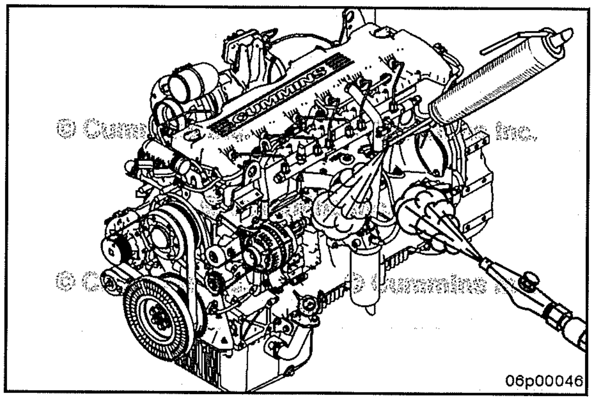


Finishing Steps

CAUTION

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

- Install the cooling fan belt tensioner and tensioner bracket. Refer to Procedure 008-087 in Section 8.
- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Operate the engine at idle speed for 3 minutes to inspect for leaks.



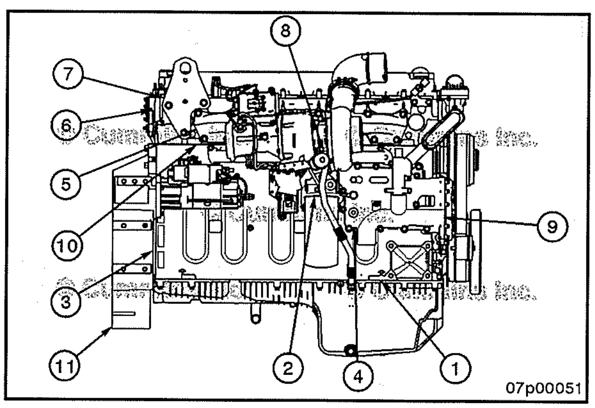
Lubricating Oil Leaks (007-024)

General Information

The cause of external oil leaks is hard to diagnose andcorrect because of the potential number of factorsinvolved. Although the location of a leak can sometimesseem obvious, it can also be difficult to isolate the exactlocation due to fan blast and road grime that can causethe leaking oil to migrate.

Before any repairs, it is important to locate the exact rootcause of the leak to prevent misdiagnosis and furtherdowntime. Use the diagrams below to troubleshoot anyexternal oil leaks.

Begin by determining in which quadrant of the engine theleak is located. It will be necessary to start out by steamcleaning the engine and then operating it on adynamometer to look for the leak. If a dynamometer is notavailable, operate the engine at high idle to increase theoil pressure. Keep in mind where the oil looks the mostconcentrated before the steam clean, as this will give agood indication of where to start looking for leaks.

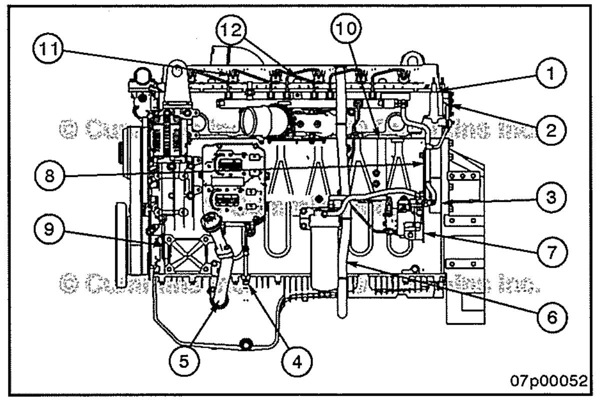


Once the quadrant has been determined, look at thefollowing diagram to get a good indication of where theleak can be coming from on the exhaust side of theengine.

1 Oil pan gasket leak
2 Oil spill from oil filter change
3 Flywheel housing gasket leak
4 Lubricating oil cooler gasket leak
5 Oil slobber from exhaust manifold
6 Camshaft cover gasket leak
7 Valve cover gasket leak
8 Turbocharger oil seal leak
9 Lubricating oil pump housing gasket leak
10 Cylinder head gasket leak
11 Rear crankshaft seal leak.

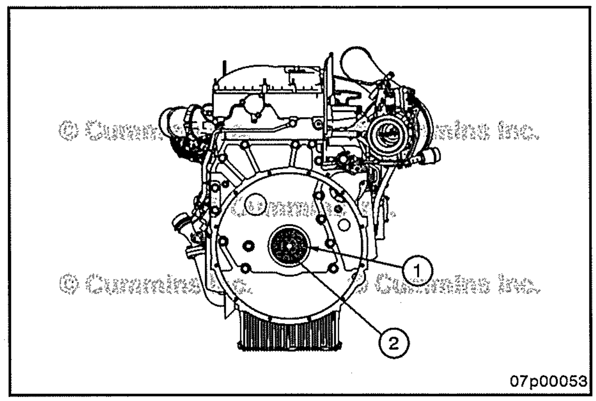
Look at this diagram to get a good indication of where the leak can be coming from on the intake side of the engine.

1 Valve cover gasket leak
2 Camshaft cover gasket leak
3 Flywheel housing gasket leak
4 Dipstick tube leak
5 Lubricating oil fill tube leak
6 Crankcase blowby tube
7 Fuel pump gasket leak
8 Air compressor or power steering pump gasket leak
9 Lubricating oil pump housing gasket leak
10 Cylinder head gasket leak
11 High pressure injector fuel line seal leak
12 Fuel injector wiring harness seal leak.



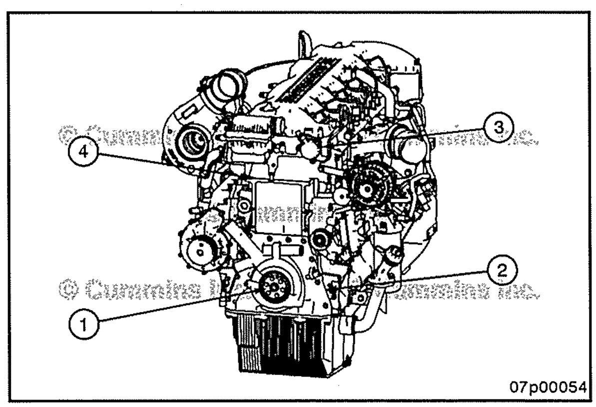
Look at this diagram to get a good indication of where the leak can be coming from on the rear of the engine.

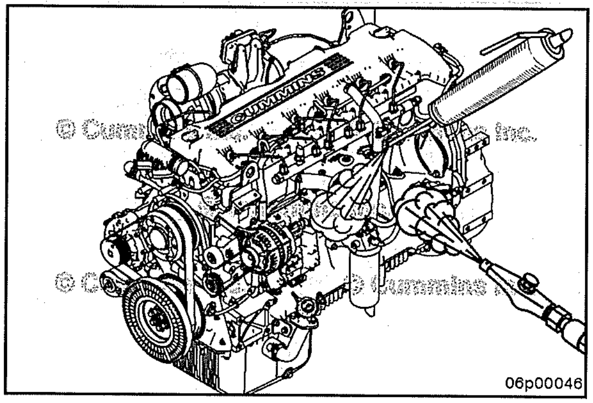
1 Rear crankshaft seal leak
2 Crankshaft gear leak.



Look at this diagram to get a good indication of where the leak can be coming from on the front of the engine.

1 Front crankshaft seal leak.
2 Lubricating oil pump housing gasket leak.
3 Timing speed ring cover gasket leak.
4 Cylinder head gasket leak.

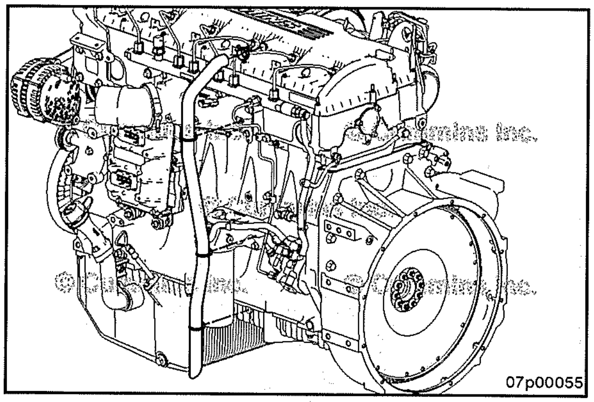




⚠WARNING⚠
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

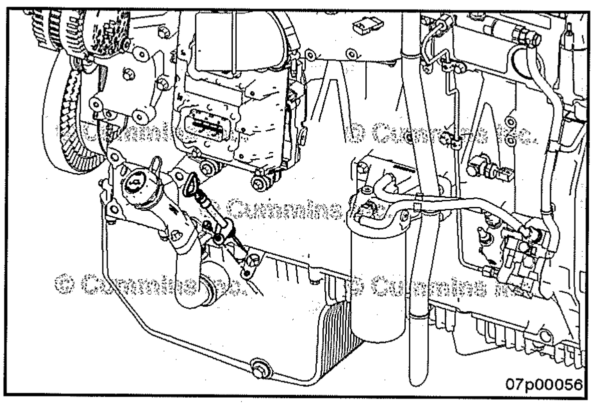
⚠CAUTION⚠
Protect all electrical components, openings, and wiring from the full force of the cleaner spray nozzle.

Use a steam cleaner or a high-pressure washer to clean the engine.

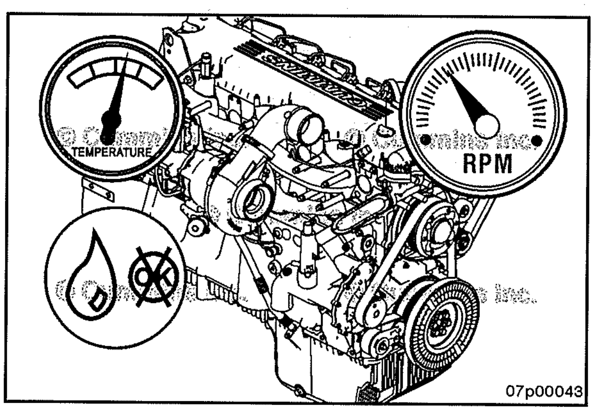


Check the engine crankcase breather tube for restriction. Refer to Procedure 003-002 in Section 3.

Add fluorescent dye tracer, Part Number 3376891, to the oil.



Check for a loose or missing oil dipstick tube, dipstick, or oil filler cap.



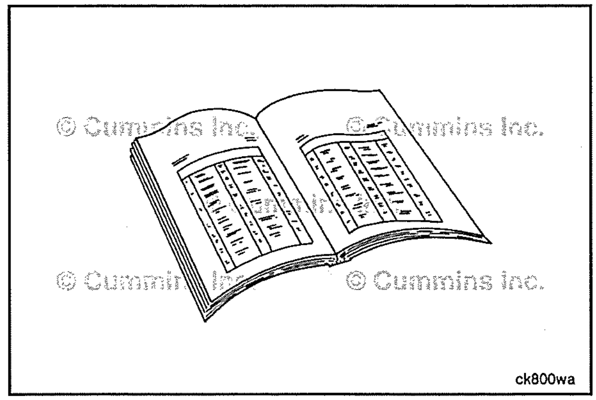
Operate the engine until the water temperature reaches 82°C [180°F]. Inspect the exterior of the engine for leaking gaskets, seals, o-rings, pipe plugs, or fittings.

Use a black light, contained in Leak Test Kit, Part Number 2892320, to locate leaks. See equipment manufacturer service information to use the black light.

NOTE: Before removing and replacing any gaskets, check the capscrews to make sure they are tightened to the correct torque value.

Lubricating Oil Pan (007-025)

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⚠

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

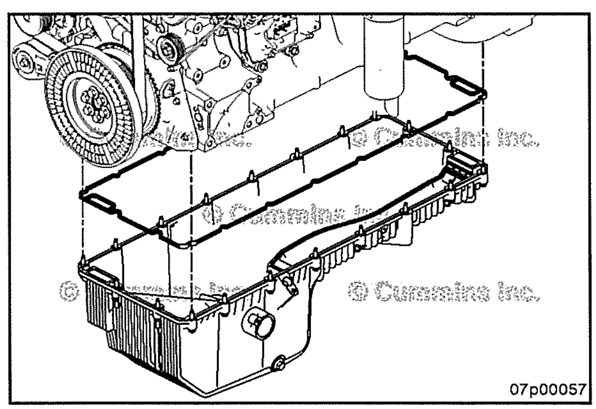
⚠WARNING⚠

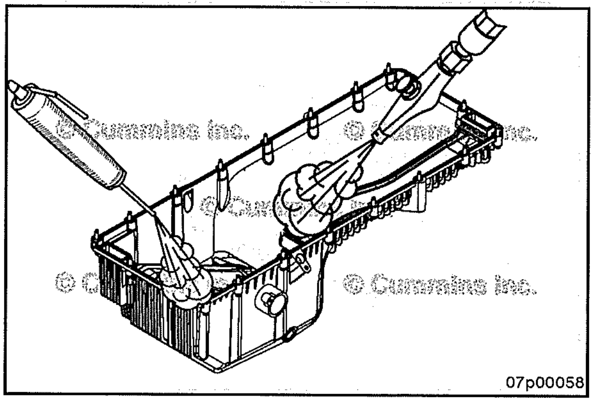
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Drain the lubricating oil. Refer to Procedure 007-037 in Section 7.
- Remove the lubricating oil dipstick. Refer to Procedure 007-009 in Section 7.
- Remove the lubricating oil dipstick tube. Refer to Procedure 007-011 in Section 7.
- Remove the lubricating oil fill tube. Refer to Procedure 007-065 in Section 7.
- Remove engine oil heater, if necessary. Refer to Procedure 007-001 in Section 7.
- Remove the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.

Remove

Remove the lubricating oil pan and pan seal.





07p00058

Clean and Inspect for Reuse

WARNING

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

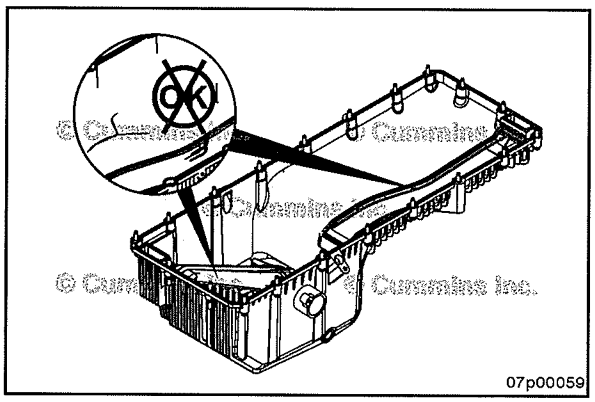
WARNING

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

Remove the reusable rubber oil pan gasket before cleaning the oil pan.

NOTE: Do **not** use air or power tools, such as high speed sanders with an abrasive pad, to clean the gasket material. The oil pan is composite and this is likely to cause damage to the sealing flange.

Steam clean the oil pan. Dry the oil pan with compressed air.

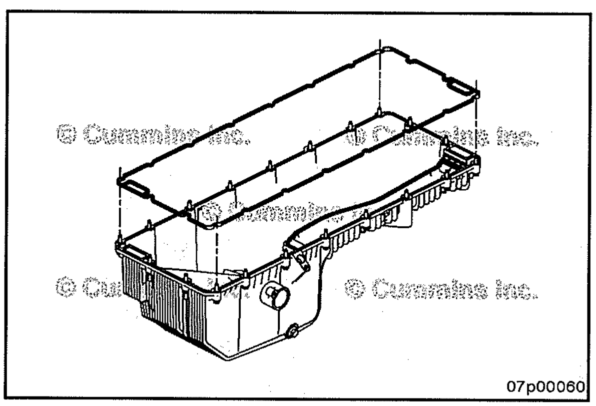


07p00059

Inspect the oil pan support flange, gasket, and suction tube, for cracks or other damage.

If cracks or other damages are found, then the oil pan **must** be replaced.

The mesh filter on the end of the oil suction tube is **not** removable. Make sure no debris is trapped in the mesh by reverse flushing the suction tube.



07p00060

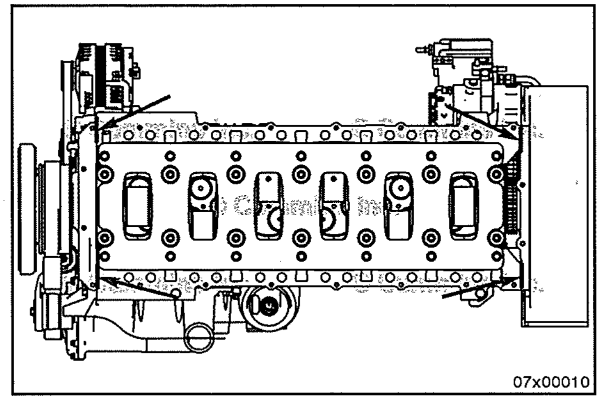
Install

Assemble the gasket fully into the oil pan gasket groove.

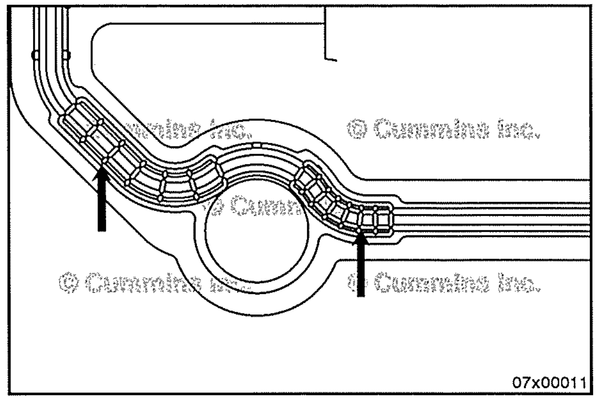
NOTE: Gasket **must** be fully seated into the groove in order to avoid gasket damage. Damage to the gasket can result in oil leaks.

Apply a thin bead of sealant, Part Number 3164070, to the t-joints shown in the illustration.

NOTE: if a new lubricating oil pump housing gasket was installed, do **not** use sealant at the two t-joints on the oil pan rail where the front gear cover meets the engine block.

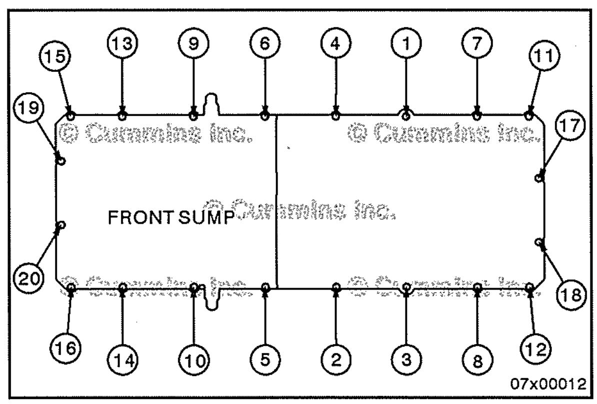


When applying sealant, apply it to the waffle patterned areas of the gasket.



Tighten all capscrews in the sequence shown in the illustration.

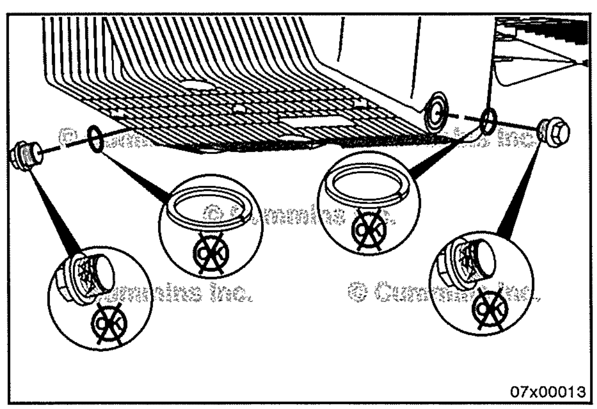
Torque Value: 23 N•m [204 in-lb]

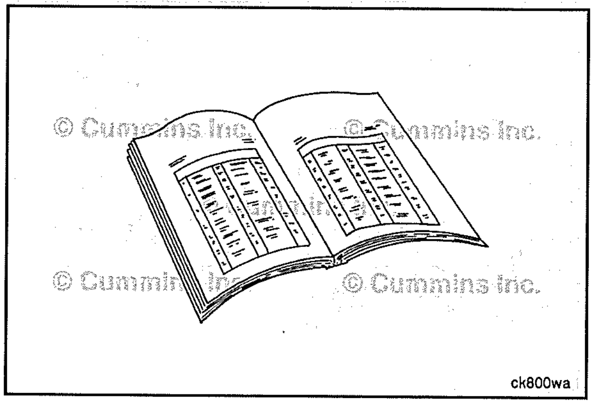


Clean and check the oil drain plug threads and sealing surface.

Inspect the oil drain plug o-ring, replace if damaged.

Torque Value: 55 N•m [41 ft-lb]



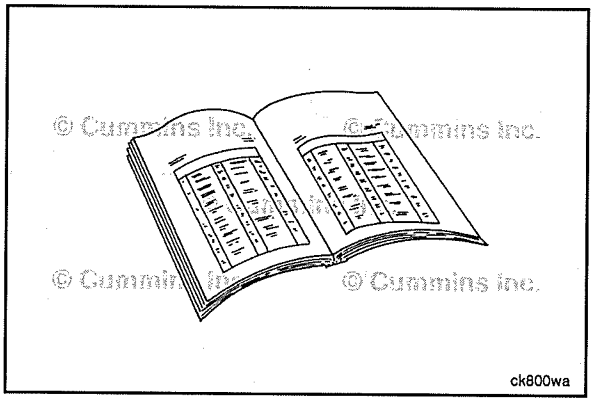


Finishing Steps

⚠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.

- Install the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.
- Install engine oil heater, if necessary. Refer to Procedure 007-001 in Section 7.
- Install the lubricating oil fill tube. Refer to Procedure 007-065 in Section 7.
- Install the lubricating oil dipstick tube. Refer to Procedure 007-011 in Section 7.
- Install the lubricating oil dipstick. Refer to Procedure 007-009 in Section 7.
- Fill the engine with clean lubricating oil. Refer to Procedure 007-037 in Section 7.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.



Lubricating Oil Pressure Regulator (Main Rifle) (007-029)

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⚠

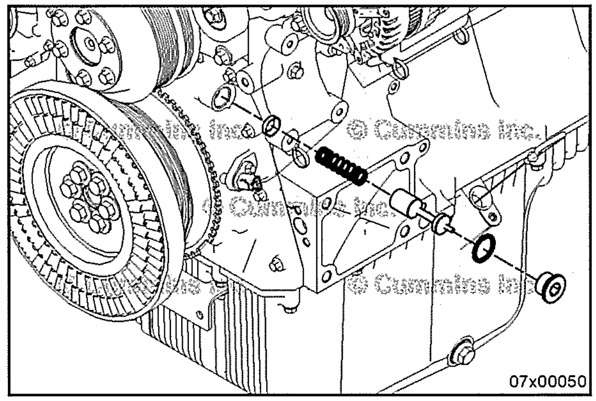
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Remove the alternator mounting bracket. Refer to Procedure 013-003 in Section 13.
- Thoroughly clean the area around the oil pressure regulator plunger with clean solvent to prevent debris from falling into the plunger bore when the plug is removed.

Remove

Remove the threaded plug, oil seal, plunger, spring, and spring retainer.

Discard the gasket.



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Clean and Inspect for Reuse

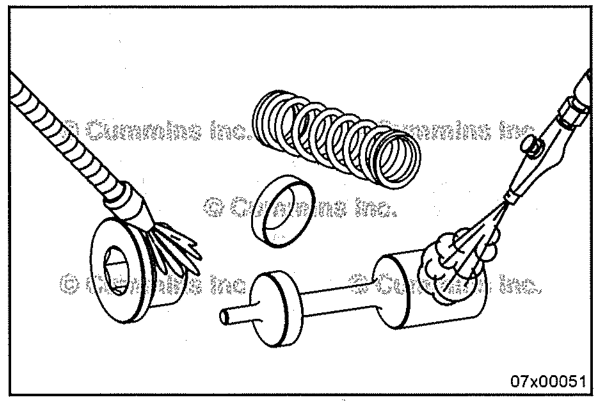
WARNING
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

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

If the plunger bore requires cleaning, remove the lubricating oil pump so debris will **not** be flushed into the engine. Refer to Procedure 007-031 in Section 7.

Use solvent to clean the threaded plug, plunger, spring, and spring retainer.

Dry the parts with compressed air.



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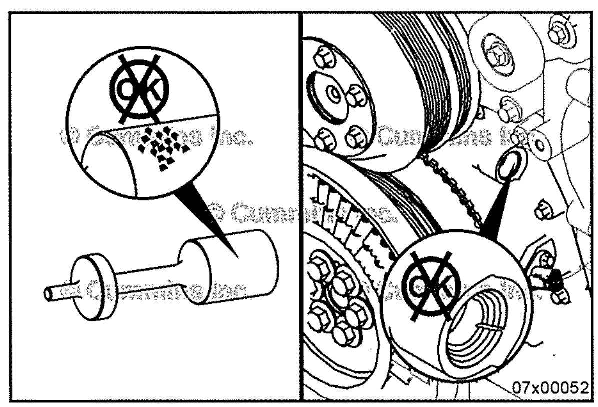
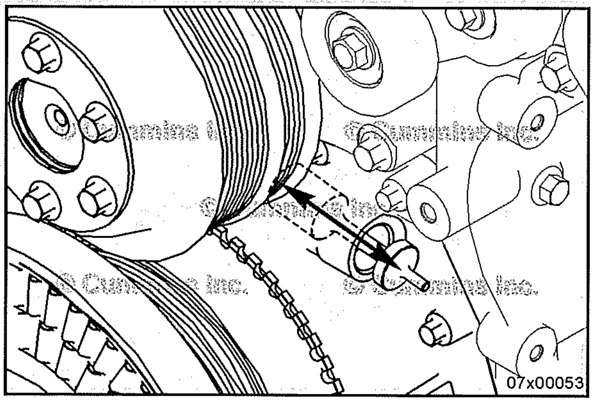
NOTE: Polished areas on the plunger and bore are acceptable.

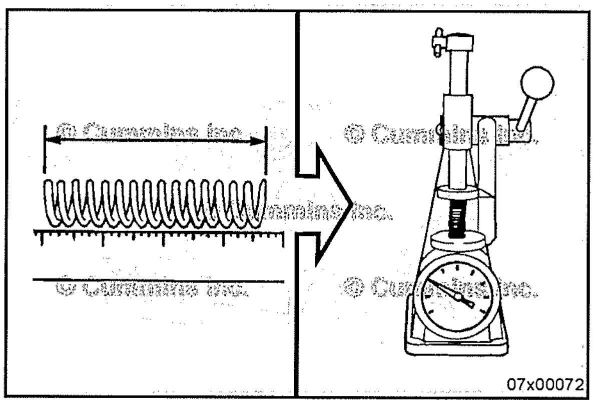
Inspect the plunger and plunger bore for nicks or scratches.



07x00052

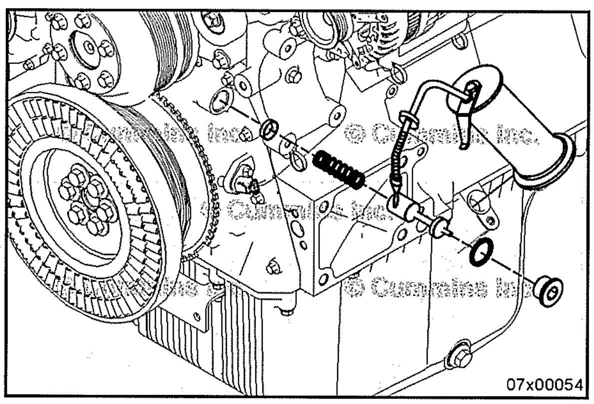


Verify that the plunger moves freely in the bore.



Use valve spring tester, Part Number 3375182, to measure the pressure regulator spring at the following heights.

Pressure Regulator Spring Pressure		
Height	N	lbf
47 mm [1.85 in]	98 to 109	22 to 24.5
36 mm [1.42 in]	153 to 169	34.4 to 38



Install

Apply a small amount of threadlocker, Part Number 3375068, to the threads of the threaded plug.

Install the spring retainer and spring into the lubricating oil pump housing.

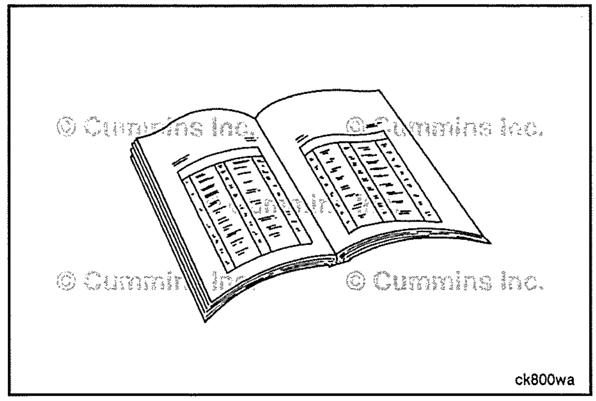
Lubricate the plunger with clean engine oil and install into the lubricating oil pump housing.

Install the new oil seal and threaded plug into the lubricating oil pump housing.

Tighten the threaded plug.

Torque Value: 60 N•m [44 ft-lb]

Finishing Steps



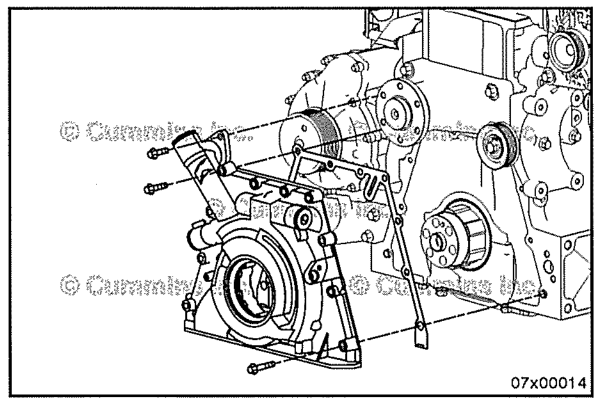
WARNING

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.

- Install the alternator mounting bracket. Refer to Procedure 013-003 in Section 13.
- Install the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Operate the engine and check for leaks.

Lubricating Oil Pump (007-031)

General Information



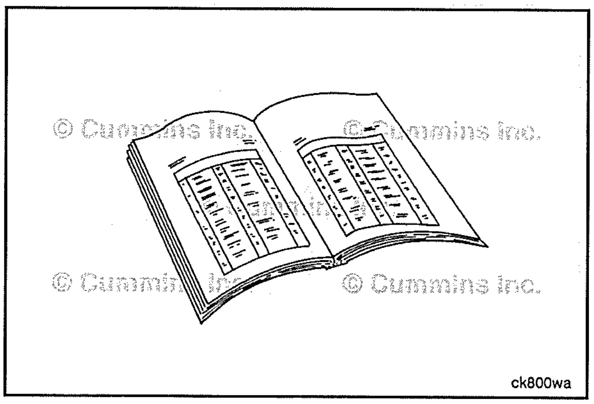
This engine uses a rotor style lubricating oil pump that is powered directly from the crankshaft nose. The lubricating oil pump, lubricating oil high pressure relief valve, and lubricating oil rifle pressure regulator are all part of the lubricating pump housing assembly.

The lubricating oil pump rotor is **not** serviceable and the pump assembly should **not** be disassembled. If any part of the lubricating oil pump assembly fails the entire lubricating pump assembly **must** be replaced. The lubricating oil high pressure relief valve and lubricating oil rifle pressure regulator are serviceable and may be removed separately.

Refer to Procedure 007-021 in Section 7 for more information on the lubricating oil high pressure relief valve.

Refer to Procedure 007-029 in Section 7 for more information on the lubricating oil pressure regulator.

The lubricating oil pump is connected to the lubricating oil cooler module with an oil transfer tube. The oil transfer tube allows for the module and pump to be removed independently of each other.



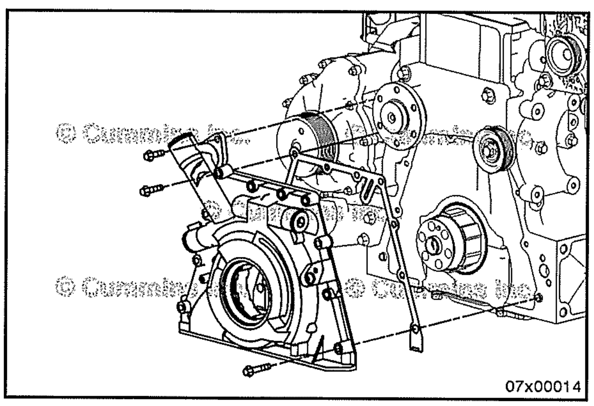
ck800wa

Preparatory Steps

WARNING

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

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Drain the lubricating oil. Refer to Procedure 007-037 in Section 7.
- Remove the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Remove the cooling fan belt tensioner. Refer to Procedure 008-087 in Section 8.
- Remove the Vibration damper. Refer to Procedure 001-052 in Section 1.
- Remove the Crankshaft pulley and speed indicator ring. Refer to Procedure 001-022 in Section 1.
- Remove the fan pulley. Refer to Procedure 008-089 in Section 8.
- Disconnect and remove the crankshaft position/speed sensor. Refer to Procedure 019-365 in Section 19.
- Remove the lubricating oil pan. Refer to Procedure 007-025 in Section 7.



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Remove

CAUTION

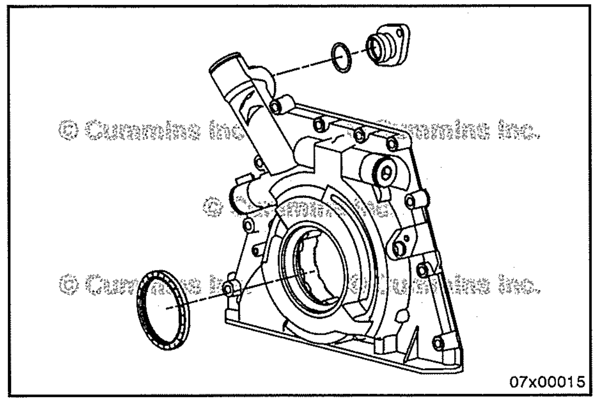
To break the seal, pry the lubricating pump assembly away from the cylinder block. Be careful not to damage the lubricating pump assembly when breaking the seal to the cylinder block.

NOTE: Document the location of the mounting capscrews, the lubricating oil transfer tube capscrews and the lubricating oil pump housing capscrews upon removal.

Remove the 10 lubricating oil pump housing mounting capscrews and 2 lubricating oil transfer tube capscrews. The two capscrews in the bottom corners of the lubricating oil pump housing are longer than the other capscrews.

Remove the lubricating oil pump assembly and lubricating oil transfer tube.

Disassemble



Remove the lubricating oil transfer tube and o-ring.

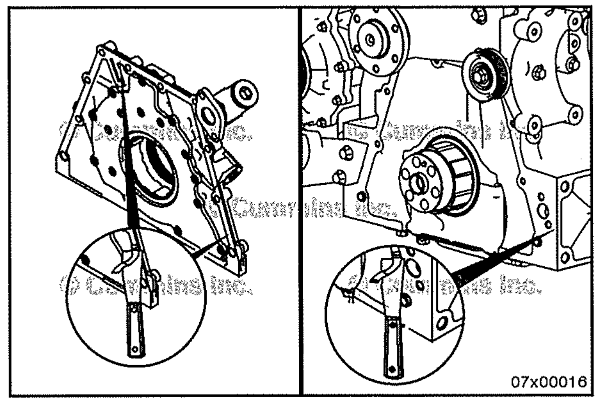
Remove the crankshaft oil seal.

NOTE: It is **not** necessary to remove the lubricating oil pressure regulator and lubricating oil high pressure relief valve unless there are signs or symptoms of damage. The lubricating oil pump may be cleaned with solvent or steam without removing the lubricating oil pressure regulator and lubricating oil high pressure relief valve.

If necessary, remove the lubricating oil pressure regulator. Refer to Procedure 007-029 in Section 7.

If necessary, remove the lubricating oil high pressure relief valve. Refer to Procedure 007-021 in Section 7.

Clean and Inspect for Reuse



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

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

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

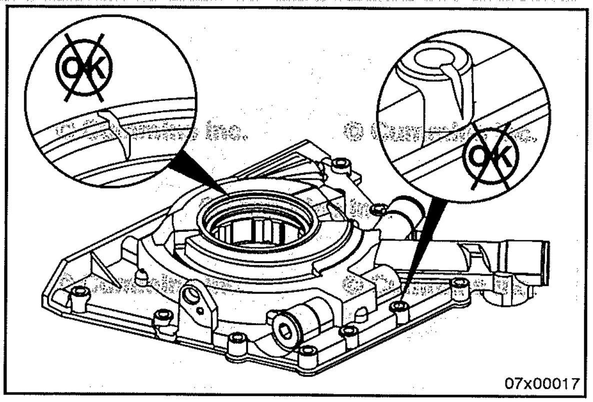
⚠CAUTION⚠
If the lubricating pump assembly requires steam cleaning, remove the lubricating oil high pressure relief valve and oil rifle pressure regulator. Refer to Procedure 007-021 in Section 7. Refer to Procedure 007-029 in Section 7.

NOTE: If the lubricating pump assembly was removed as part of another repair, it is **only** necessary to clean the sealing surfaces.

Clean the sealant or gasket from the lubricating pump assembly and from the cylinder block.

Use solvent or steam to clean the lubricating pump assembly.

Dry the assembly with compressed air.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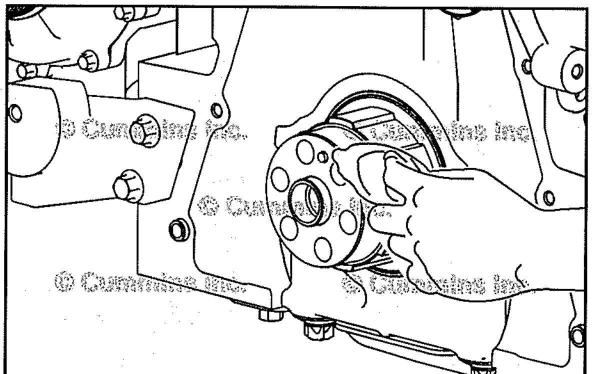
Inspect the lubricating pump housing for cracks or other damage.

Replace the lubricating pump assembly if any damage is found.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WARNING

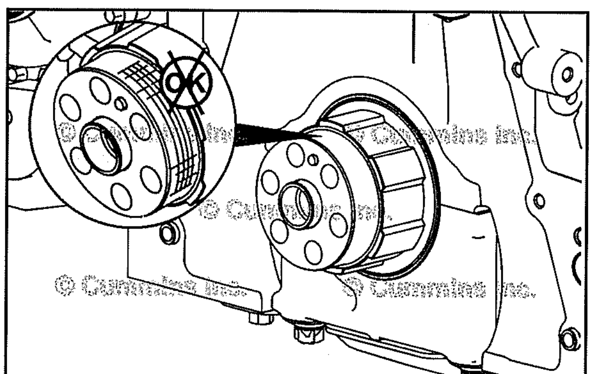
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

Use solvent to clean the oil and seal residue from the crankshaft surface.

Dry with compressed air.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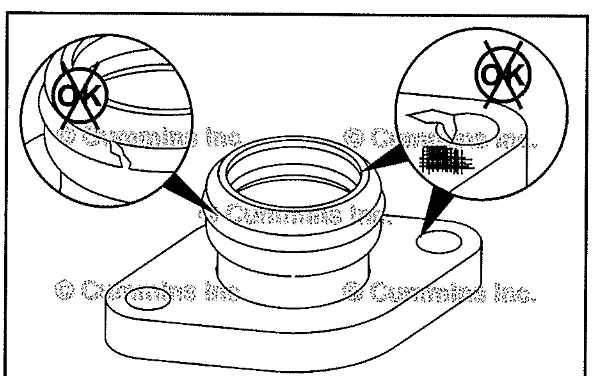
Inspect the nose of the crankshaft for excessive wear.

Use a fine crocus cloth to remove any nicks or burrs.

Refer to Procedure 001-016 in Section 1 for further inspection of the crankshaft nose.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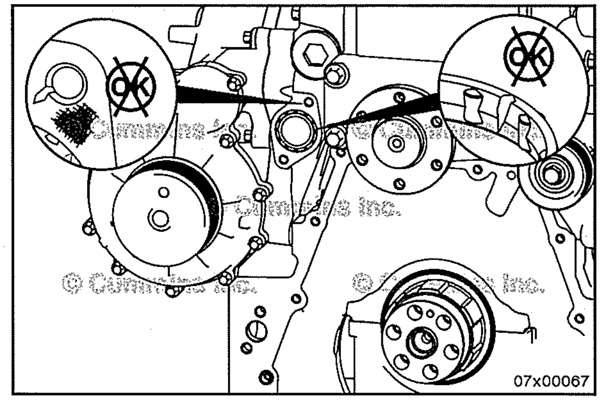
Inspect the lubricating oil transfer tube for cracks or other damage.

Inspect the lubricating oil transfer tube o-ring for damage.

Replace the o-ring if damage is found.

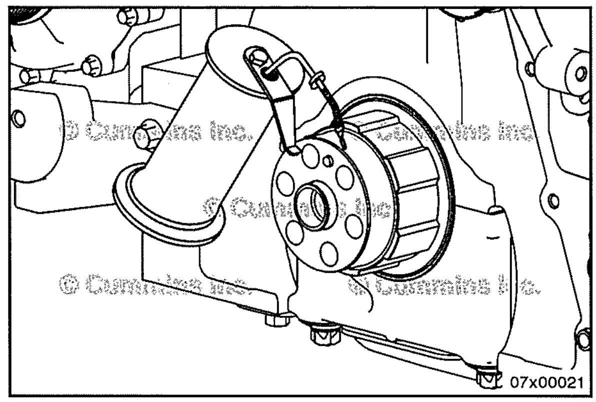
Inspect the lubricating oil transfer tube mating surface and gasket on the lubricating oil cooler housing for cracks or other damage.

Inspect the press in place gasket for cuts or other damage. If damage is found the gasket **must** be replaced.



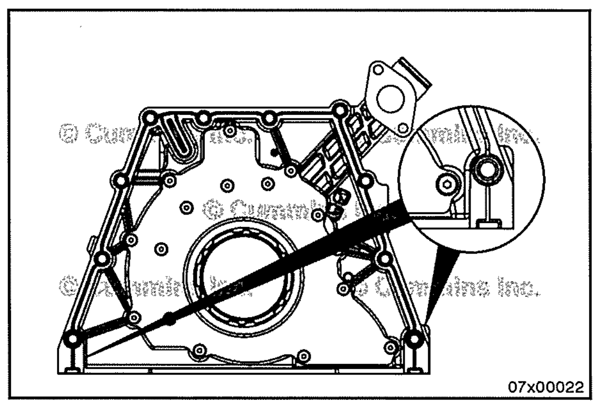
Install

Lubricate the outside surface of crankshaft with clean engine oil.



When installing the lubricating pump housing gasket, take care **not** to damage the rubber seal on the bottom edges of the gasket.

NOTE: This gasket features pre-installed sealant to seal the joint between the lubricating oil pump housing, engine block and lubricating oil pan. If this sealant is damaged, the gasket **must** be replaced.



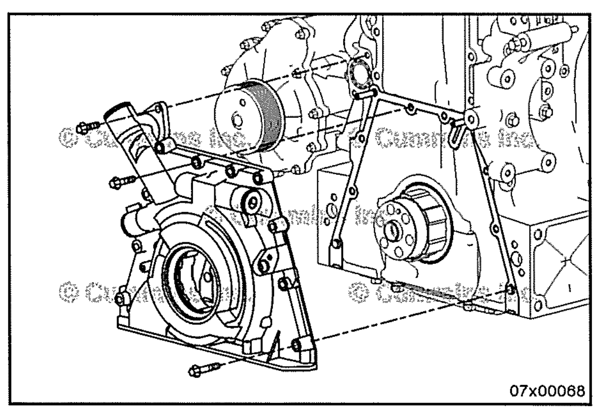
Install guide pins, Part Number 3164977, in the top corner capscrew locations as indicated.

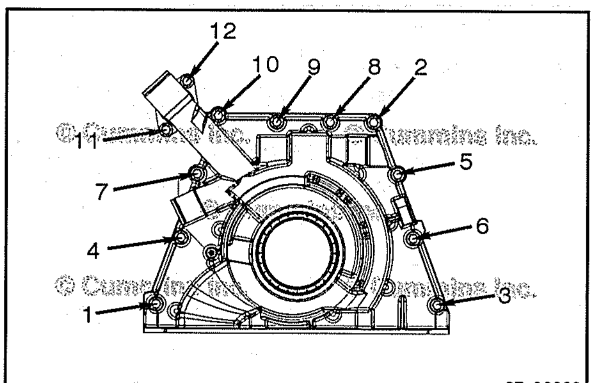
Install the lubricating oil pump gasket. Use the guide pins and dowel rings in the cylinder block to locate and temporarily hold the lubricating oil pump gasket in place.

NOTE: If needed, rotate the lubricating oil pump in the lubricating pump housing to align with the lubricating oil pump drive gear on the crankshaft.

Install the lubricating oil pump.

NOTE: As documented during removal, make sure to install the mounting capscrews in the correct locations.





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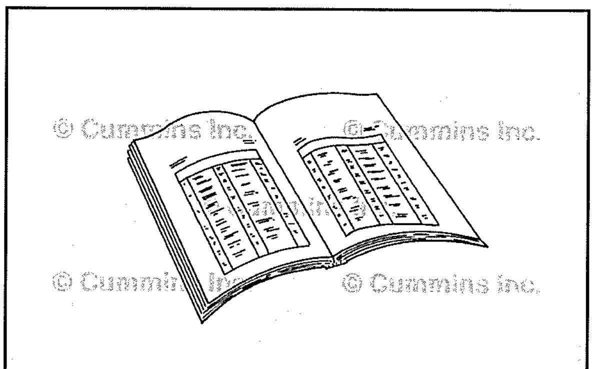
Install the eight lubricating oil pump capscrews and two lubricating oil transfer tube capscrews. Ensure correct length fasteners are used in the correct location. Tighten the capscrews finger tight.

Remove the guide pins and install the two remaining capscrews.

Tighten the capscrews in the sequence shown.

Torque Value: 23 N•m [204 in-lb]



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Finishing Steps

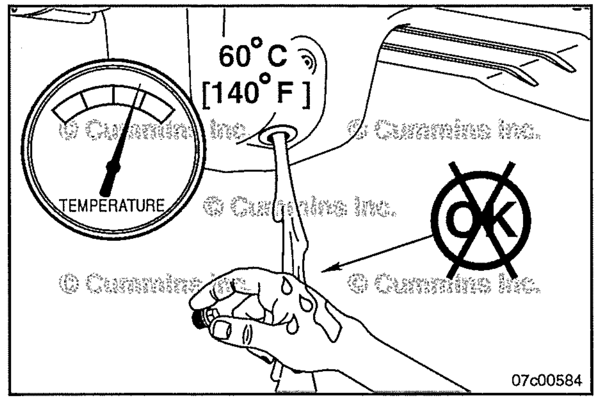
WARNING

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 lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Install and connect the crankshaft position/speed sensor. Refer to Procedure 019-365 in Section 19.
- Install the front crankshaft lubricating oil seal. Refer to Procedure 001-023 in Section 1.
- Install the fan pulley. Refer to Procedure 008-089 in Section 8.
- Install the crankshaft pulley and speed indicator ring. Refer to Procedure 001-022 in Section 1.
- Install the vibration damper. Refer to Procedure 001-052 in Section 1.
- Install the cooling fan belt tensioner. Refer to Procedure 008-087 in Section 8.
- Install the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Prime the lubricating oil system. Refer to Procedure 014-005 in Section 14.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Fill the engine with clean lubricating oil. Refer to Procedure 007-037 in Section 7.
- Operate the engine and check for leaks and proper operation.

Lubricating Oil System (007-037)

Drain



WARNING

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

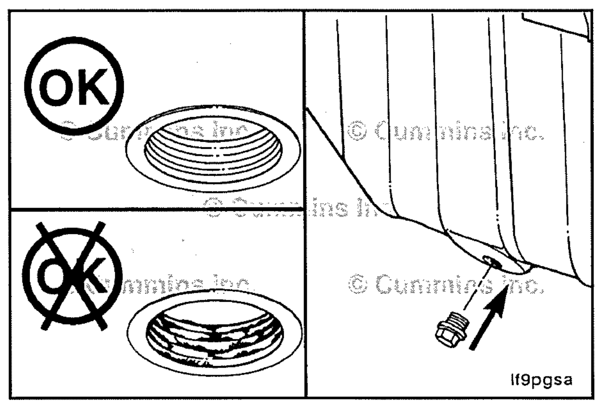
WARNING

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 45.5 liters [48 qt] of lubricating oil.

- Operate the engine until the water temperature reaches 60°C [140°F].
- Shut the engine off.
- Remove the oil drain plug.
- Drain the oil immediately to make sure all the oil and suspended contaminants are removed from the engine.
- If performing an oil drain as part of a service maintenance interval, remove and replace the oil filter. Refer to Procedure 007-013 in Section 7.

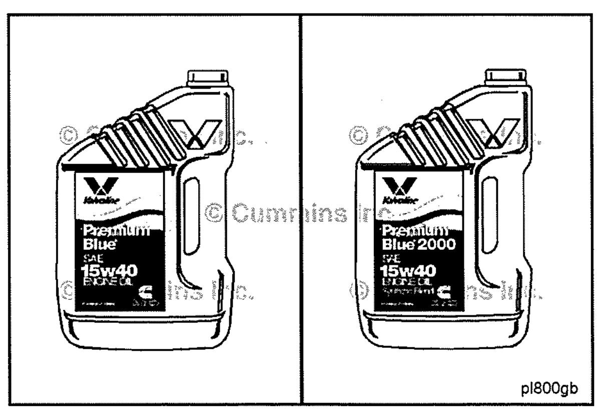
Fill



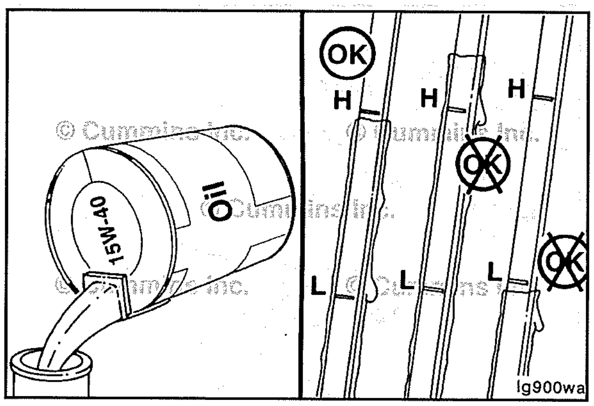
Clean and check the lubricating oil drain plug threads and sealing surface.

Install the oil pan drain plug.

Torque Value: 55 N•m [41 ft-lb]



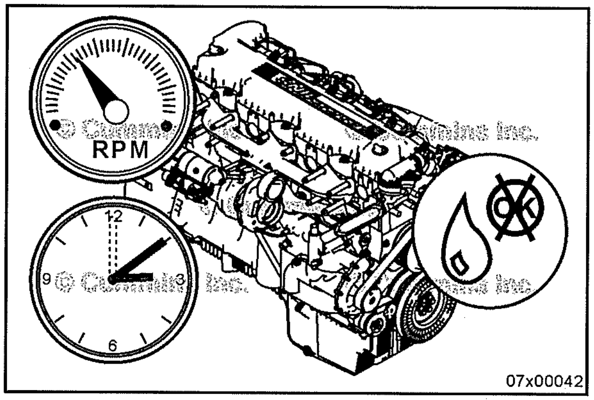
Use a high quality 15W-40 multiviscosity oil, such as Cummins® Premium Blue™, or equivalent, in Cummins® engines. Choose the correct oil for your operating climate. Refer to Cummins® Engine Oil and Oil Analysis Recommendations, Bulletin 3810340.



NOTE: To avoid spilling oil the engine must be filled while level.

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

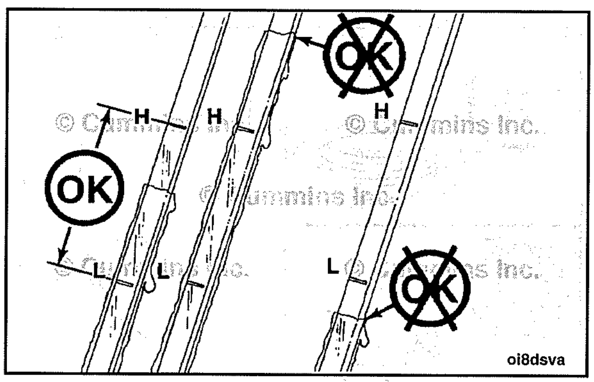
Use the following procedure for oil pan capacities. Refer to Procedure 018-017 in Section V.



CAUTION

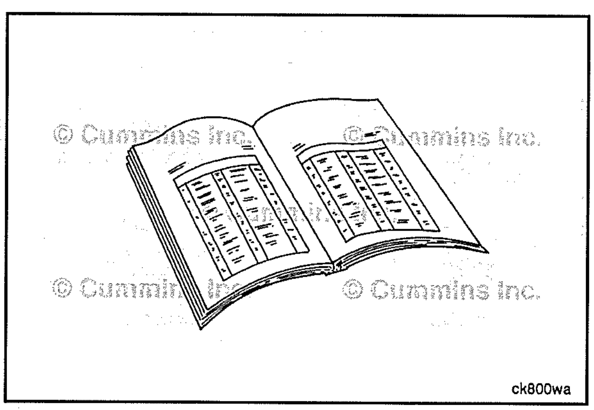
If no oil pressure is noted within 15 seconds after the engine is started, shut down the engine to reduce the possibility of internal engine damage.

Operate the engine until the water temperature reaches 82°C [180°F], and check for leaks.



Shut the engine off. Wait approximately 10 minutes to let the lubricating oil from the upper parts of the engine drain back into the lubricating oil pan. Check the lubricating oil level again.

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



Lubricating Oil Thermostat (007-039)

Preparatory Steps

WARNING

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

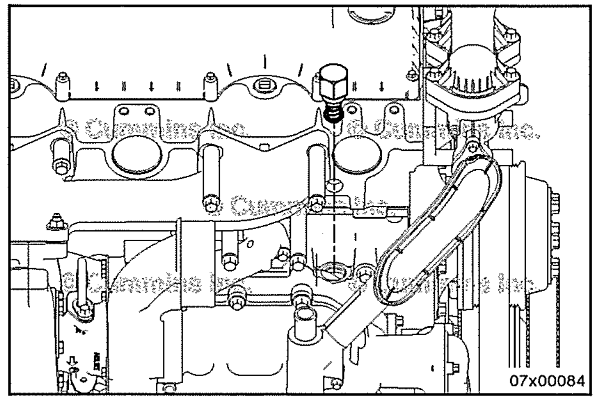
- Disconnect the batteries. See equipment manufacturer service information.
- Clean the area around the lubricating oil thermostat to prevent debris from entering the system.

Remove

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

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

Remove the lubricating oil thermostat.



Clean and Inspect for Reuse

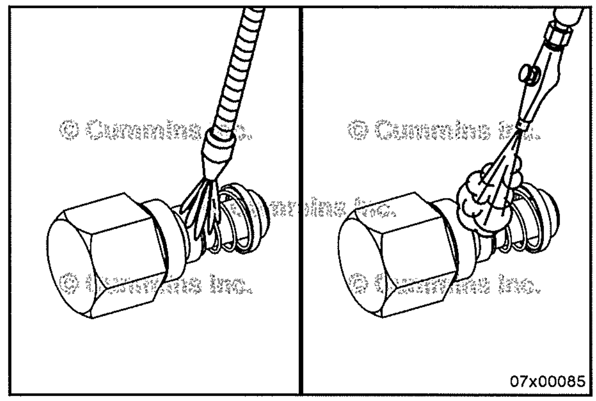
⚠WARNING⚠
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

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

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

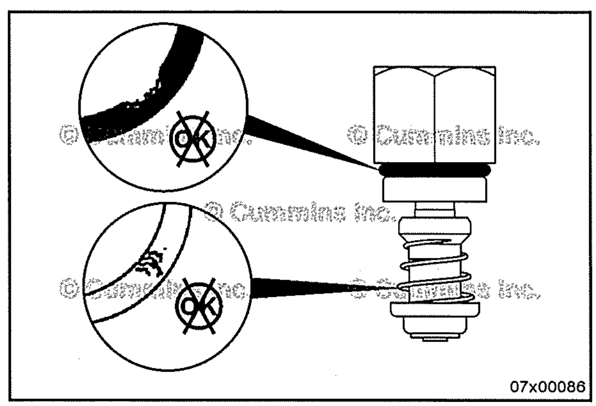
Clean the thermostat with solvent.

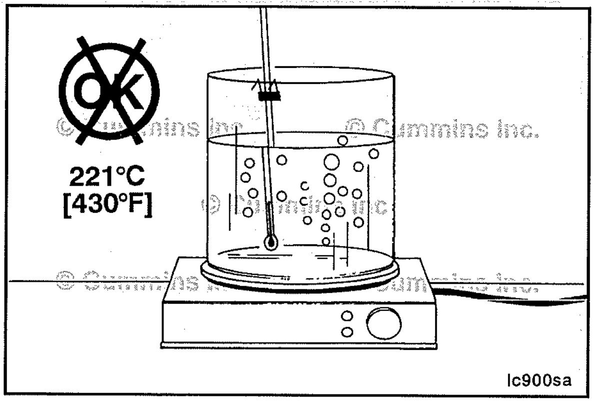
Dry with compressed air.



Inspect for a damaged o-ring, broken spring, or other damage.

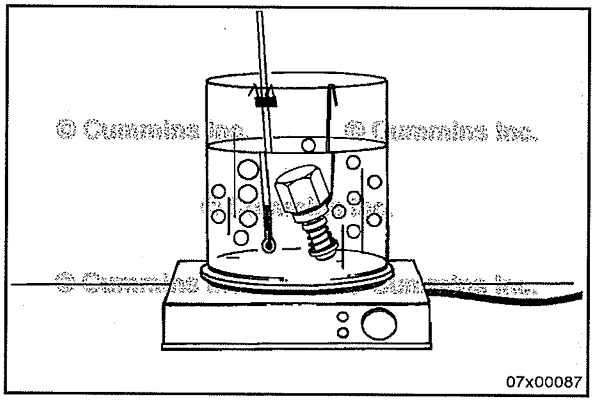
If any damage is found, the component **must** be replaced.





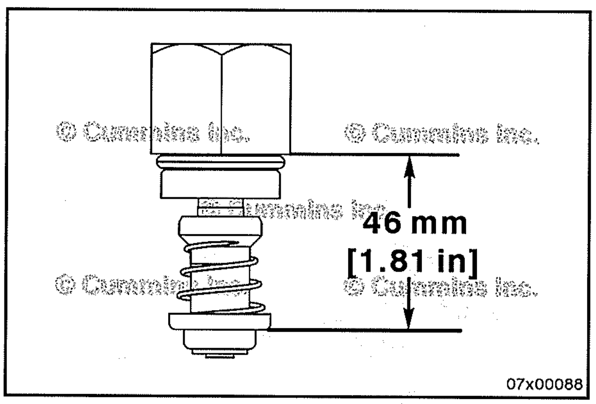
WARNING

The flash point of new lubricating oil is approximately 221°C [430°F]. Do not allow oil temperature in the container to exceed 150°C [300°F]. Do not allow water droplets to enter the container of hot oil. Water droplets will cause a violent reaction, that can cause personal injury.



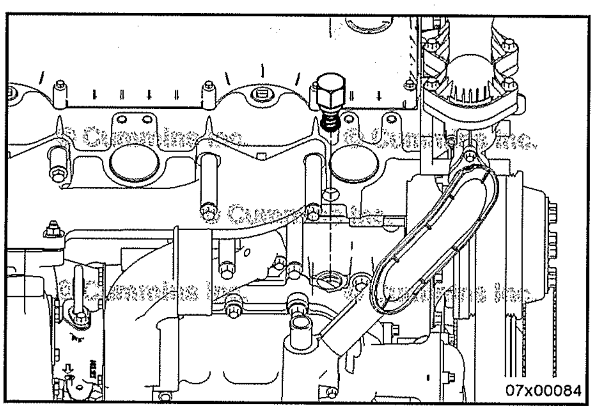
Suspend the thermostat and a 116°C [241°F] thermometer in a container of new lubricating oil. Do **not** allow the thermostat or the thermometer to touch the sides of the container.

Heat the lubricating oil.



NOTE: Record the temperature when the thermostat is fully extended. The thermostat **must** be fully extended at least 46 mm [1.81 in] when the temperature reaches 116°C [241°F].

Replace the thermostat if it does **not** operate as described.



Install

Install the lubricating oil thermostat.

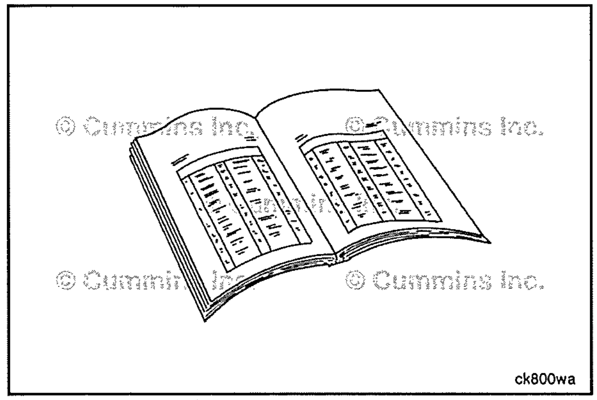
Torque Value: 50 N•m [37 ft-lb]

Finishing Steps

WARNING

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



Lubricating Oil Contamination (007-044)

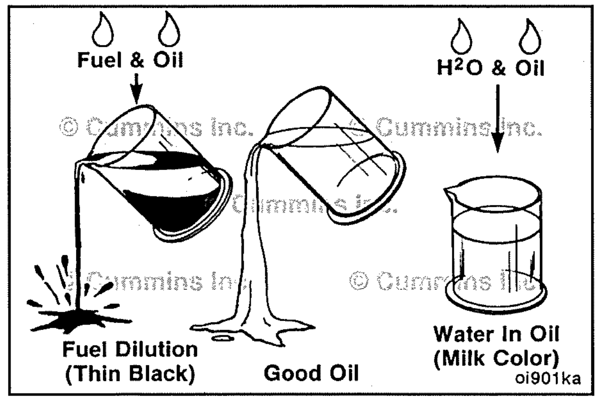
Initial Check

CAUTION

Diluted oil can cause severe engine damage.

Check the condition of the lubricating oil.

- Thin, black lubricating oil is an indication of fuel in the oil.
- Milky discoloration is an indication of coolant in the lubricating oil.

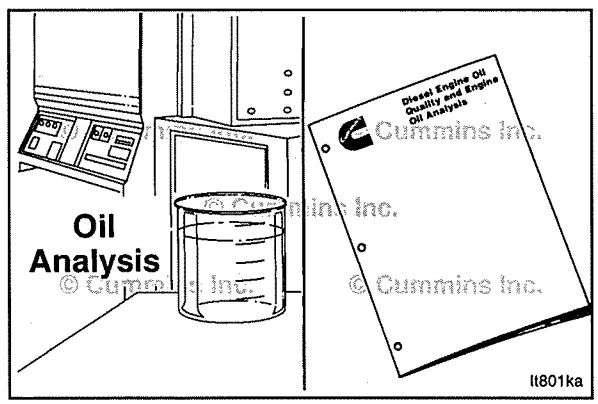


General Information

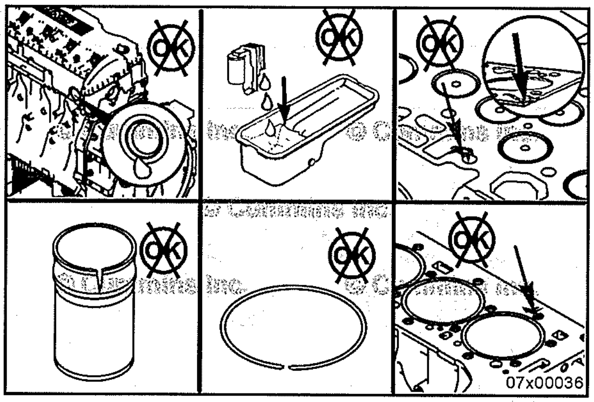
A used oil analysis can monitor engine oil contamination and help to determine if it was caused by one of the following:

- Oil diluted with dust
- Oil diluted with coolant
- Oil diluted with fuel
- Extended oil drain interval
- Possible engine wear.

Please reference the following chart to assist with diagnosis:



Material in Sample	Likely Cause	Action
Silicon	Dust Ingestion via Air Intake	Check cylinder blowby. Refer to Procedure 014-010 in Section 14.
Calcium/Sodium	Coolant Leak	Reference Coolant-Diluted Lubricating Oil in this procedure.
Fuel	Fuel Leak	Reference Fuel-Diluted Lubricating Oil in this procedure.
Soot	Extended Oil Drain Interval	Change Oil or shorten oil change intervals.
Wear Metal	Possible Engine Wear	Refer to Procedure 007-083 in Section 7.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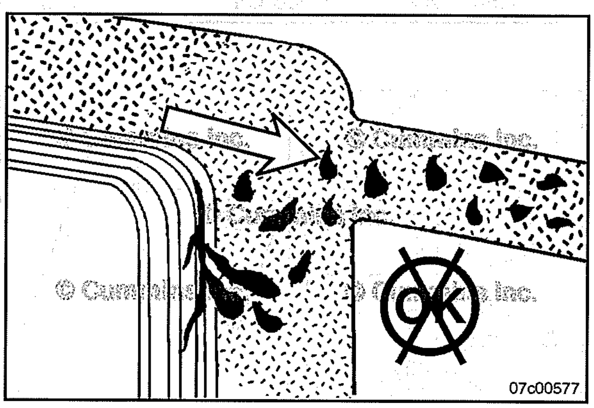
Coolant in the oil can be caused by:

- Expansion plugs leaking
- Lubricating oil cooler element leaking
- Damaged cylinder head or gasket
- Cylinder Liner
- Liner o-ring
- Cracked engine block
- Casting porosity.

Refer to Cummins® Engine Oil and Oil Analysis Recommendations, Bulletin 3810340 for further information.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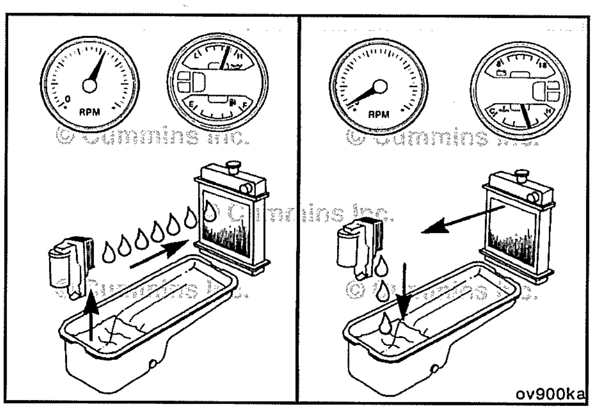
Coolant Diluted Lubricating Oil

To check for leaks in the lubricating oil cooler, pressure test the oil cooler as an assembly. Refer to Procedure 007-046 in Section 7.



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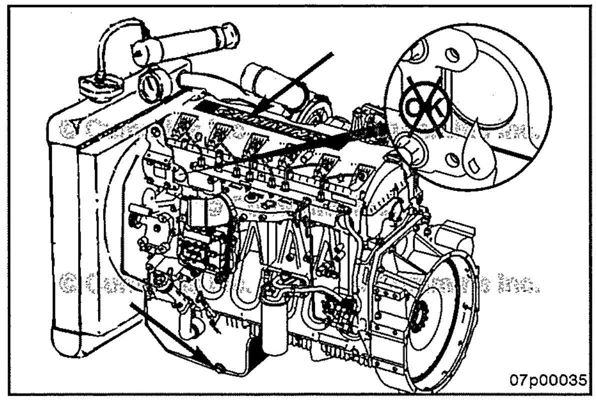
During operation, the lubricating oil pressure will be higher than coolant pressure. A leak in the lubricating oil cooler will therefore show as lubricating oil in the coolant.

However, following an engine shutdown, the residual pressure in the coolant system can cause coolant to seep through the leak path into the lubricating oil.

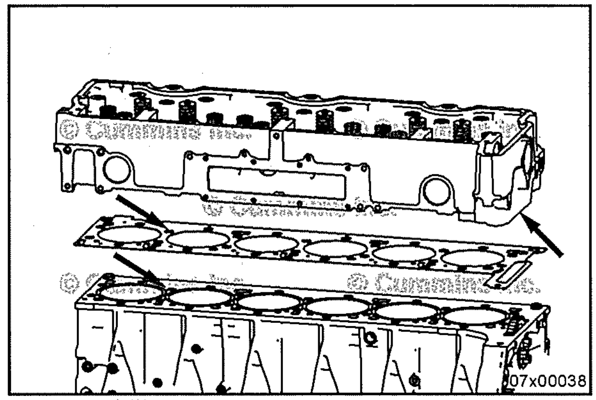
To check for leaks, pressurize the cooling system to a maximum of 140 kPa [20 psi]. With the system pressurized, remove the following components, and inspect for leaks.

- Valve cover (leaks indicate cracked head)
- Lubricating oil drain plug (leaks indicate defective lubricating oil cooler, head gasket, cracked head or block).



Coolant in the lubricating oil can be caused by a damaged cylinder head gasket or cracked cylinder head or block.

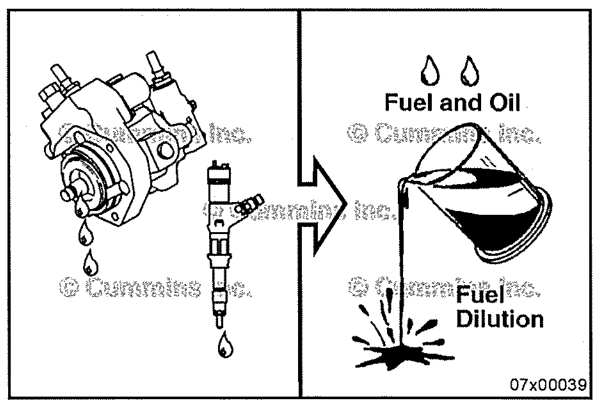
Remove the cylinder head and gasket, and inspect for cracks or other damage.



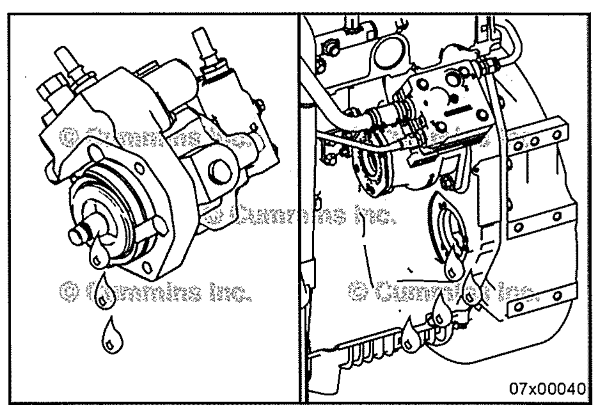
Fuel Diluted Lubricating Oil

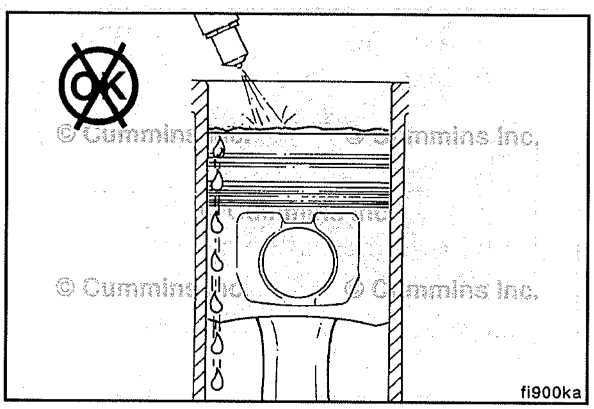
Fuel dilution is limited to five potential sources:

- Injection pump shaft seal
- Fuel leaking by the rings
- Engine idle time excessive
- A crack in the cylinder head injector drain passage
- Injector leakage.



If oil dilution with fuel is suspected, use the following steps to locate the source of the fuel in the lubricating oil.

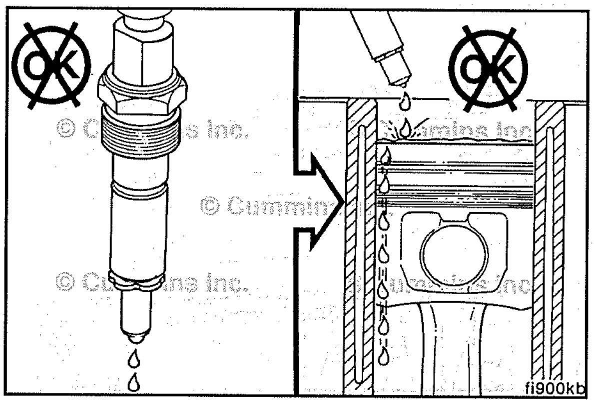




Incomplete combustion in the cylinders can result in unburned fuel draining into the oil pan.

This condition can be caused by a leaking injector or reduced compression caused by inadequate piston ring sealing.

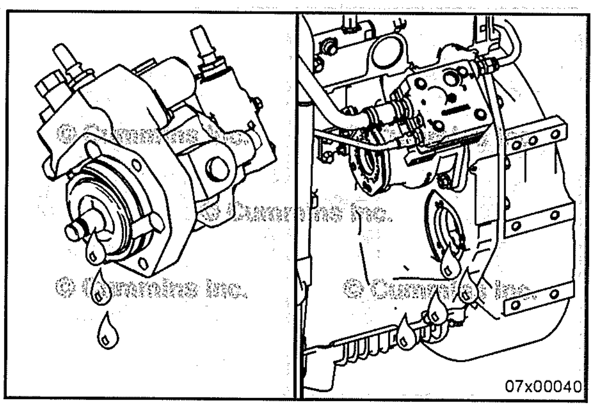
Measure blowby and compare to the specifications. Refer to Procedure 014-010 in Section 14.



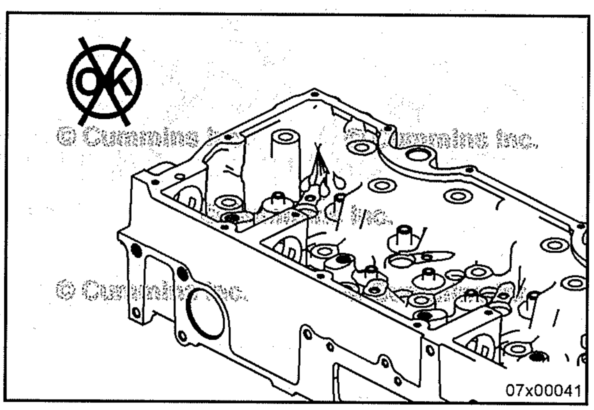
An increase in white exhaust smoke during the first start of the day is a symptom that an injector is leaking.

An injector leak will also cause the engine to run rough and have low power.

Remove and repair or replace leaking injectors. Refer to Procedure 006-026 in Section 6.



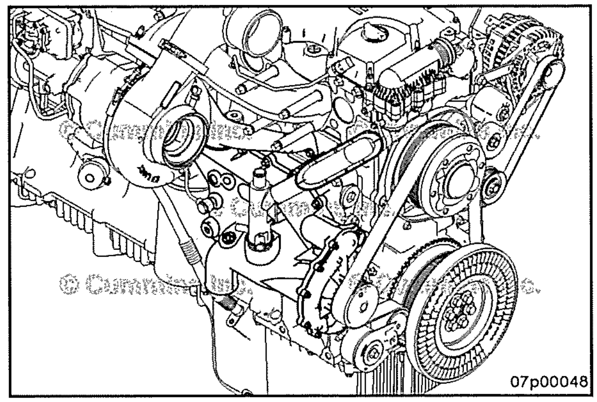
It is possible the fuel pump may introduce fuel into the lubricating oil if **not** functioning properly. Use the following procedure to troubleshoot the pump. Refer to Procedure 005-016 in Section 5.



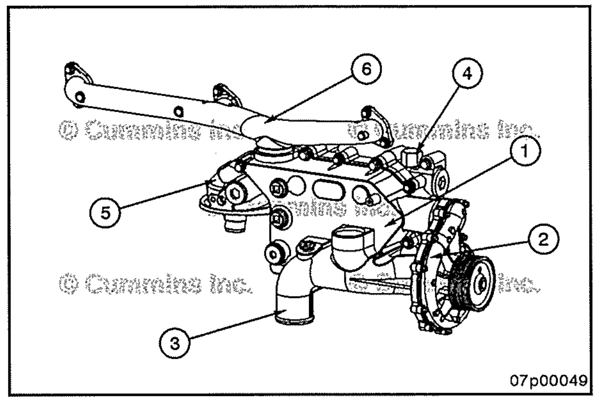
Another remote possibility is that a crack or porosity in the head casting will allow fuel to leak to the lubricating oil.

Lubricating Oil Cooler Housing (007-046)

General Information

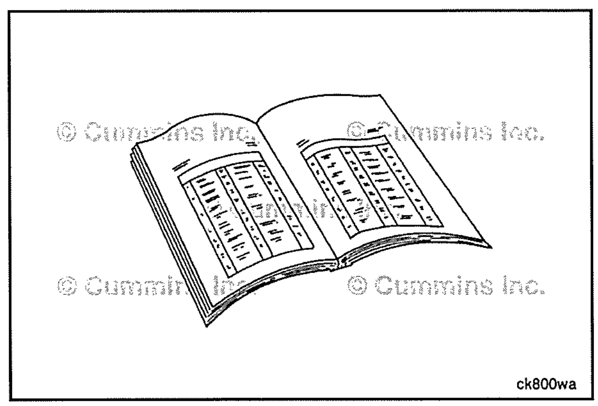


The lubricating oil cooler module includes the lubricating oil cooler, water pump,coolant manifold, coolant inlet connection, lubricating oil thermostat, and lubricating oil filter head.



1 Lubricating oil cooler
2 Water pump
3 Coolant inlet connection
4 Lubricating oil thermostat
5 Lubricating oil filter head
6 Coolant manifold

Preparatory Steps

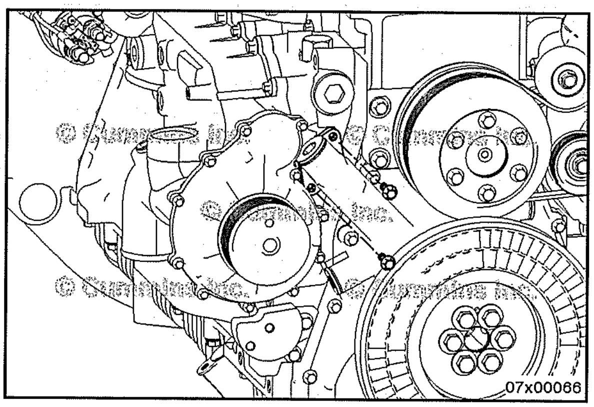


⚠WARNING⚠
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

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

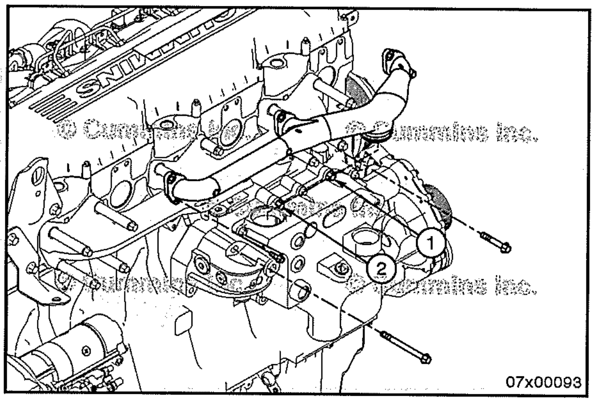
⚠WARNING⚠
To reduce the possibility of personal injury, avoid direct contact of hot oil with your skin.

- Clean the area around the lubricating oil cooler module and coolant manifold.
- Drain the cooling system. Refer to Procedure 008-018 in Section 8.
- Drain lubricating oil system. Refer to Procedure 007-037 in Section 7.
- Remove turbocharger. Refer to Procedure 010-033 in Section 10.
- Remove lubricating oil filter. Refer to Procedure 007-013 in Section 7.
- Remove thermostat housing and coolant bypass tube. Refer to Procedure 008-014 in Section 8.



Remove

Remove two capscrews securing lube oil transfer tube to lubricating oil cooler module. Slide lube oil transfer tube towards front of engine, into lube oil pump.



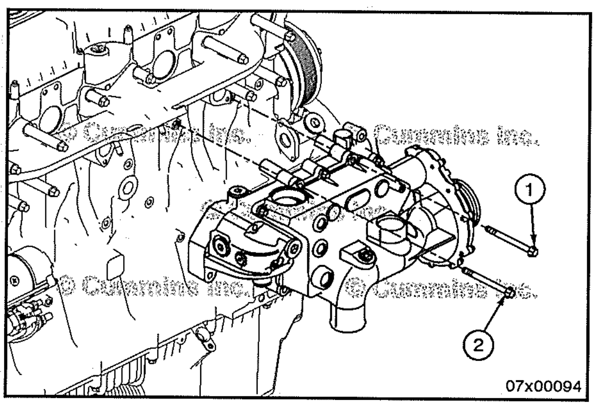
Loosen capscrews 1 and 2 first.

Remove remaining 13 capscrews holding lubricating oil cooler module and coolant manifold to block.

Rock lubricating oil cooler module and coolant manifold assembly away from block.

Remove coolant manifold.

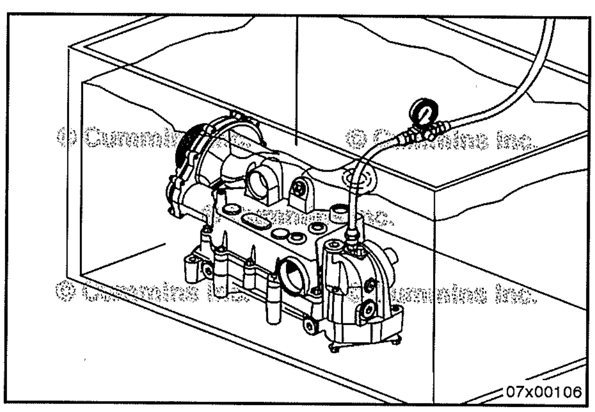
NOTE: The lubricating oil cooler module **must** be removed as an assembly. Take precaution to prevent it from falling.



Remove last two capscrews holding lubricating oil cooler module to block.

Remove lubricating oil cooler module.

NOTE: Take care that no debris enters the lubricating oil or coolant passages in the block.

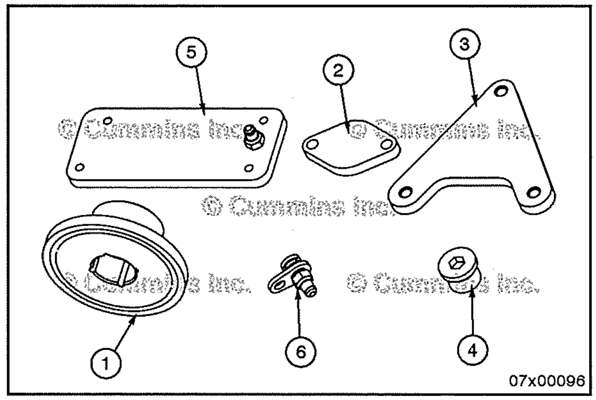


Leak Test

It is important to leak test the oil cooler assembly as a unit so leaks at the mounting joints can be identified. These leaks can **not** be found when testing individual elements that have been removed from the assembly. An element is replaced **only** if it is found to be leaking.

The lubricating oil cooler test kit, Part Number 5298873, comes with 5 block off plates and an air adapter fitting.

1 Oil filter adapter - Part Number 5298871
2 Oil flow block-off plate - Part Number 5298869
3 Oil flow block-off plate - Part Number 5298870
4 M27 block off plug - Part Number 3678611
5 Oil cooler element block off plate - Part Number 5298824
6 Air connection adapter assembly - Part Number 5298968.



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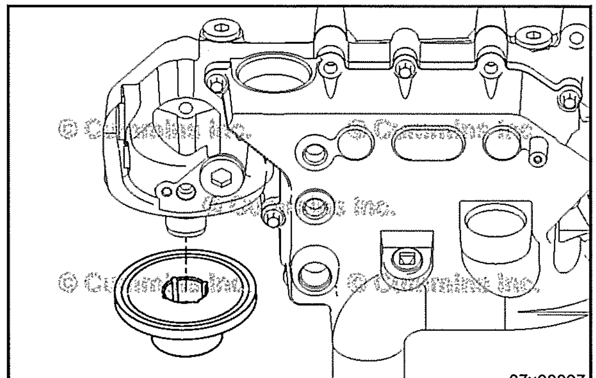
Install oil filter adapter, Part Number 5298871, oil flow block-off plate, Part Number 5298869, oil flow block-off plate, Part Number 5298870, M27 block off plug, Part Number 3678611, and air adapter fitting, Part Number 5298968.

For oil filter adapter - lubricate o-ring with engine oil. Tighten until there is contact between the oil filter head and adapter. Turn 1/2 turn more.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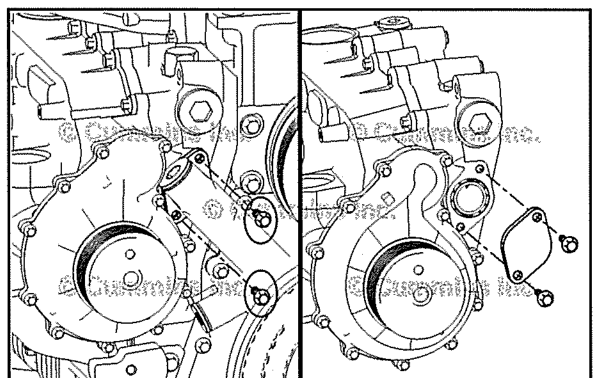
For oil block off plate, Part Number 5298869 - remove the two capscrews from the lubricating oil transfer tube and use to install the oil block off plate.

Torque Value: 23 N•m [204 in-lb]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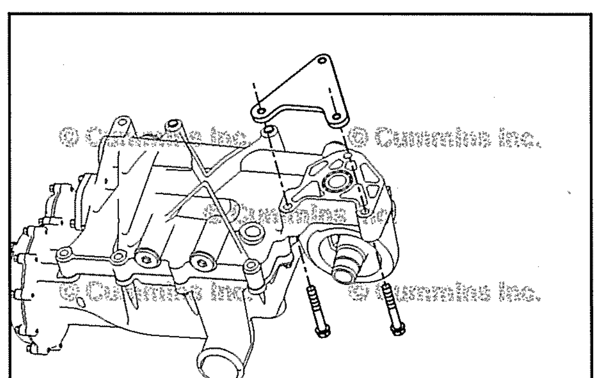
For oil flow block-off plate, 5298870, use the three bolts previously holding the lubricating oil filter head to the block to secure the block off plate. These bolts will be inserted from the front of the filter head and threaded into plate 5298870.

Torque Value: 46 N•m [34 ft-lb]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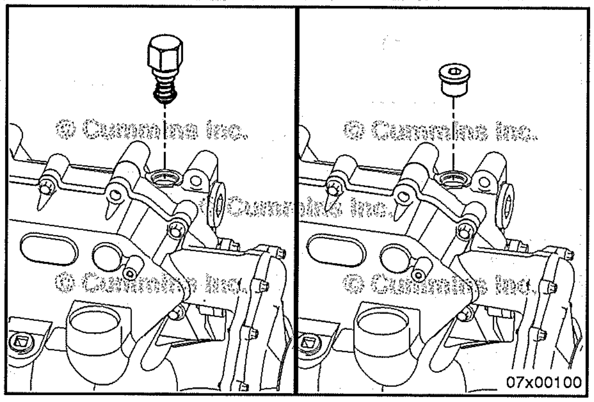
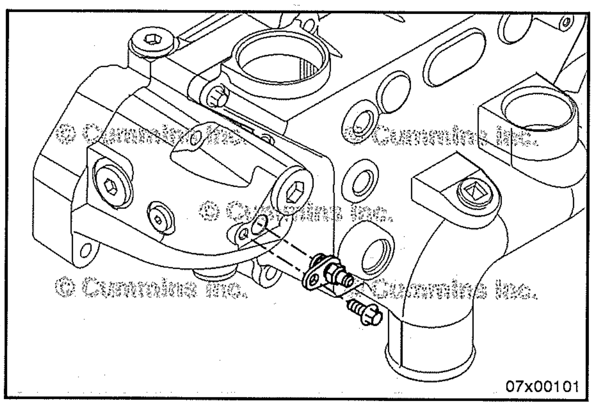


Remove lubricating oil thermostat.

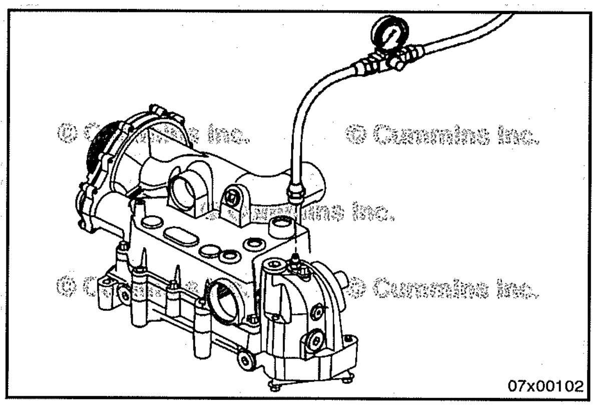
Install M27 plug, Part Number 3678611, into lubricating oil thermostat port.

Torque Value: 68 N•m [50 ft-lb]



Install the turbo oil supply block off plate, Part Number 5298968, fitting on the lubricating oil filter head and secure with turbo oil supply line flange bolt.

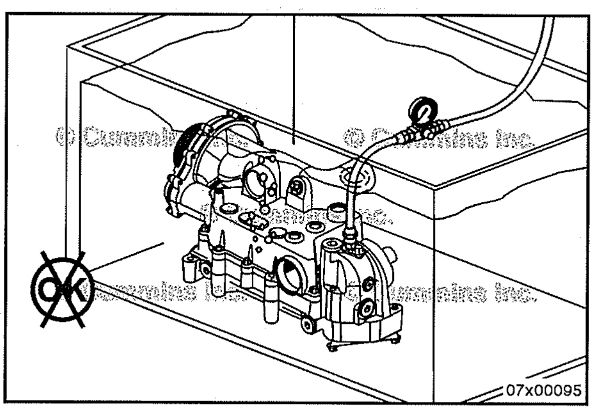
Torque Value: 26 N•m [230 in-lb]



Attach air pressure regulator, Part Number 3164231 or equivalent, to the air fitting of the test assembly.

Pressurize the assembly.

Lubricating Oil Cooler Test Assembly 689 kPa [100 psi]

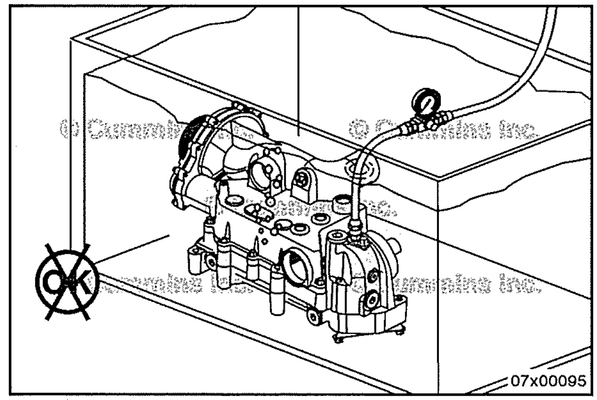


⚠WARNING⚠

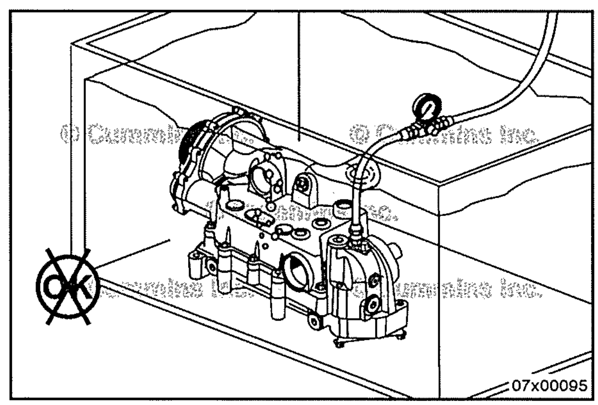
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Place the oil cooler assembly under water.

If bubbles are observed, carefully determine the source of the bubbles.

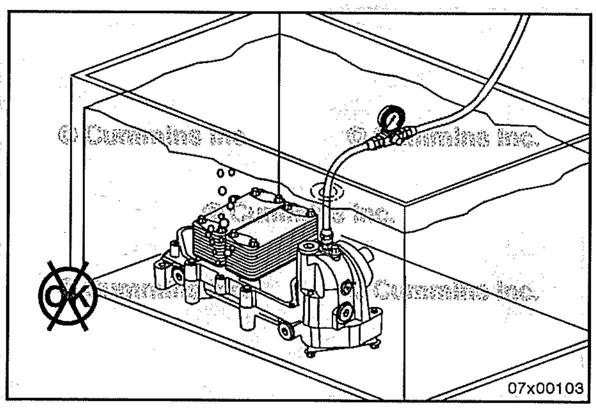


- If bubbles are observed from any of the plugs in the oil cooler module remove pipe plugs, clean threads, apply appropriate sealant reinstall and torque as appropriate. Retest module.
- If bubbles are coming out around the block-off plates from the test kit, verify torque on bolts from leaking plates and retest. If bubbles still come out, remove block-off plates and check for flatness or gouges, replace as necessary and retest (paying attention to torque). If bubbles still come out, replace diamond ring seals. Verify repair.
- If bubbles are coming out around the filter adapter, give the adapter 1/8 additional turn and retest. If bubbles still come out, remove adapter, inspect o-ring, replace as necessary and retest. If bubbles still come out, the threaded boss for the filter is damaged, and the module should be replaced. Verify repair.
- If bubbles are coming out around the turbo oil supply fitting, this suggests that the fitting could **not** be sealing against the module threads, the face seal o-ring could be damaged/missing, the adapter fitting could be loose on the turbo oil supply fitting or the fitting on the air pressure regulator could be loose on the adapter fitting. Systematically check all of these and retest. Verify repair.



- If bubbles are coming out around the joint between the two halves of the module assembly, the gasket has most likely failed. Disassemble module halves and replace gasket. Also inspect the gasket surfaces for damage. Repair damage if you can, if **not**, replace module. Reassemble with new gasket and verify repair.
- If bubbles are coming out of the coolant manifold port, the one piece gasket where the coolers mount to the module has failed, or the coolers themselves have failed. Disassemble the module halves to investigate further.
- If no leaks are found, the element does **not** need to be removed but the capscrew torque **must** be checked and tightened to the specified torque.

Remove the oil cooler leak test kit.



Remove capscrews securing lubricating oil cooler front cover to back plate.

Remove front cover revealing lubricating oil cooler elements.

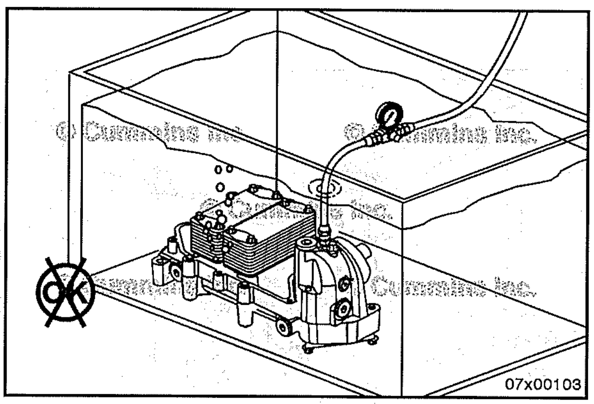
Resubmerge oil cooler element half of the module into water.

Pinpoint if the bubbles are coming from the oil coolers or the one piece gasket where the oil cooler elements mount to oil cooler module.

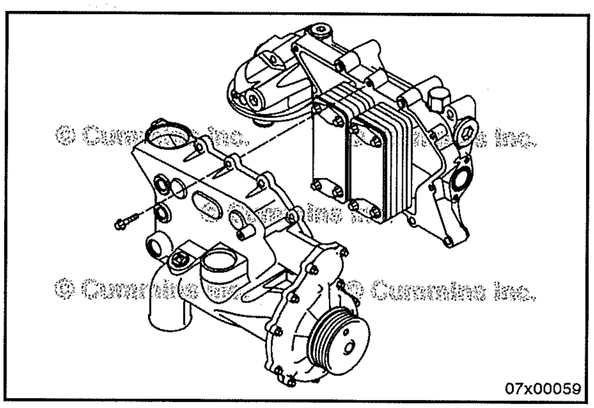
- If the bubbles are coming from an oil cooler element, replace the element and restest the module.
- If bubbles are coming from the one piece gasket, remove both elements and replace the one piece gasket. Replace oil cooler elements and retest the module.

Use oil cooler element testing plate, Part Number 5298824, as necessary to verify failed oil coler elements.

- If bubbles are present but don't appear to be coming from any of the above potential problem locations, the most likely failure mode is that the module is cracked, and needs to be replaced.



If bubbles are present but don't appear to be coming from any of the above potential problem locations, the module is most likely cracked and needs to be replaced.



Disassemble

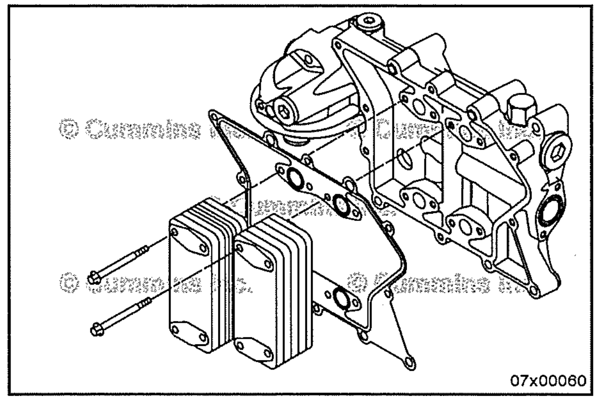
NOTE: Only disassemble lubricating oil cooler module if necessary.

Remove the oil cooler housing from the back plate.

The lubricating oil cooler module has two cooling elements. Remove the eight capscrews holding the lubricating oil cooler elements to the back plate.

Remove oil cooler elements and gasket from lubricating oil cooler module back plate.

Discard gasket.



If necessary, test the lubricating oil cooler elements. Install oil cooler element block off plate, Part Number 5298824, onto the back of the oil cooler element using the cooler element mounting bolts.

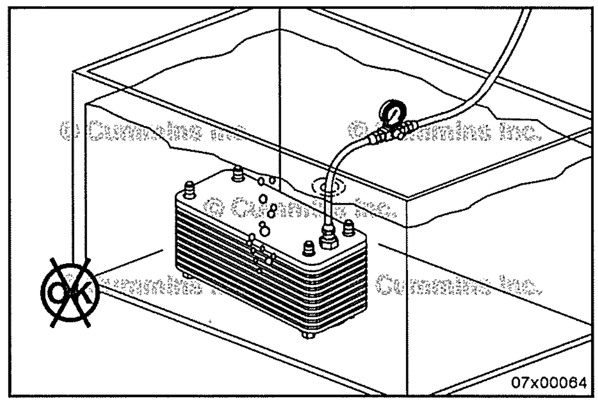
Attach air pressure regulator, Part Number 3164231 or equivalent, to the outlet plate air fitting of the test assembly.

Pressurize the assembly.

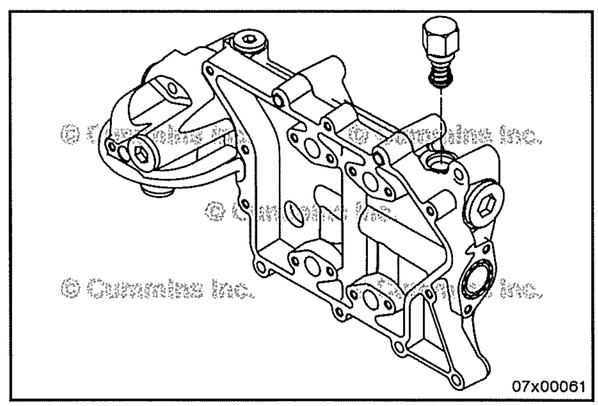
Lubricating Oil Cooler Test Assembly 689 kPa [100 psi]

Place element underwater and inspect for bubbles. If bubbles are found, replace element.

Perform on second element as necessary.

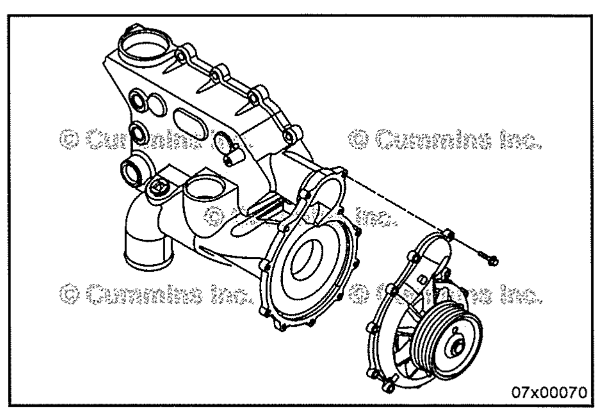


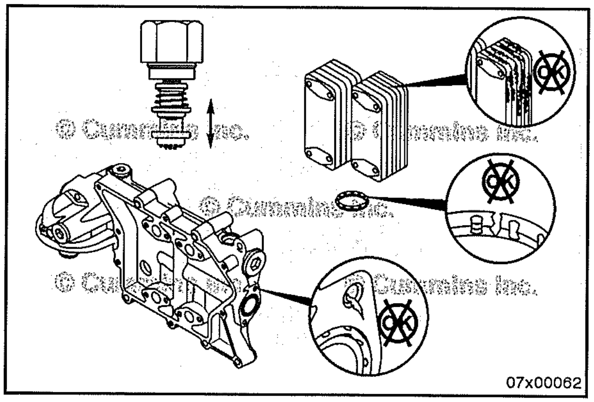
Remove the lubricating oil thermostat. Refer to Procedure 007-039 in Section 7.



If necessary, remove water pump. Refer to Procedure 008-102 in Section 8.

NOTE: The water pump **only** needs to be removed if the lubricating oil cooler housing is being replaced. The water pump does **not** need to be removed for cleaning.





Clean and Inspect for Reuse

CAUTION

Do not reuse a lubricating oil cooler element after a debris related engine malfunction since there is no practical method for cleaning the cooler element. Metal particles which can circulate through the lubricating system can remain in the cooler core and cause engine damage. Do not allow dirt to enter the oil passages when cleaning the oil cooler.

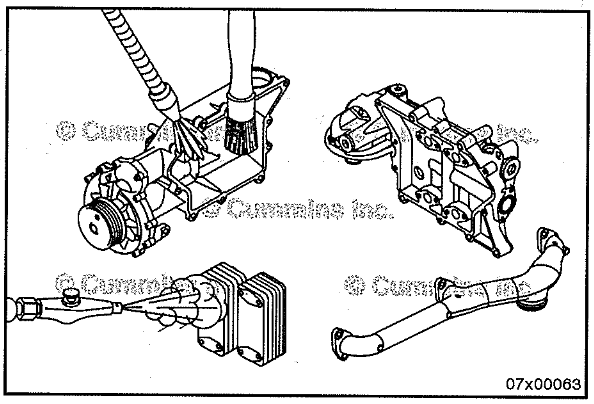
Inspect the lubricating oil cooler module elements for signs of debris.

Replace the lubricating oil cooler element if debris is found.

Inspect other components, sealing surfaces, o-rings and diamond seals for signs of cracks, nicks, or other damage.

Inspect the lubricating oil thermostat. Refer to Procedure 007-039 in Section 7.

Replace any damaged part.



WARNING

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

WARNING

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

CAUTION

Do not allow dirt or foreign material to enter oil passages in the cooler housing when cleaning the gasket sealing surfaces. Connecting rod bearing or main bearing failures can be caused if debris is introduced into the cylinder block or lubricating oil cooler housing oil passages. The use of power tools combined with abrasive pads to clean gasket surfaces is not recommended.

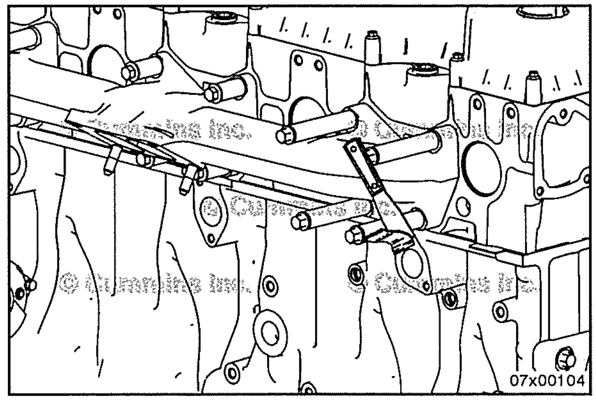
If needed, clean gasket surfaces by hand with a cleaning pad, Part Number 3823258 or equivalent. If the gasket material residue can **not** be felt with a fingernail, the surface is ready to accept the new gasket.

Use solvent to clean and flush the lubricating oil cooler module and coolant manifold passages and cores.

Dry with compressed air.

If necessary, clean the block face joint with a gasket scraper and solvent.

NOTE: It is important to keep debris out of lubricating oil passages in block and lubricating oil cooler module.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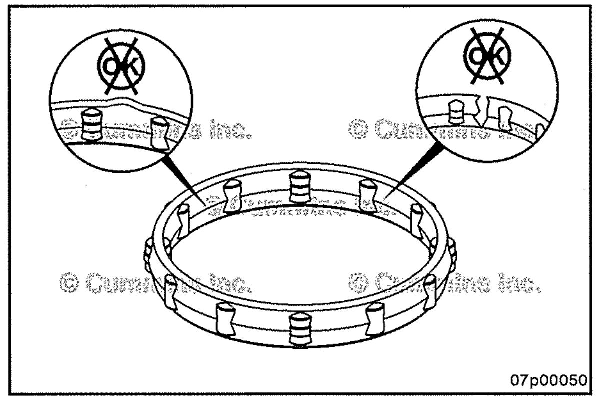
Inspect the diamond seals for swelling and damage.

Replace any damaged seals.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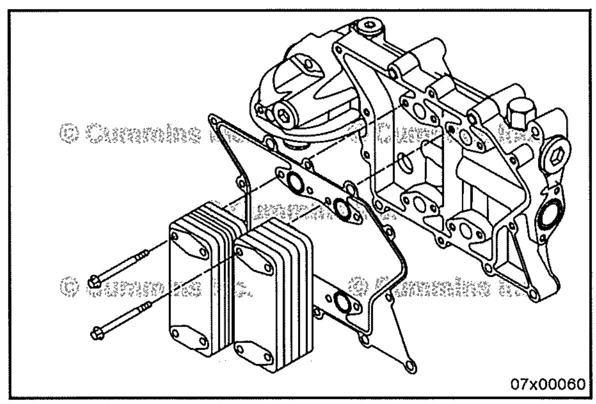
Assemble

Install the oil cooler element gasket, elements, and capscrews.

Torque Value: 23 N•m [204 in-lb]

NOTE: Oil cooler element gasket is integrated with the lubricating oil cooler module gasket.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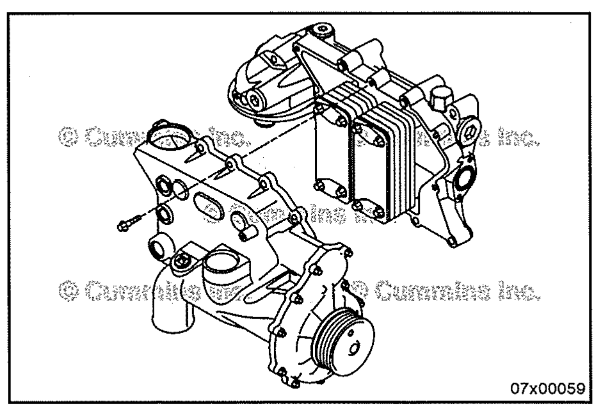
Install lubricating oil cooler housing to the back plate.

Tighten capscrews in a pattern starting inside and working out.

Torque Value: 23 N•m [204 in-lb]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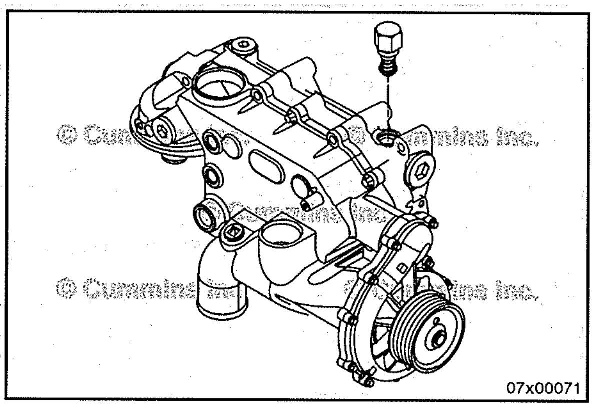
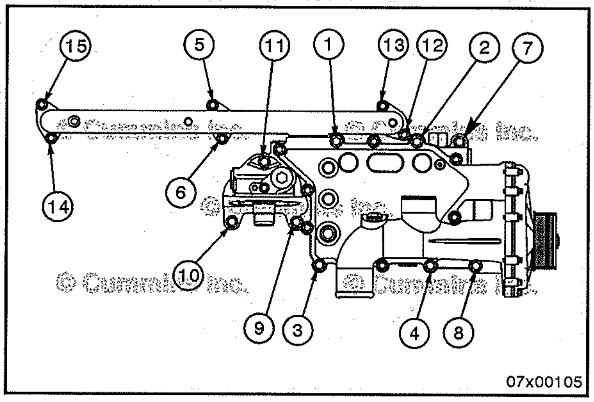


Lubricate the thermostat o-ring with clean engine oil.

Install the lubricating oil thermostat. Refer to Procedure 007-039 in Section 7.



Install

NOTE: Ensure 5 diamond ring seals are present and undamaged prior to installation. 3 in coolant manifold and 2 in lubricating oil cooler module back plate.

Install lubricating oil cooler module to block with 2 capscrews loosely threaded into block.

Lubricate o-ring with non-petroleum based lubricant, P80 or similar, and slide the coolant manifold into lubricating oil cooler housing.

NOTE: Ensure o-ring stays seated in groove while inserting water manifold into lubricating oil cooler housing.

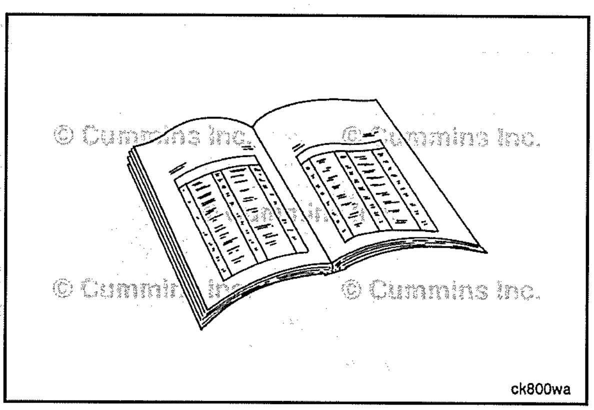
Install capscrews securing the coolant manifold to the block and capscrews securing the lubricating oil cooler module to the block.

NOTE: Ensure diamond seals stay in place when securing water manifold to block.

Tighten according to torque procedure.

Torque Value:
Water manifold 23 N•m [204 in-lb]

Torque Value:
Lubricating oil cooler module 46 N•m [34 ft-lb]



Finishing Steps

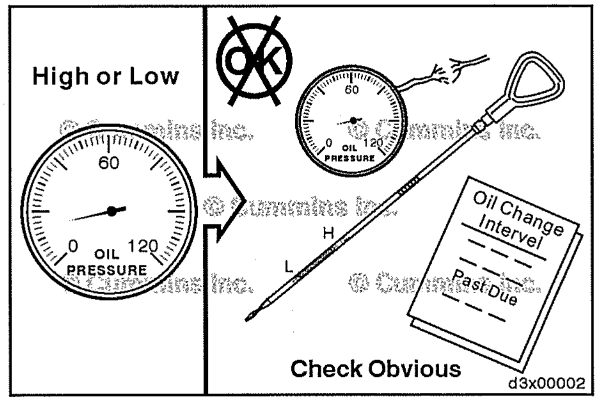
- Install thermostat housing and coolant bypass tube. Refer to Procedure 008-014 in Section 8.
- Install lubricating oil filter. Refer to Procedure 007-013 in Section 7.
- Install turbocharger. Refer to Procedure 010-033 in Section 10.
- Fill lubricating oil system. Refer to Procedure 007-037 in Section 7.
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine and check for leaks.

Lubricating Oil System Diagnostics (007-048)

General Information

Lubricating Oil Pressure

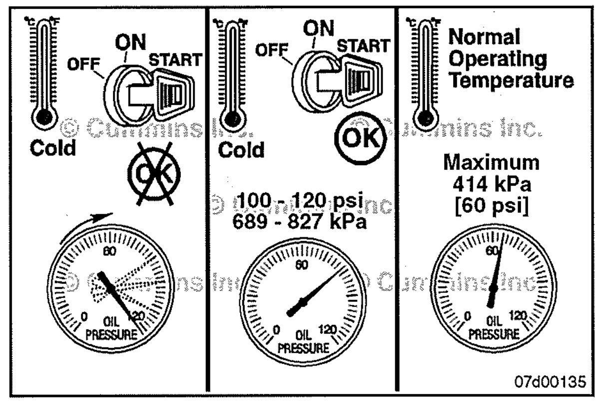
When diagnosing lubricating oil system malfunctions, check all obvious items related to oil pressure, such as gauges, high and low oil level, excessive oil contamination, and oil viscosity.



High lubricating oil pressure occurs after the engine is first started in cold weather.

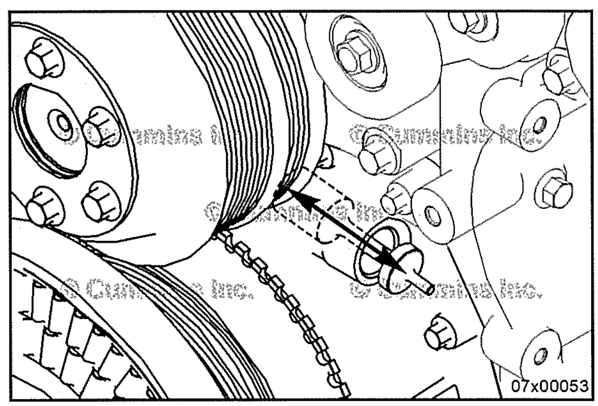
Cold-start oil pressure is approximately 689 to 827 kPa [100 to 120 psi].

If the pressure regulator plunger is operating properly, the oil pressure **must** drop back to approximately 189.6 kPa [27.5 psi] when normal operating temperature is reached.



The engine will have high oil pressure at normal operating temperature if the lubricating oil pressure regulator valve sticks in the closed position.

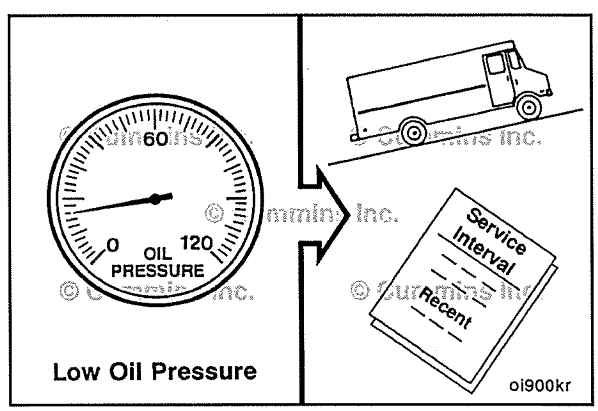
Check the regulator for freedom of movement. Refer to Procedure 007-029 in Section 7.

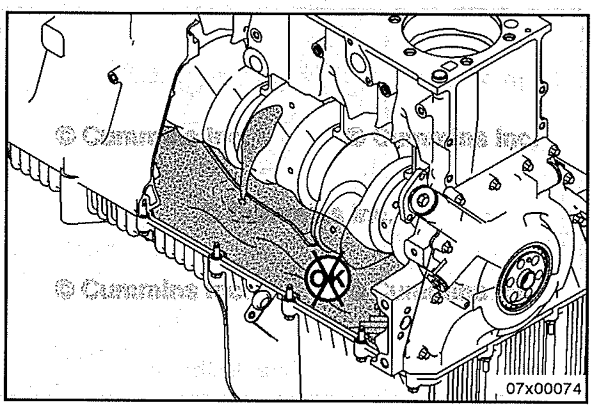


Low lubricating oil pressure (or no oil pressure) can be caused by several lubricating system-related malfunctions.

To begin the investigation, determine the engine operating conditions when the low pressure was first observed. The following are potential conditions for low lubricating oil pressure:

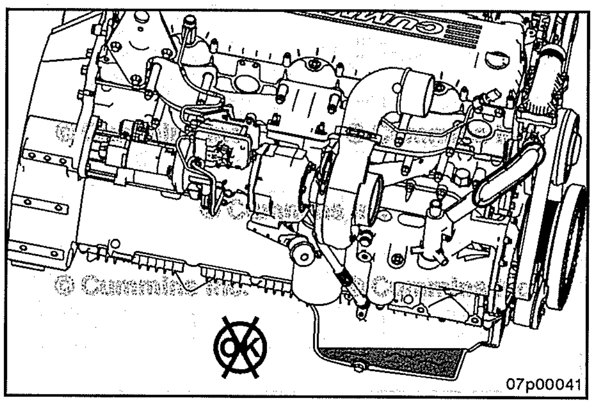
- Following a service interval
- At idle **only**
- Operating on a steep grade





High lubricating oil level can cause low oil pressure.

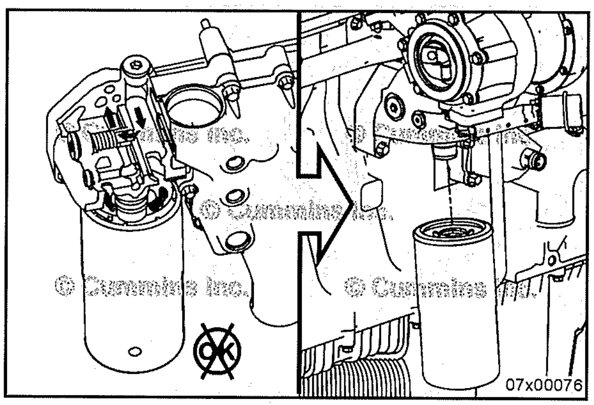
If the oil level is high enough for the connecting rods to dip into the oil while operating, the oil can become aerated, resulting in low oil pressure.



Low oil level will **not** normally appear as low oil pressure.

It will typically appear as an intermittent loss of oil pressure when rounding a corner or operating on a steep grade.

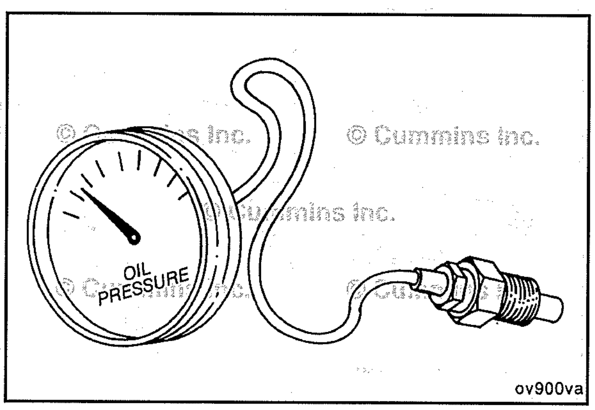
This condition exists when the oil level is extremely low and the suction tube cannot pick up oil during all modes of operation.



A plugged lubricating oil filter will cause a gradual loss of oil pressure, by approximately 69 kPa [10 psi].

The pressure will return to normal when the filter bypass valve opens.

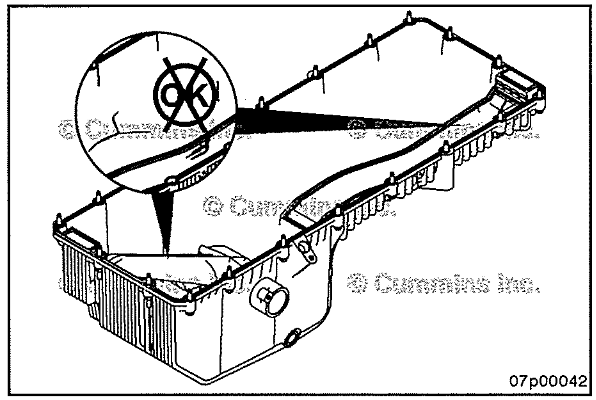
If **not** corrected, this will result in severe engine wear, as the engine is running on unfiltered oil when the bypass valve is open.



Check the lubricating oil gauge and pressure sensor, to make sure they are operating correctly, by verifying the pressure with a manual gauge.

A damaged oil pan gasket or crack in the oil pan integrated oil suction tube can cause a loss of prime for the oil pump.

The engine will have low oil pressure or no oil pressure during starting, followed by normal oil pressure.



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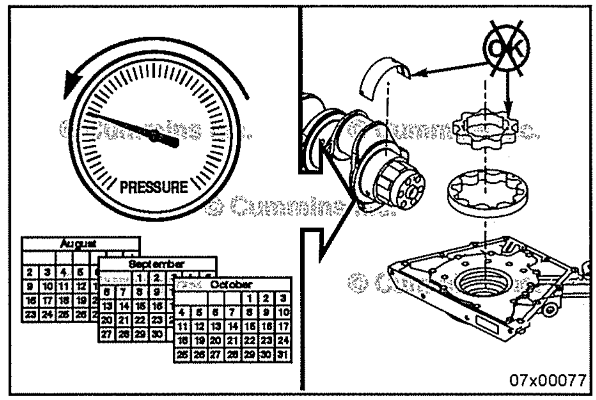
A steady decrease in oil pressure over a long period can be an indication of worn bearings or excessive lubricating oil pump wear.



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Lubricating Oil Dilution

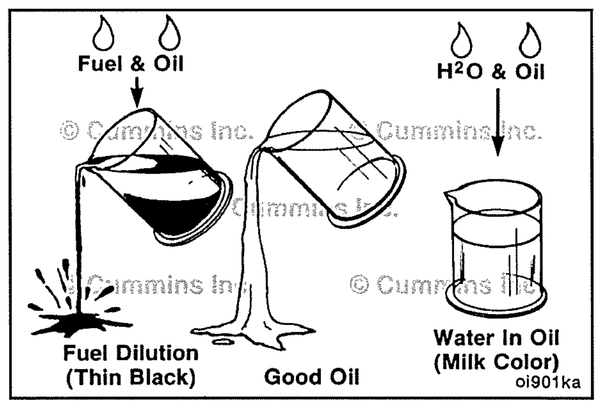
⚠CAUTION⚠

The use of diluted oil can cause severe engine damage.

Check the condition of the lubricating oil:

- Thin, black oil is an indication of fuel in the oil
- Milky discoloration is an indication of coolant in the oil.

For more information on how to check for diluted lubricating oil, Refer to Procedure 007-044 in Section 7.



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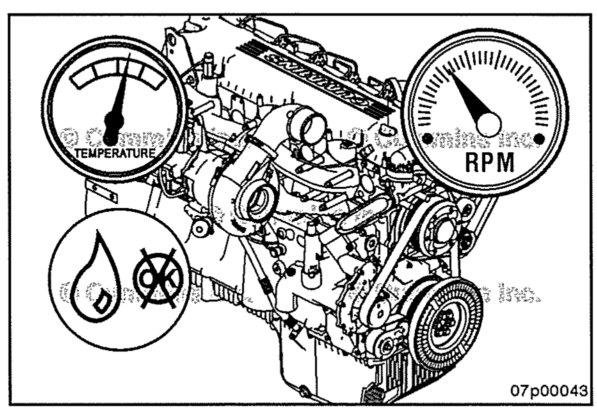
Lubricating Oil Consumption and Leaks

Various gaskets, seals, and plugs are used to contain the lubricating oil. Most leaks can be identified during routine inspections of the engine and vehicle.

For more information on how to check for lubricating oil leaks, Refer to Procedure 007-024 in Section 7.



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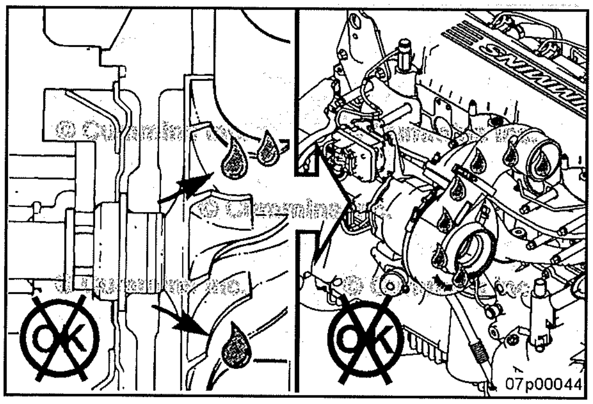
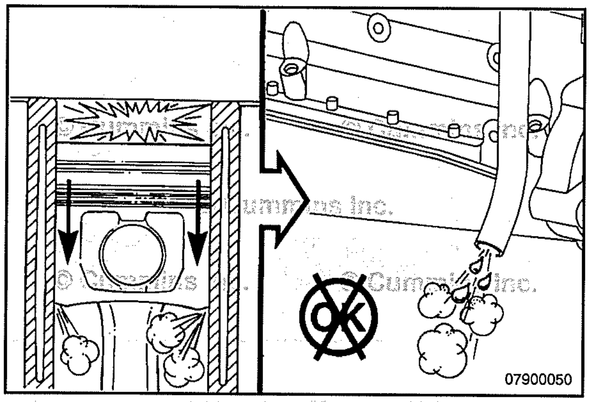


Worn or damaged seals in the turbocharger can allow oil to leak into the charge-air cooler system and be burned in the engine. Refer to Procedure 010-033 in Section 10.

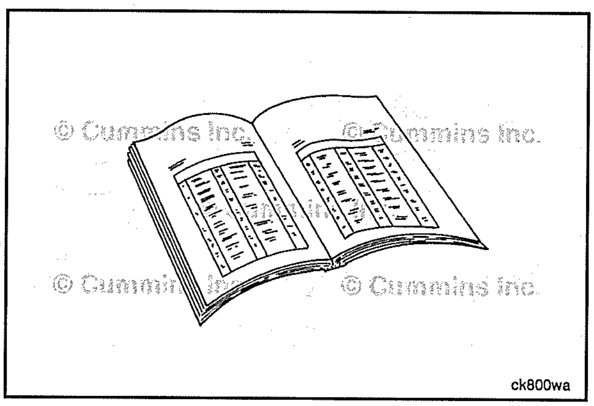
The condition can be verified by removing the charge air cooler tubing and looking for oil. Refer to Procedure 010-027 in Section 10 for oil leaks internal to the turbocharger.

If there is oil found in the turbocharger the aftertreatment **must** be removed to inspect for oil. Refer to Procedure 011-049 in Section 11.

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



Inadequate sealing of the piston rings will result in excessive oil out of the crankcase breather system and/or being consumed by the engine. Refer to Procedure 014-010 in Section 14.



Lubricating Oil Fill Tube (007-065)

Preparatory Steps

WARNING

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

WARNING

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

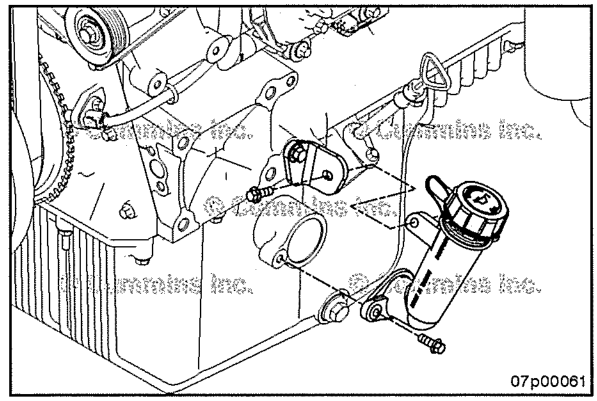
- Drain the lubricating oil. Refer to Procedure 007-037 in Section 7.

Remove

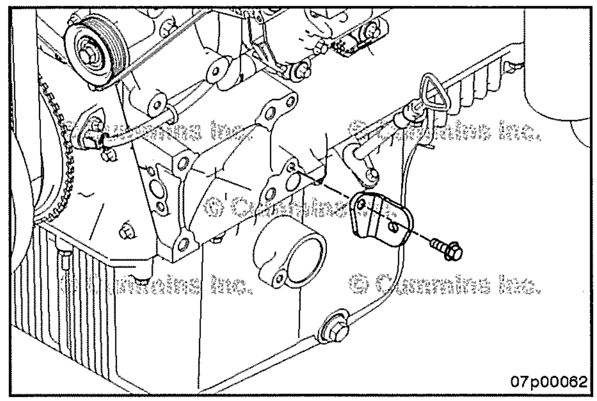
Remove the tube brace capscrew from the oil fill tube.

Remove the tube capscrew from the oil pan.

Remove the oil fill tube.



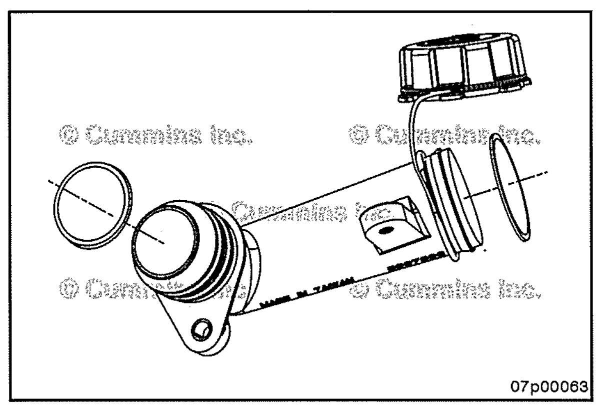
Remove the tube brace and capscrew from the block.



Remove the ring seals from the oil fill tube and the oil fill tube cap.

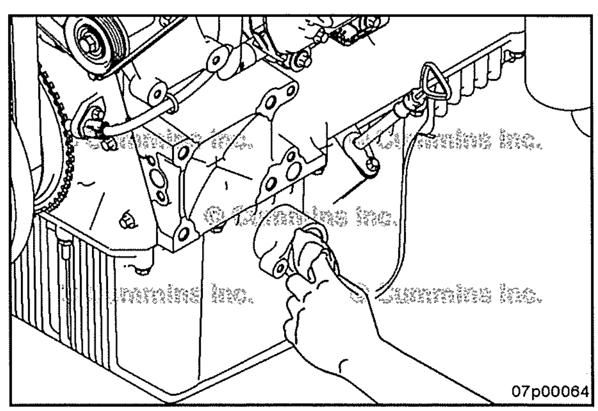
Discard the ring seals.

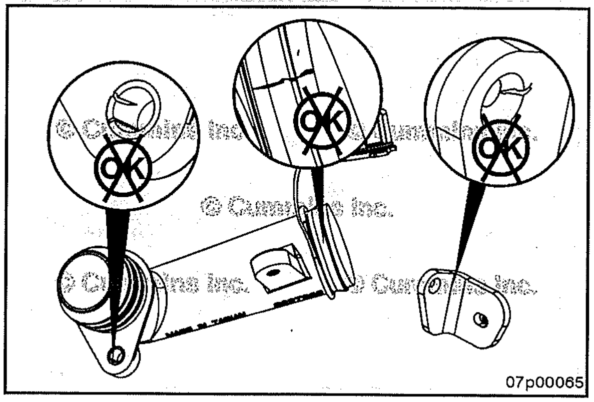
- Oil fill tube o-ring
- Oil fill cap seal



Clean and Inspect for Reuse

Clean the oil pan seal surface.

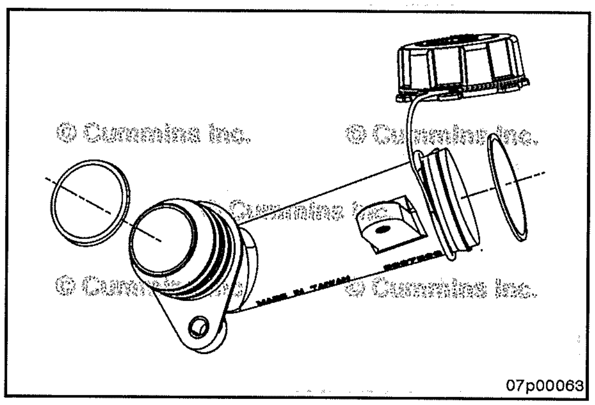




Inspect the oil fill tube and fill tube threads for cracks or other damage.

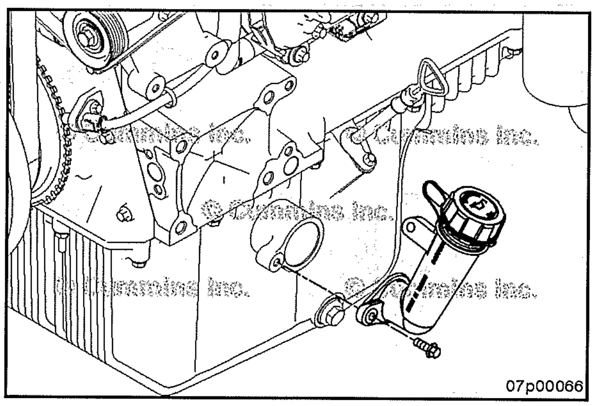
Inspect the oil fill tube sealing surfaces for cracks or other damage.

Inspect the tube brace for cracks or other damage.



Install

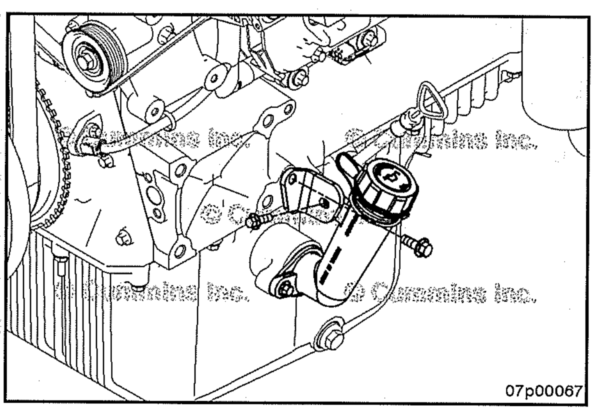
Install the new o-ring on the bottom of the oil fill tube and a new ring seal on the oil fill tube cap.



Install the oil fill tube.

Tighten the capscrew.

Torque Value: 23 N•m [17 ft-lb]



Install the tube brace.

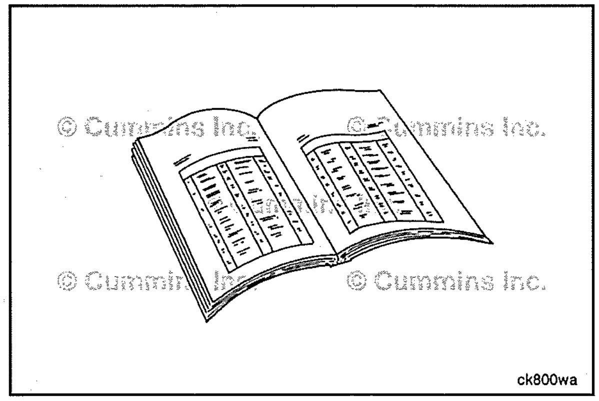
Torque Value:
Tube Brace Capscrew into block 46 N•m [407 in-lb]

Torque Value:
Tube Brace Capscrew into Tube 23 N•m [203 in-lb]

Finishing Steps

NOTE: To prevent oil spills, the engine **must** be on level when filling the lubricating oil.

- Fill the engine with lubricating oil. Refer to Procedure 007-037 in Section 7.

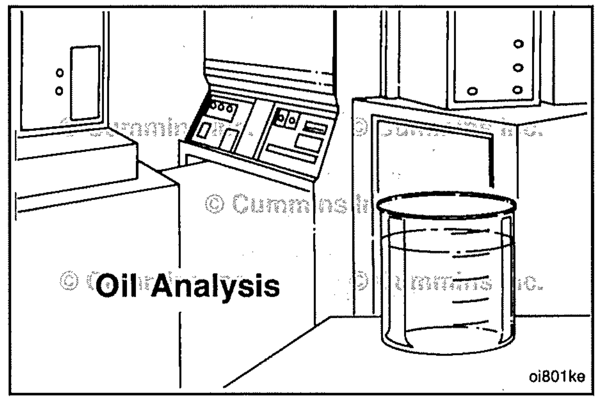


Lubricating Oil and Filter Analysis (007-083)

Inspect

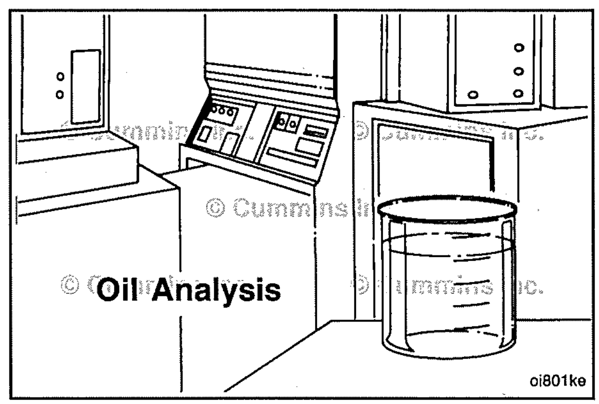
An analysis of used oil can help diagnose internal engine damage and determine if it was caused by one of the following:

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



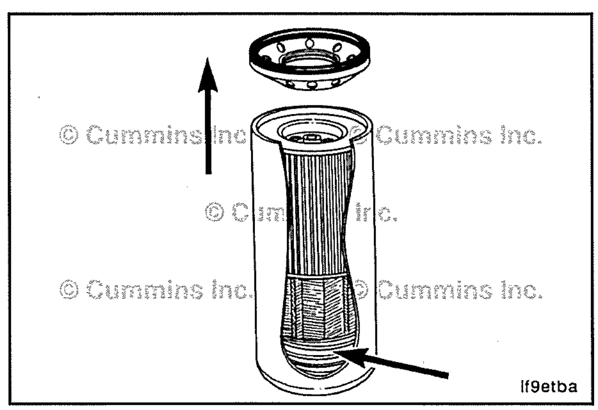
For additional oil analysis information, refer to Cummins® Engine Oil and Oil Analysis Recommendations, Bulletin 3810340.

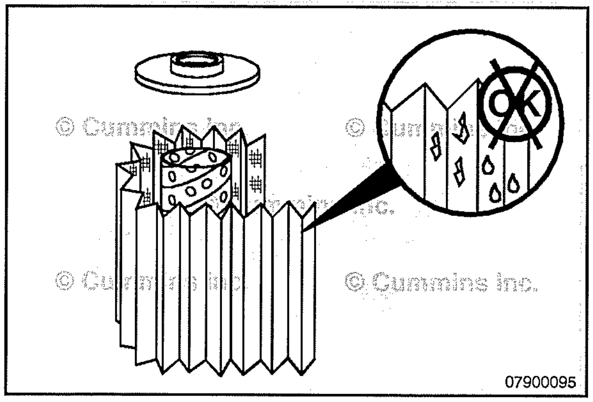
NOTE: Do **not** disassemble an engine for repair based solely on the results of an oil analysis. Inspect the oil filters. If an oil filter shows evidence of internal engine damage, find the source of the problem and repair the damage. Reference the appropriate procedure(s) based on the following oil filter inspection.



⚠WARNING⚠

Restrain the full flow lubricating oil filter and use care when cutting open the upper section of the combination filter. The filter element spring is under compression and can cause personal injury.





Use tube cutter, Part Number 3376579, to open the upper section of the bypass full-flow oil filter.

Inspect the filter element for evidence of moisture or metal particles.

Metal	Possible Source
Copper	Bearings and bushings
Chromium	Piston rings
Iron	Cylinder liners
Lead	Bearing overlay material
Aluminum	Piston wear or scuffing

Lubricating Oil Filter Differential Pressure Measurement Test (007-095)

General Information

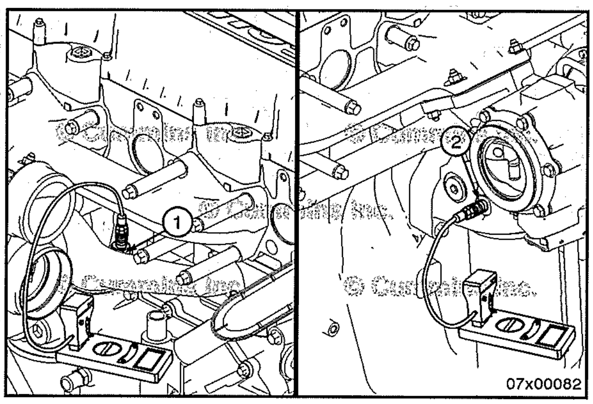
WARNING

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

Use this procedure for engines with plugged oil filters. The technician **must** follow the appropriate troubleshooting trees for the symptoms that exist.

A plugged oil filter can be detected by taking the proper oil pressure measurements. The oil pressure of an engine with a plugged filter will be high before the filter and low after the filter. A large pressure drop, greater than 172 kPa [25 psi] across the oil filter, will distinguish this issue from other issues that cause Fault Code 143.

See Lubricating Oil Filter Plugged symptom tree to determine the cause of filter plugging, if filter plugging is occurring at a high frequency.



Pressure Differential Test

Remove the oil plugs from the lubricating oil cooler housing at the filter inlet (1) and outlet (2) pressure ports and install manual gauges.

The following parts, or equivalent, are available for use:

Part Number	Quantity	Description
3164489	2	Digital Multimeter
3376920	2	Female Compucheck
3164491	2	Pressure Adapter
3824844	1	M14 compucheck fitting
5298824	1	M27 compucheck fitting Assembly

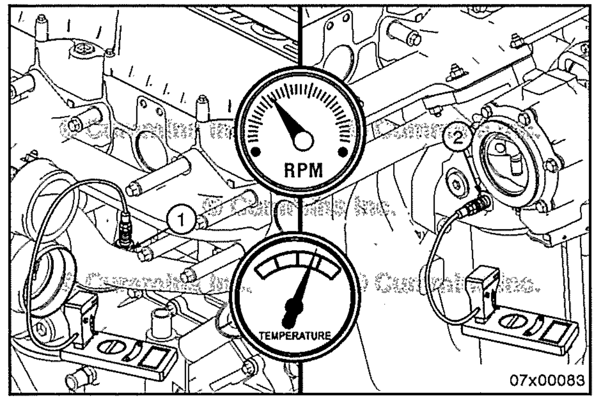
NOTE: The digital multimeter and pressure adapter are both included in the multimeter test kit - Part Number 3400162. Do **not** purchase items independently.

Start and operate the engine until the oil temperature reaches or exceeds 70°C [158°F].

Engine Information	
Oil Filter Type	
Kilometers [Miles] on Filter	
Oil Type	

Operate the engine at each rpm specified. Record the corresponding pressure values:

Oil Temperature	
Start of Test	
End of Test	



	Engine RPM	Oil Pressure Filter Inlet	Oil Pressure Filter Outlet	Inlet - Outlet = Differential Pressure	INSITE™ Electronic Service Tool
Low Idle					
High Idle					

A pressure drop greater than 172 kPa [25 psi], at operating temperature, using 10W-30 oil, indicates the filter is plugged.

Identify the causes of a plugged filter. Verify that the Cummins Inc. maintenance guidelines are being met.

Use the following procedure to identify possible fluid contamination. Refer to Procedure 007-083 in Section 7.

Change both the lubricating oil and lubricating oil filter, if plugged.

Refer to the Cummins® Engine Oil and Oil Analysis Recommendations, Bulletin 3810340 for additional information about lubricating oil filter plugging.

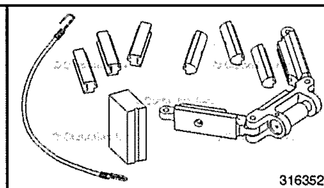
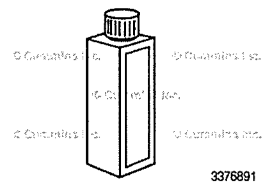
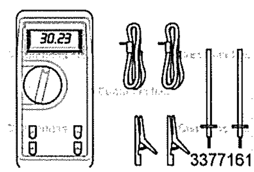
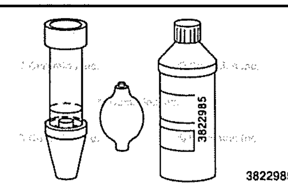
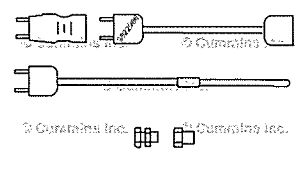
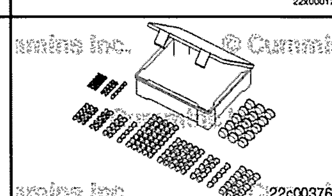
Section 8 - Cooling System - Group 08

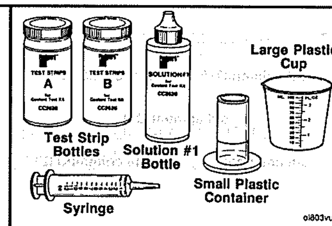
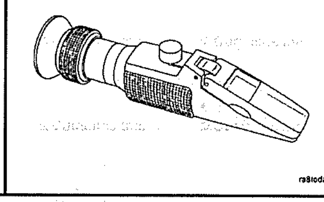
Section Contents

Service Tools

Cooling System

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3163524	**Pulley Alignment Tool** Used to align pulleys.	
3377438	**Fluorescent Tracer** Used with black light, Part Number 2892320, to find coolant leaks.	
3400162	**Digital Multimeter Kit** Includes deluxe multimeter 3164489, pressure adapter 3164491, and immersion probe 3164492.	
3822985	**Combustion Gas Leak Test Kit** Used to detect combustion gas leaks. The kit includes test fluid, Part Number 3822986, adapter, Part Number 3822987, and instructions, Part Number 3877612.	
3822988	**Thermocouple Extension Wire Kit** The kit includes adapter, Part Number 3822989, thermocouple, Part Number 3822990, thermocouple wire assembly, Part Number 3822991, and bushing (1/8 NPT), Part Number 3822992.	
4919073	**Fuel System Clean Care Kit** Used to cap or plug fittings during service to prevent debris from entering the coolant system.	

Tool No.	Tool Description	Tool Illustration
CC-2602	**Cooling System Test Kit - Fleetguard®** Used to measure supplemental coolant additive (SCA) concentration.	
CC-2800	**Refractometer** Used to measure glycol (antifreeze) concentration.	

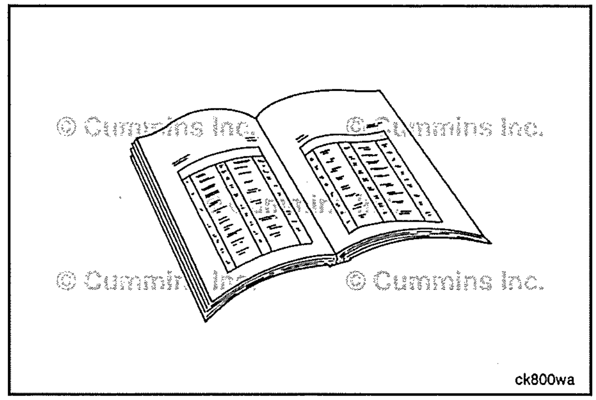
Drive Belt, Cooling Fan (008-002)

Preparatory Steps

WARNING

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

- Disconnect the batteries. See equipment manufacturer service information.



ck800wa

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

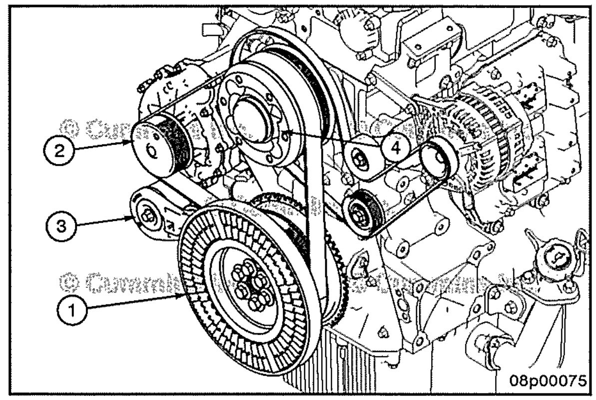
The cooling fan belt routing consists of the following components.

1 Crankshaft pulley/vibration damper

2 Water pump pulley

3 Tensioner(s)

4 Fan pulley.



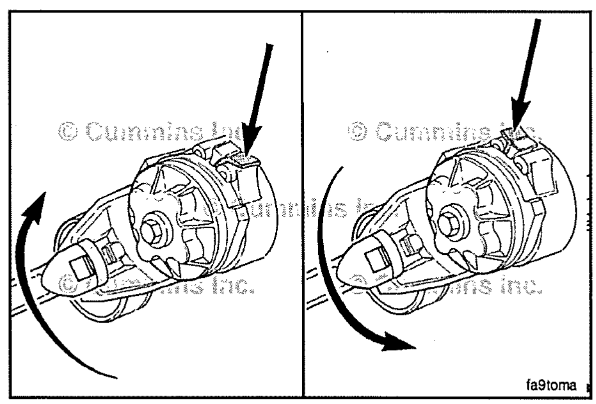
08p00075

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 or cause personal injury.

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



fa9toma

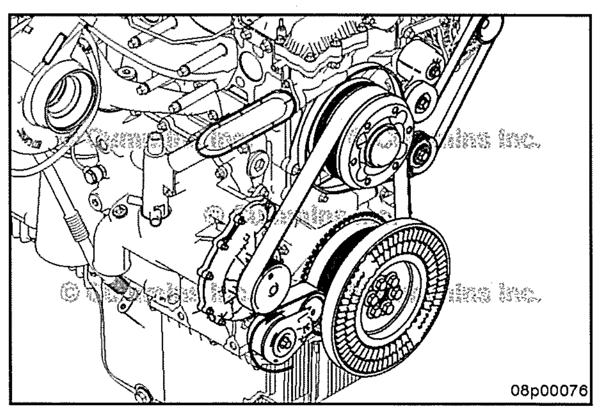
CAUTION

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.

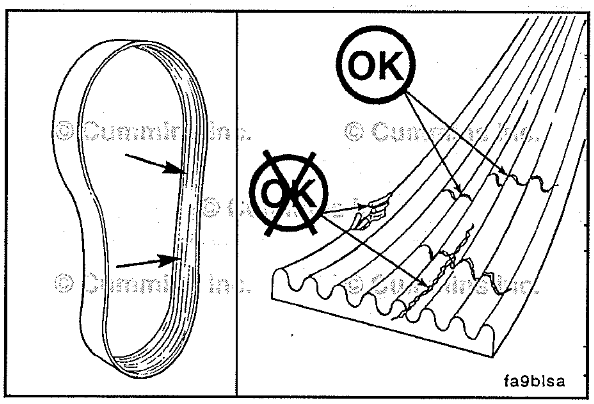
Make a diagram of the belt arrangement prior to removing the drive belt to aid in installation and provide proper routing of the cooling fan drive belt.

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

Remove the drive belt.



08p00076



fa9blsa

Clean and Inspect for Reuse

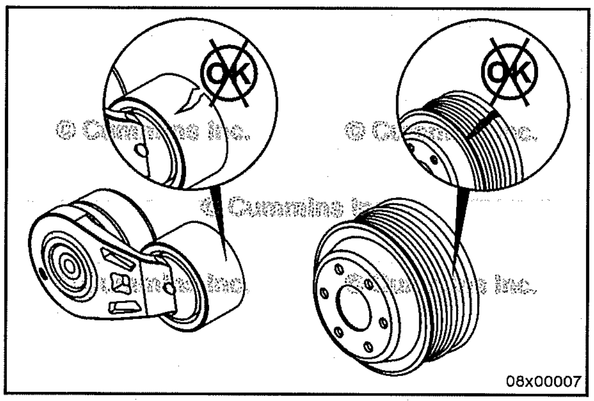
Check the belt for damage. Transverse (across the belt width) cracks are acceptable. Longitudinal (direction of the belt length) cracks that intersect with transverse cracks are **not** acceptable. If the belt is frayed or has any piece of material missing, the belt is unacceptable and needs to be replaced.

Inspect the belt for:

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

Replace the belt if any damage is found.

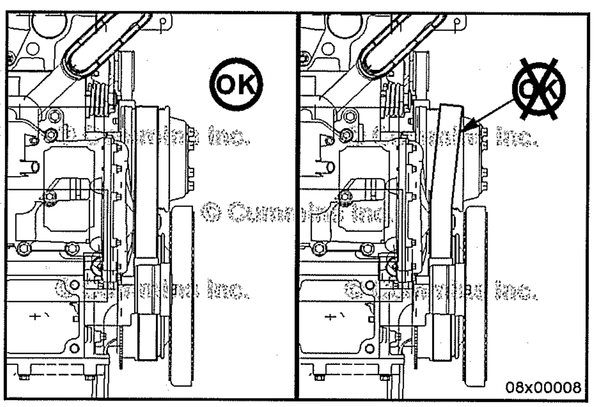
NOTE: If a damaged belt has spun on a pulley, inspect the pulley and assembly for damage. Refer to Procedure 008-089 in Section 8.



08x00007

Inspect the pulleys for wear or cracks.

Inspect the belt tensioner. Refer to Procedure 008-087 in Section 8.



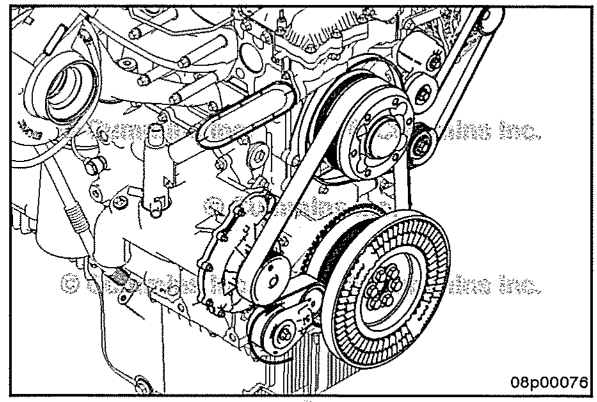
08x00008

Inspect the pulley alignment.

Pulley misalignment **must not** exceed 6 mm for each meter [1/16 inch for each 12 inches] of distance between the pulley centers.

The pulley alignment fixture, service tool Part Number 3163524, should be used to check alignment.

Install


08p00076

⚠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 or cause personal injury.

⚠CAUTION⚠

To reduce the possibility of damage to the pulley and new belt, do not roll the belt over the pulley or pry it on with a tool.

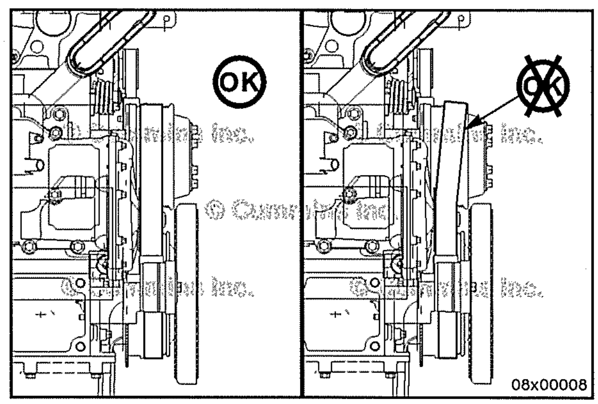
Use the belt diagram created in the remove section to route the drive belt on the engine.

Install a new fan belt on the pulleys.

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

Release the tensioner to apply tension to the drive belt.

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



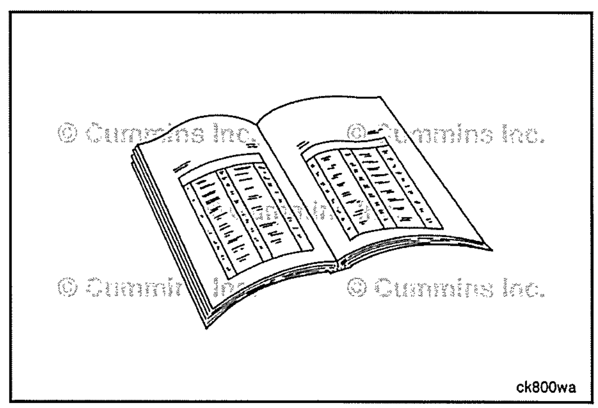
08x00008

Inspect the pulley alignment.

Pulley misalignment **must not** exceed 6 mm for each meter [1/16 inch for each 12 inches] of distance between the pulley centers.

The pulley alignment fixture, service tool Part Number 3163524, should be used to check alignment.

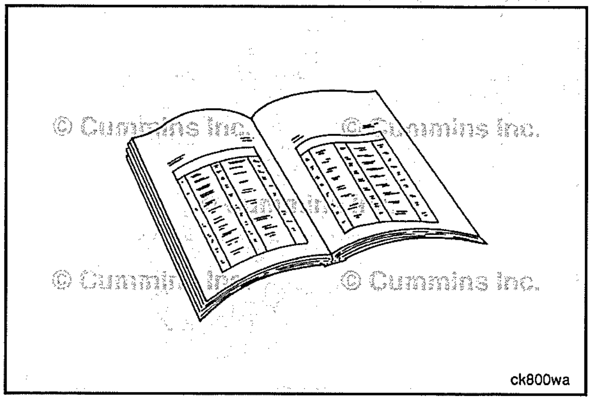
Finishing Steps


ck800wa

⚠WARNING⚠

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

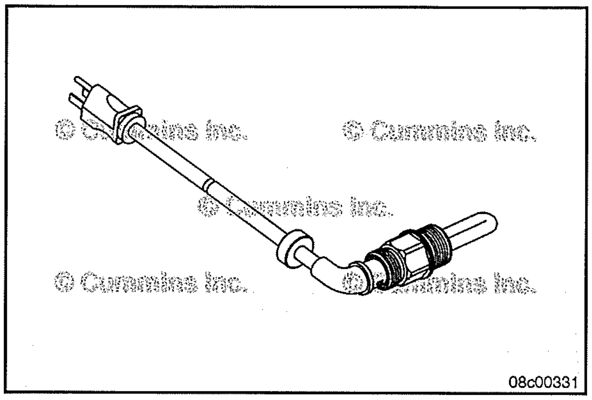
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for belt squeal. Excessive belt squeal indicates belt slippage.
- If belt squeal is present, check the routing of the belt and make sure that the belt is installed correctly on each pulley.



Coolant Bypass Tube (008-005)

General Information

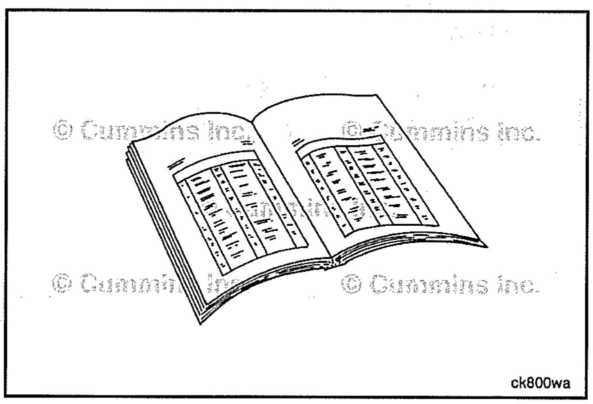
The coolant bypass tube on this engine **must** be serviced as an assembly with the thermostat housing. Refer to Procedure 008-014 in Section 8.



Coolant Heater (008-011)

General Information

Some heaters will operate continuously when plugged into the correct voltage electrical socket. Operate the heater **only** when the ambient temperature is below 0°C [32°F].



Preparatory Steps

WARNING

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

WARNING

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

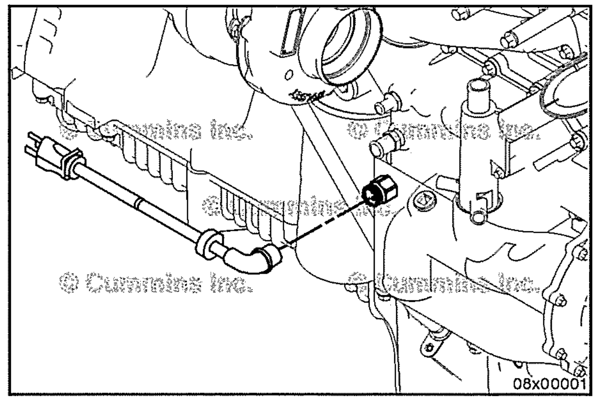
- Disconnect the batteries. See equipment manufacturer service information.
- Drain the cooling system. Refer to Procedure 008-018 in Section 8.

Remove

Some engines may **not** be equipped with a threaded coolant heater. Check if the engine is equipped with a coolant heater located adjacent to the lubricating oil cooler.

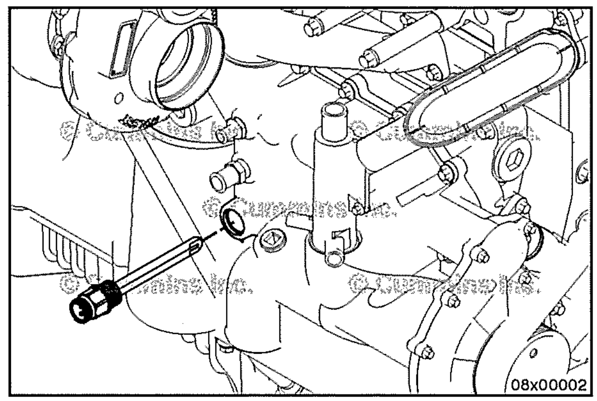
If engine is **not** equipped, a plug, Part Number 3678611, should be used in the coolant heater port.

Disconnect the coolant heater electrical cord.



08x00001

Unscrew and remove the coolant heater from the cooling module.



08x00002

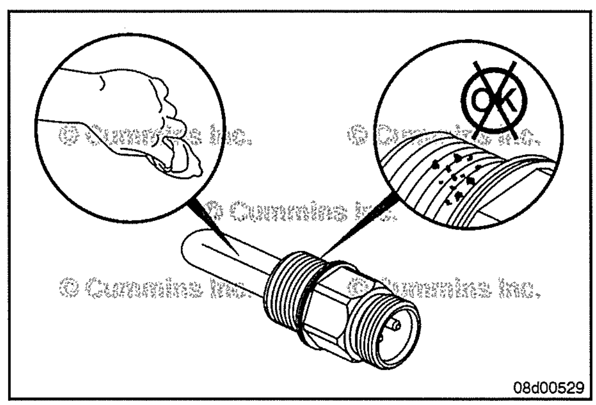
Clean and Inspect for Reuse

Clean the coolant heater port thoroughly with a clean rag.

Make sure there are no burrs, metal shavings, or sharp edges that can possibly cut the o-ring.

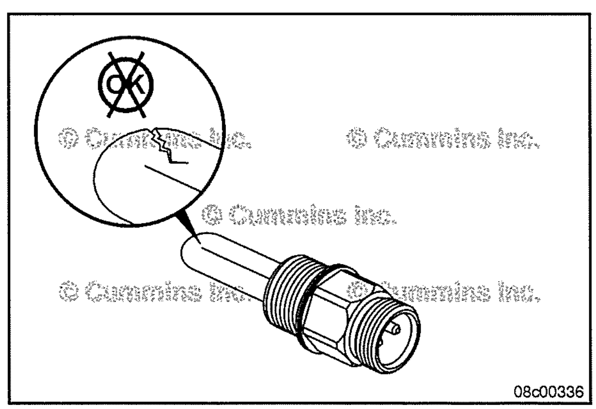
Check the o-ring for and cuts or damage. Replace o-ring if damaged.

Clean the coolant heater thoroughly with a clean rag. Make sure the heating element is free of debris and buildup and the sealing area is clean.

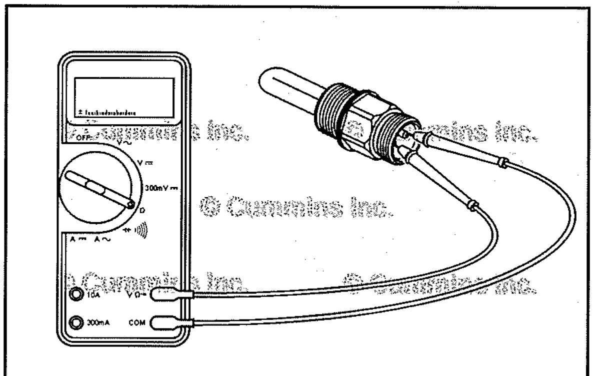


08d00529

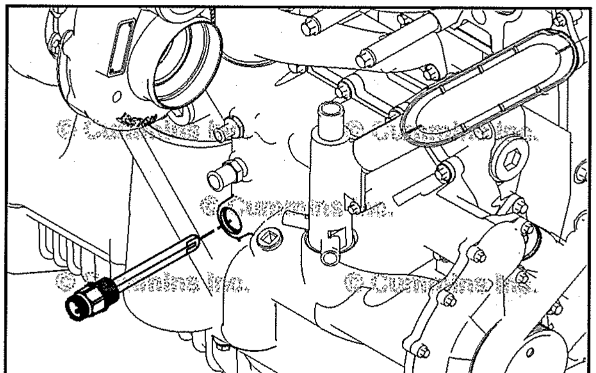
Check the coolant heater for cracks on the element.



08c00336


08c00337

Test the coolant heater resistance. The resistance **must** read between 36 and 42 ohms.

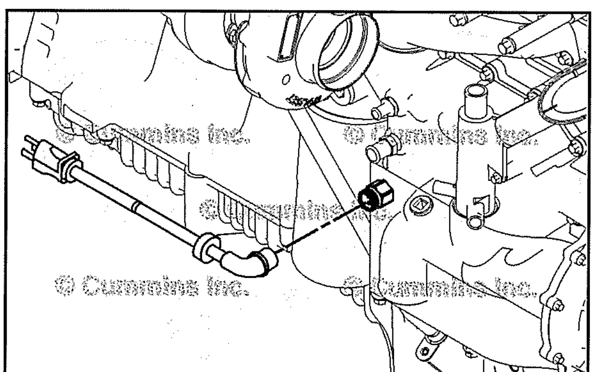

08x00002

Install

Install the coolant heater into the cooling module and tighten.

If no coolant heater is to be installed, use a plug, Part Number 3678611, in the coolant heater port.

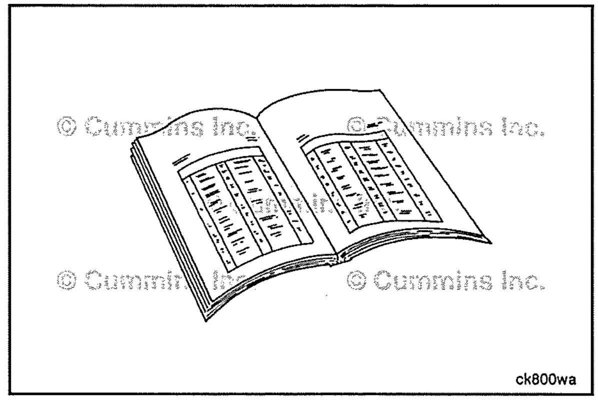
Torque Value: 68 N•m [50 ft-lb]


08x00001

Insert the power cord into the socket. Be careful to align the pins with the sockets of the power cord. Tighten the retaining nut by hand.

NOTE: Do **not** apply power to the element until the cooling system is filled, and the engine has run long enough for the thermostat to open and allow the air to escape.

Finishing Steps



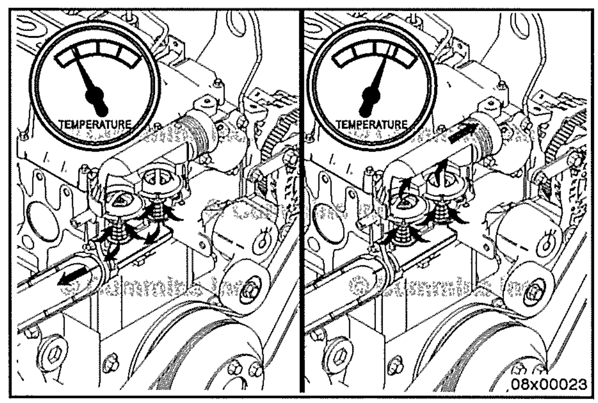
WARNING
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

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

- Fill the engine cooling system. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine to check for leaks.
- Apply power to the heating element to check for proper operation.

Coolant Thermostat (008-013)

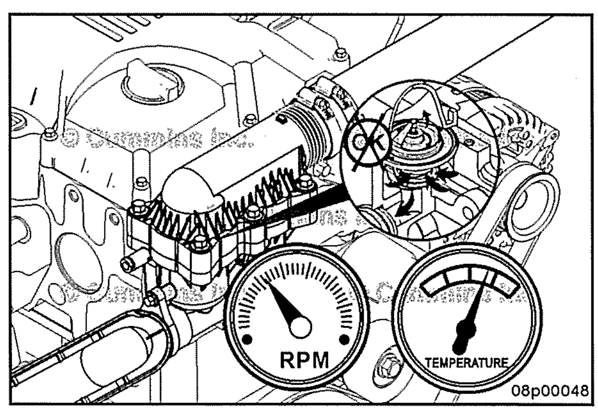
General Information



The thermostats control the engine coolant temperature. When the coolant temperature is below the operating range, engine coolant is bypassed back to the inlet of the water pump. When the engine coolant temperature reaches the operating range, the thermostat opens, sealing off the bypass, forcing engine coolant to flow to the radiator or heat exchanger.

This engine is equipped with two modulating thermostats. The dual thermostat design increases the coolant flow area. This increased flow area reduces the pressure necessary to circulate coolant.

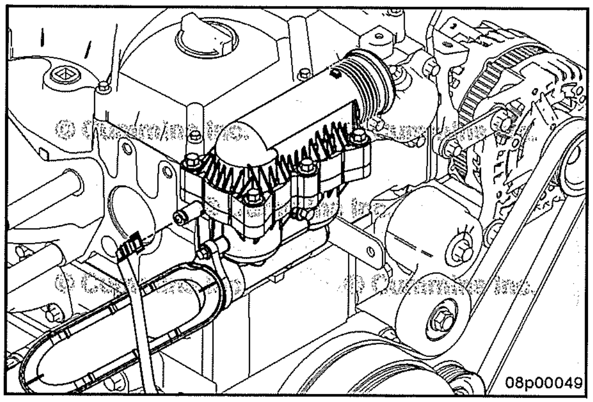
An incorrect or malfunctioning thermostat can cause the engine to run too hot or too cold.



CAUTION
Always use correct thermostats or the engine may overheat or run too cold. Never operate engine without thermostats installed or the engine may overheat.

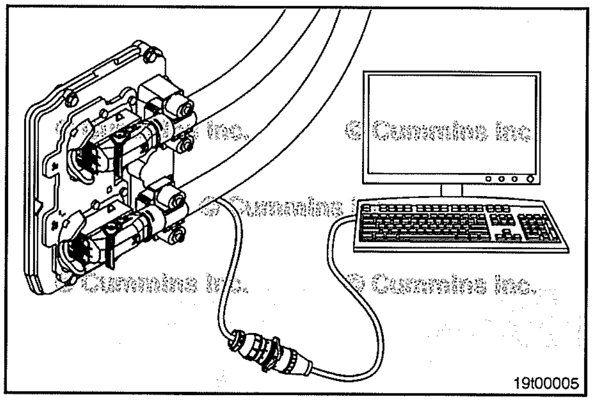
This engine is equipped with two thermostats. The low range thermostat opens from 82 to 95°C [180 to 203°F] The high range thermostat opens from 88 to 97°C [190 to 207°F].

Always run this engine with both of the correct thermostats.



Be sure air is vented during the fill process. A deaeration port is located next to the water outlet connection, which connects to the top tank/coolant recovery tank of the cooling system.

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



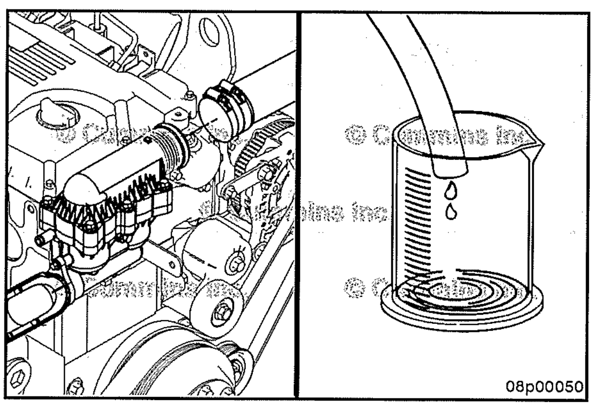
Leak Test

If the thermostat is suspected to be leaking, the following steps can be performed to check for leakage.

The following check **must** be performed with the thermostat closed for 1 minute of engine operation.

Use an INSITE™ electronic service tool to monitor the coolant temperature. The coolant temperature should be less than 38°C [100°F] to ensure the thermostat does **not** open during the test.

Refer to Procedure Procedure 022-999 in Section F for more instructions on connecting with INSITE™.



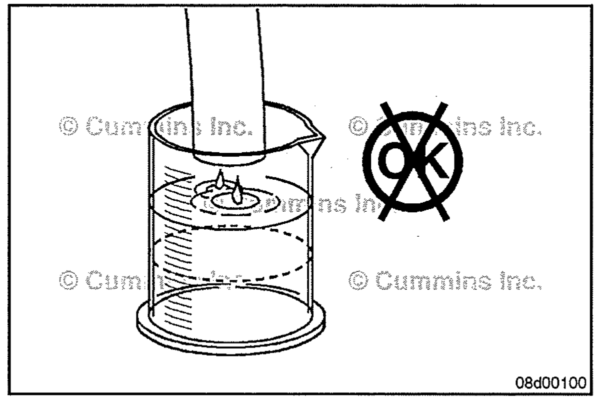
Disconnect the radiator top hose from the water outlet connection.

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

Install and tighten a hose clamp on the outlet connection.

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

The coolant temperature should be monitored during this test to determine if the coolant temperature reaches the nominal opening temperature of the thermostats. See the Measurement step of this procedure for nominal opening temperature.) If a thermostat opens during this test, the test is invalid and **must** be repeated.



08d00100

Operate the engine at rated rpm for 1 minute.

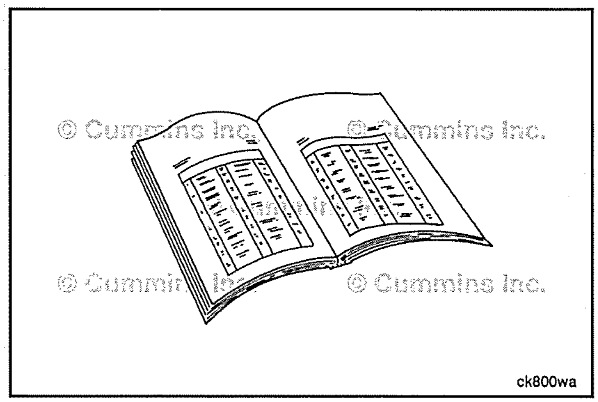
Stop the engine and measure the amount of coolant collected in the container.

The amount of coolant **must not** be more than 100 cc [3.4 fl oz].

If more than 100 cc [3.4 fl oz] of coolant is collected, one or both of the thermostats is leaking. Measure each thermostats opening temperature to diagnose the leaking thermostat. This thermostat **must** be replaced.

Procedures for measuring the thermostat opening temperature are included in the "Measure" step of this document.

Preparatory Steps



ck800wa

⚠WARNING⚠

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

⚠WARNING⚠

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

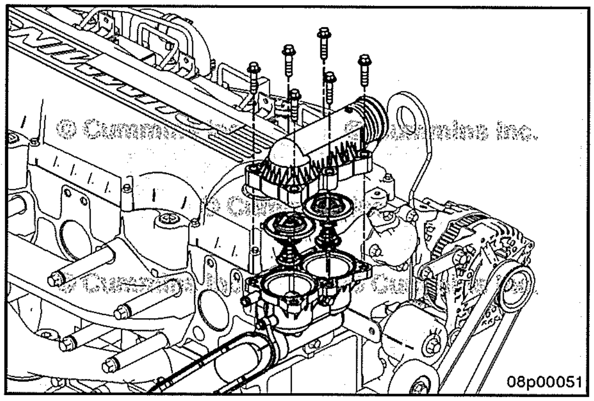
⚠WARNING⚠

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

⚠CAUTION⚠

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.

- Disconnect the batteries. See equipment manufacturer service information..
- Drain the coolant below the level of the thermostat. Refer to Procedure 008-018 in Section 8.
- Disconnect the upper radiator hose from the water outlet connection. See equipment manufacturer service information.

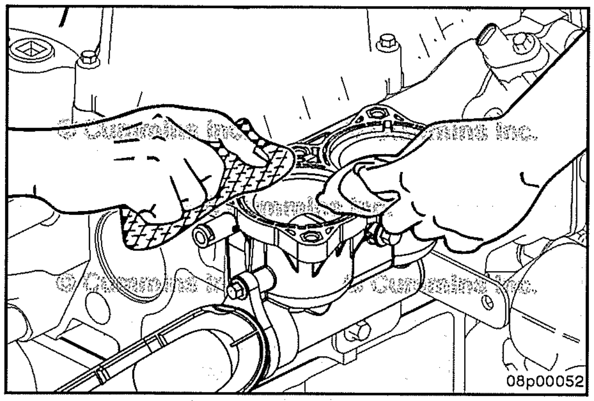


Remove

Remove the water outlet connection capscrews.

Remove the water outlet connection.

Remove the thermostats.

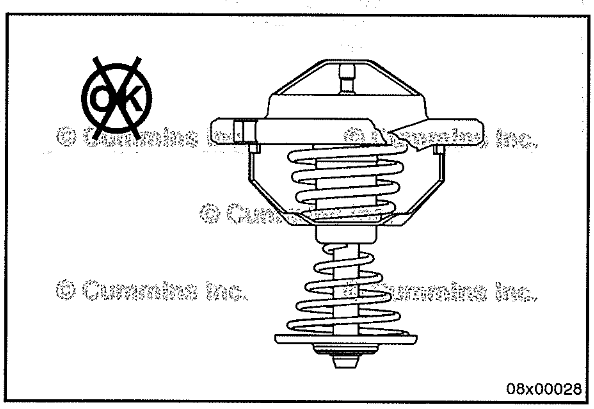


Clean and Inspect for Reuse

CAUTION

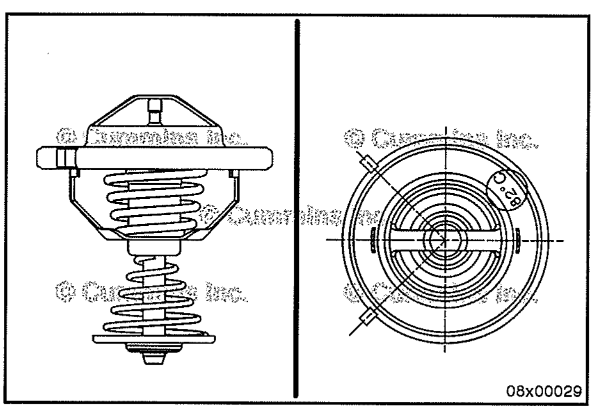
Do not let any debris fall into the thermostat cavity when cleaning the gasket surfaces. Damage to the cooling system and engine can occur.

Clean the mating surfaces with a clean cloth. Do **not** use an abrasive pad on the plastic surface of the thermostat housing.



Inspect each thermostat for external damage. Inspect for cracks, embedded debris, damaged seat, and other damage.

Replace the thermostat if any damage is found.



Measure

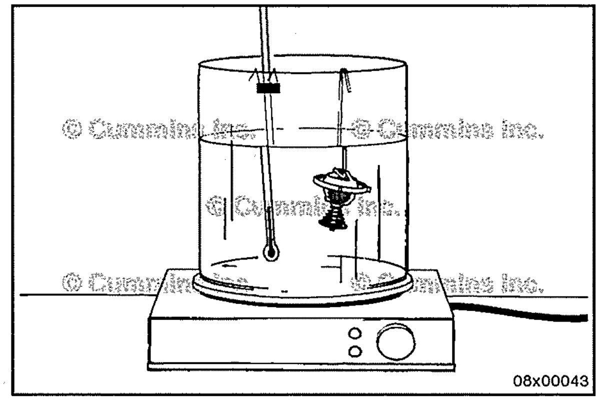
If a thermostat is suspected to be malfunctioning, the opening temperature of each thermostat should be measured to determine if each thermostat is functioning correctly.

Identify each thermostat in order to measure the appropriate opening and closing values.

The thermostat temperature is stamped onto the top of the thermostat. 82°C [180°F] signifies the low range thermostat and 88°C [190°F] is the high range thermostat.

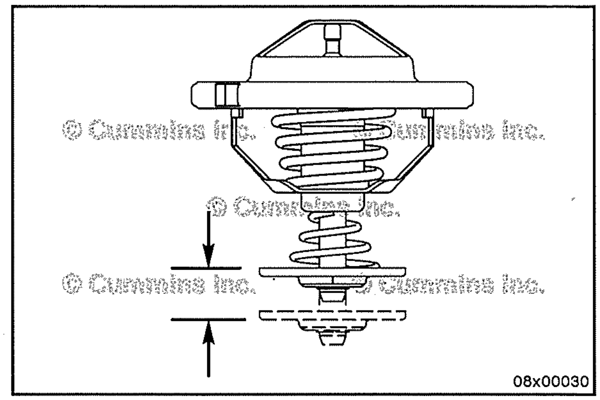
NOTE: Do **not** allow the thermostat or thermometer to touch the container.

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



Heat the water and check the thermostat as follows:

NOTE: The nominal operating temperature is stamped on the thermostat. To verify the correct temperature range thermostat is installed, make sure to see the appropriate Part Information resources.



The Low Range Thermostat **must** meet the following criteria:

82°C [180°F] Nominal Temperature Thermostat

Thermostat Opening Temperature			
	°C		**°F**
Initial Opening	82	MIN	180
Fully Opened	95	MAX	203

The High Range Thermostat **must** meet the following criteria:

88°C [190°F] Nominal Temperature Thermostat

Thermostat Opening Temperature			
	°C		**°F**
Initial Opening	88	MIN	190
Fully Opened	97	MAX	207

Install

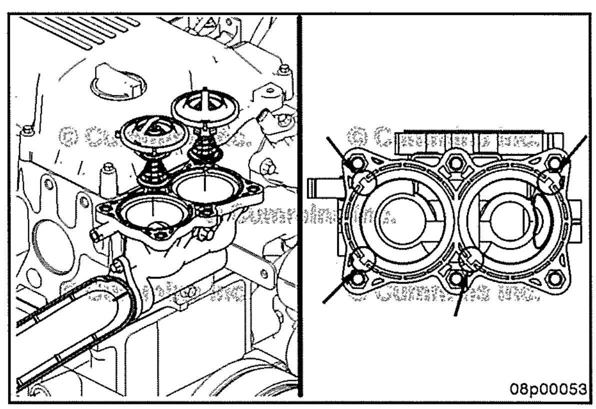
CAUTION

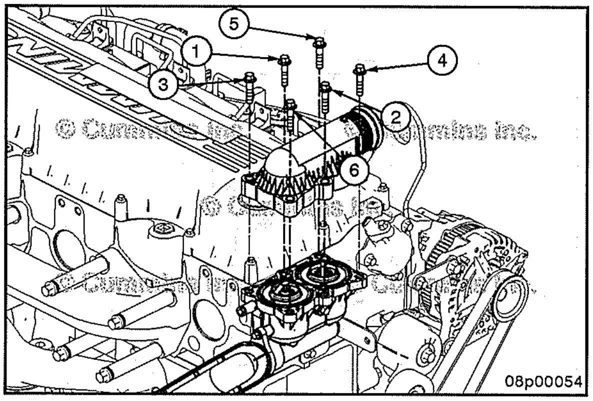
Always use correct thermostats or the engine may overheat or run too cold. Never operate engine without thermostats installed or the engine may overheat.

NOTE: If the previously installed thermostats are being used, install new thermostat seals.

Install the thermostats into the thermostat housing.

Use unique locators on each thermostat to determine the correct location.

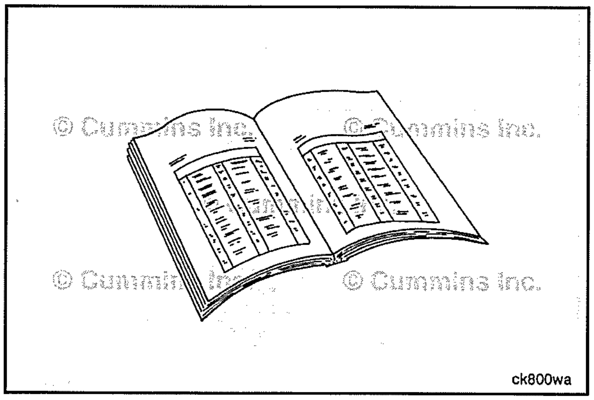




Install the water outlet connection and mounting capscrews.

Tighten the capscrews in the sequence shown.

Torque Value: 18 N•m [159 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.

CAUTION

Always vent the engine during filling to remove air from the coolant system, or overheating can result.

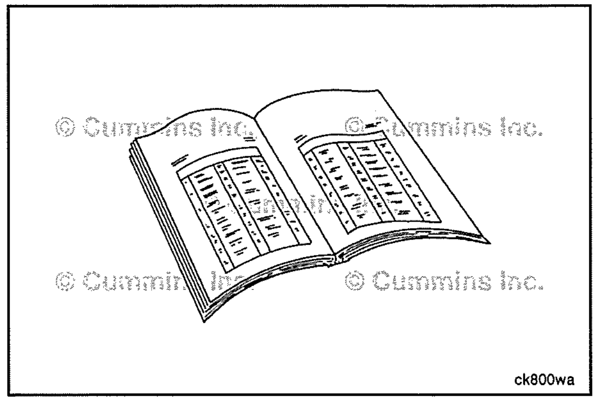
- Connect the upper radiator hose to the water outlet connection. See equipment manufacturer service information.
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

Coolant Thermostat Housing (008-014)

General Information

The thermostat housing is secured to the front of the cylinder head. It has provisions for the coolant bypass tube, coolant outlet, and coolant temperature sensor. The coolant outlet is secured to the top of the thermostat housing, clamping the thermostat in place.

Preparatory Steps



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

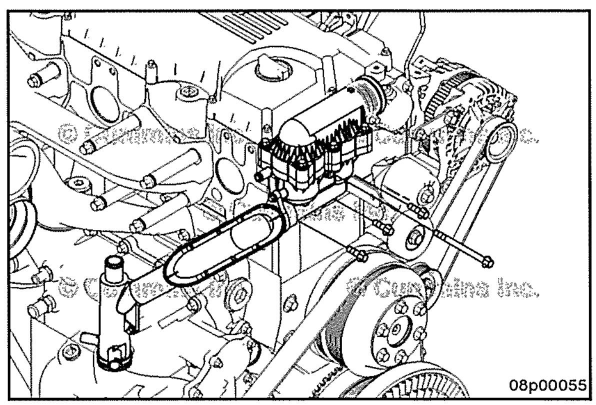
⚠WARNING⚠
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

⚠WARNING⚠
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.

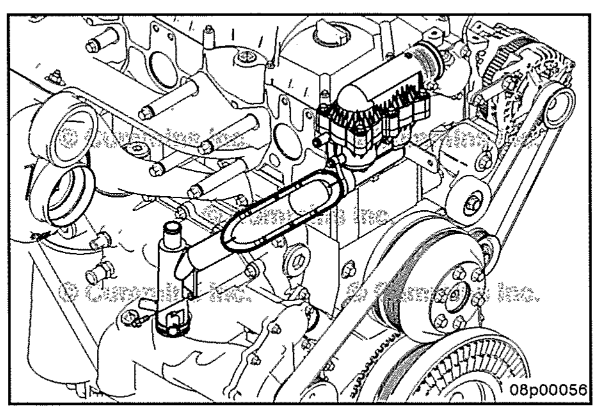
- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Drain the coolant system. Refer to Procedure 008-018 in Section 8.
- Remove the coolant hoses from the thermostat housing, coolant outlet connection, and coolant bypass tube.
- Remove the coolant temperature sensor electrical connections. Refer to Procedure 019-019 in Section 19.

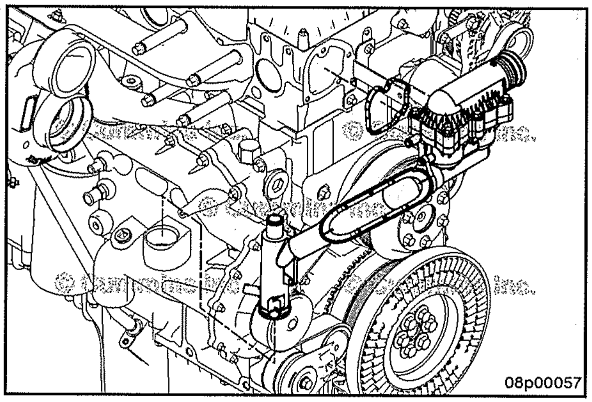
Remove

Remove the capscrews securing the thermostat housing to the cylinder head.

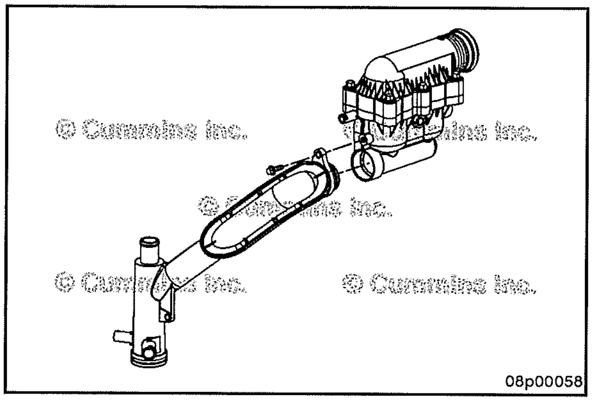


Remove the capscrew securing the coolant bypass tube to the lube oil cooler.





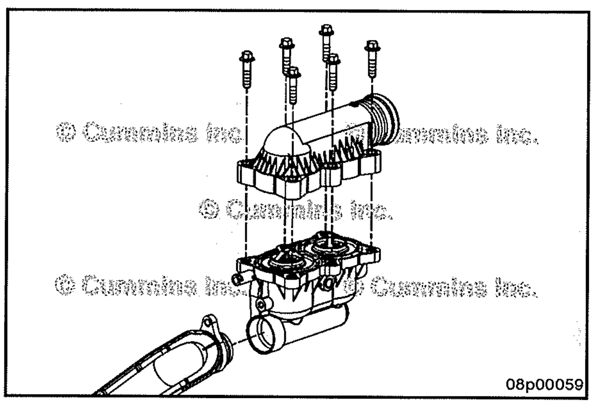
Lift and remove thermostat housing, coolant bypass tube, and coolant outlet connection assembly off of lube oil cooler.



Disassemble

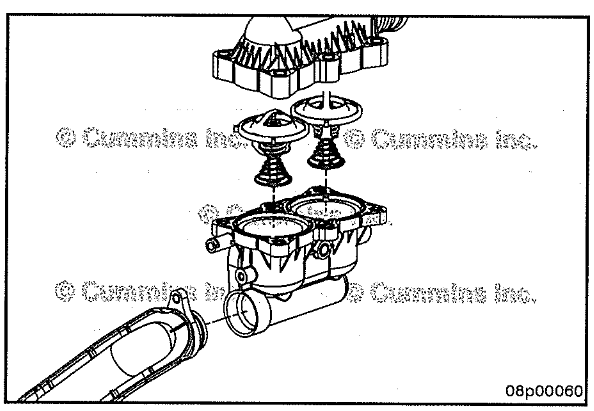
Remove the capscrew securing the coolant bypass tube to the thermostat housing.

Slide thermostat off of coolant bypass tube.



Remove the capscrews securing the coolant outlet connection to the thermostat housing.

NOTE: Coolant outlet connection can be installed in two different orientations. Make note of orientation during removal.



Remove thermostats from housing.

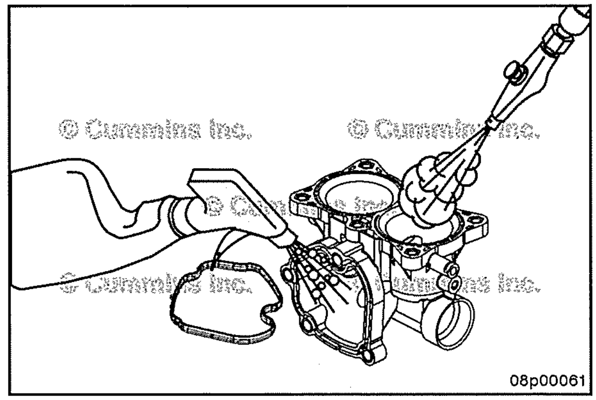
Clean and Inspect for Reuse

WARNING

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

Clean the parts with soap and water.

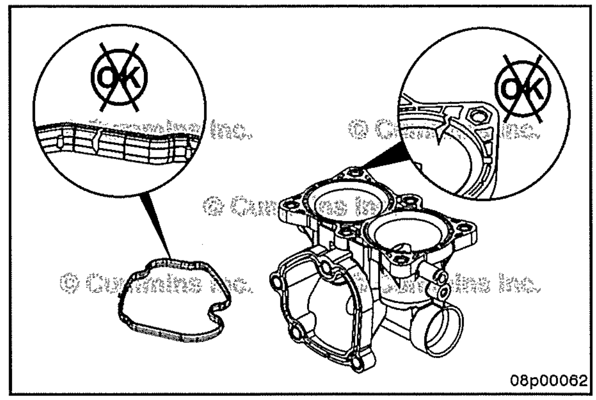
Dry with compressed air.



Inspect the components for cracks, nicks, or other damage.

Inspect the thermostat housing to cylinder head seal for cracks or signs of wear. If the seal is damaged or worn, the seal **must** be replaced.

Replace any damaged parts.



Install

Lubricate the o-ring seals with a water-silicon based lubricant.

Slide thermostat housing onto coolant bypass tube.

NOTE: Ensure o-ring remains in o-ring groove during installation.

Loosely install capscrew securing thermostat housing to coolant bypass tube.

Slide coolant bypass tube into lube oil cooler.

NOTE: Ensure o-ring remains in o-ring groove during installation.

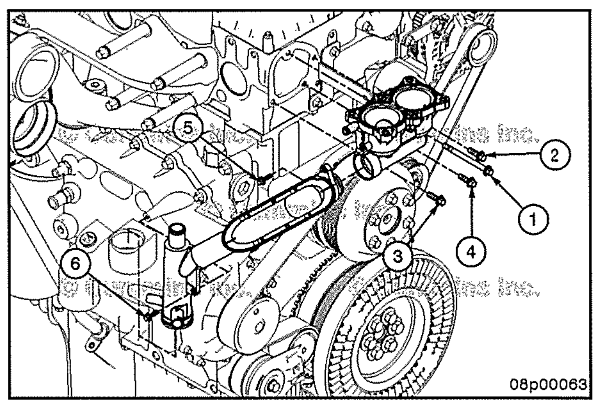
Install the thermostat housing to the cylinder head.

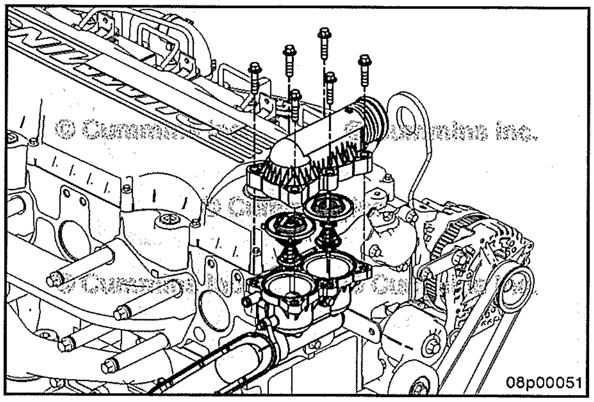
Tighten thermostat housing to cylinder head capscrews according to torque sequence.

Torque Value: 23 N•m [204 in-lb]

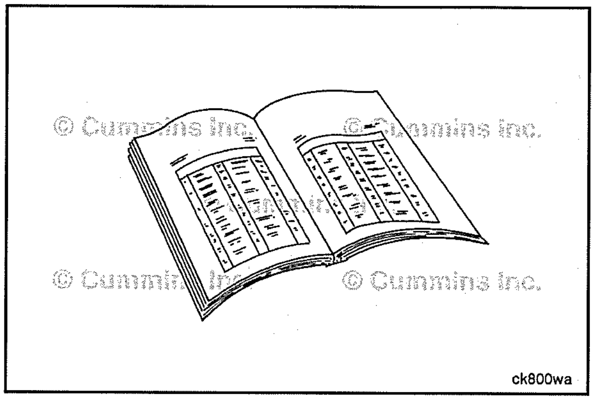
Tighten capscrews securing coolant bypass tube to thermostat housing and lube oil cooler.

Torque Value: 7.4 N•m [65 in-lb]





Install thermostats and coolant outlet connection. Refer to Procedure 008-013 in Section 8.

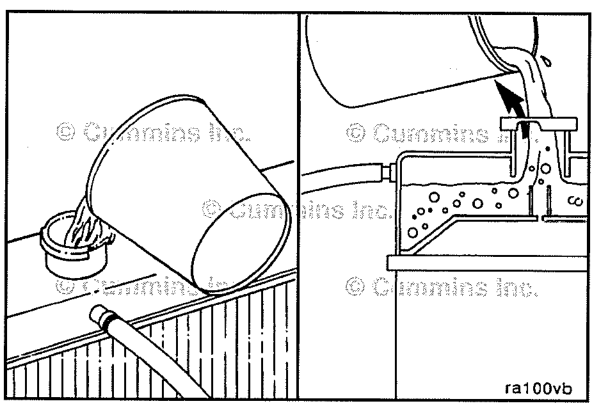


Finishing Steps

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 coolant temperature sensor electrical connections. Refer to Procedure 019-019 in Section 19.
- Install the coolant hoses on coolant outlet connection and coolant bypass tube.
- Fill the engine cooling system. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Operate the engine and check for leaks.

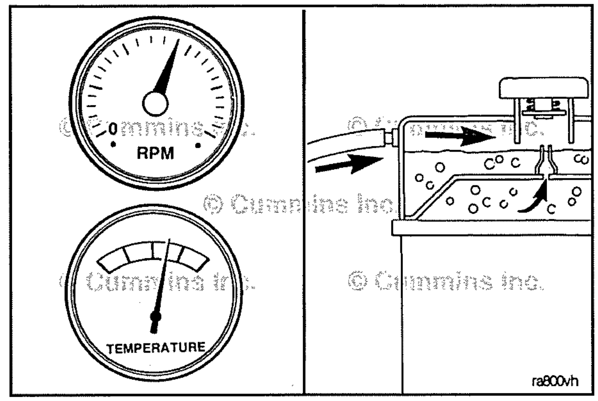


Coolant Vent Lines (008-017)

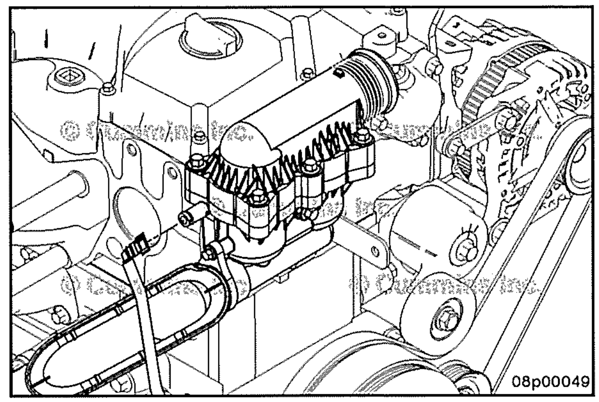
Initial Check

The cooling system **must** be designed to allow air to escape while filling the coolant system.

During engine operation, coolant will continuously flow through the engine vent line to remove air from the coolant.



The cooling system vent line is plumbed from a special connection located on the side of the thermostat housing. The line then goes to the radiator fill tank or auxiliary tank above the coolant level.



Cooling System (008-018)

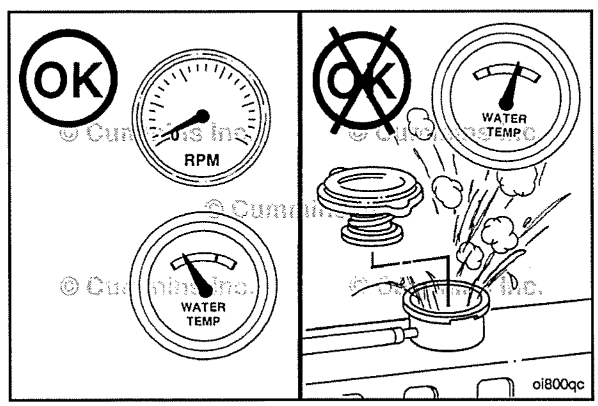
General Information

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.

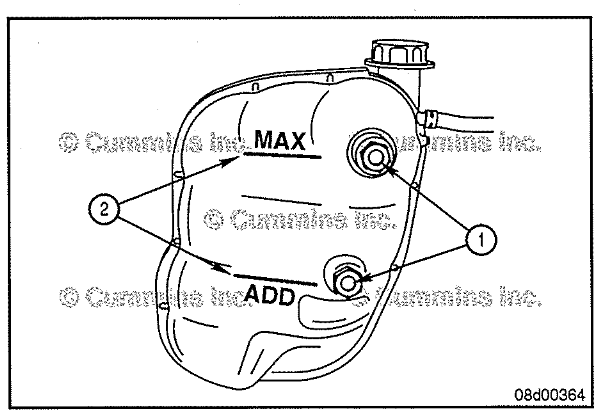


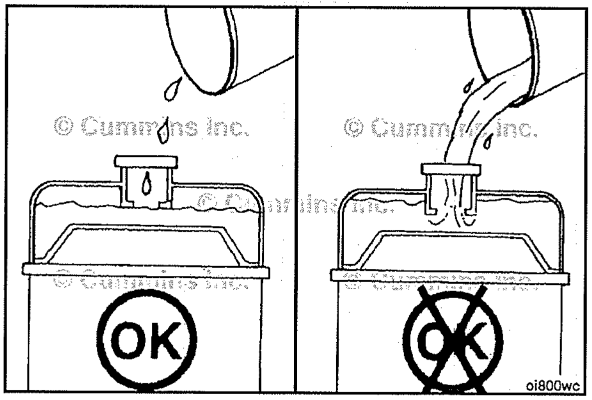
CAUTION

Do not add cold coolant to a hot engine. Engine castings can be damaged. Allow the engine to cool below 50°C [122°F] before adding coolant.

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

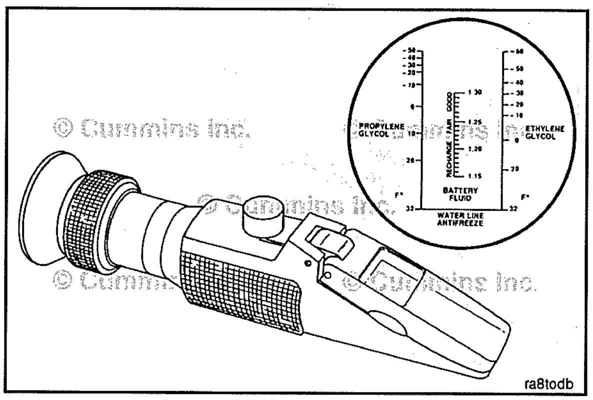
Many coolant recovery/expansion tanks, also called "top tanks", have sight glasses (1) or are made of a clear material (**not** shown) to aid in checking the coolant level (2) without removing the radiator cap.





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

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



Maintenance Check

CAUTION

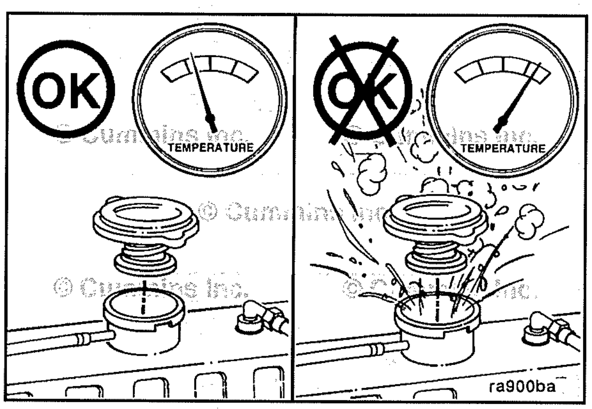
Over-concentration of antifreeze or use of high silicate antifreeze can cause damage to the engine.

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

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

Antifreeze is essential in every climate as it broadens the operating temperature by lowering the coolant freezing point and by raising its boiling point.

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



Drain

WARNING

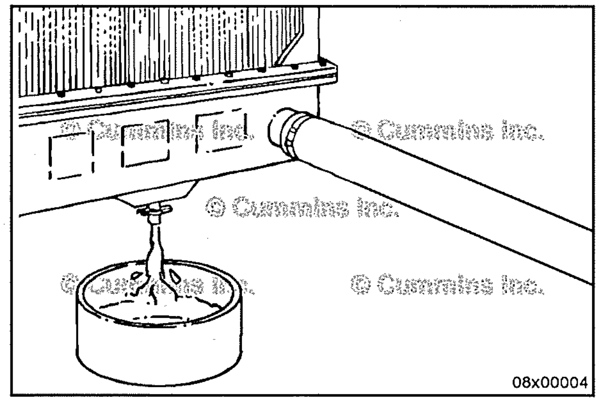
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Remove the radiator/expansion tank cap.

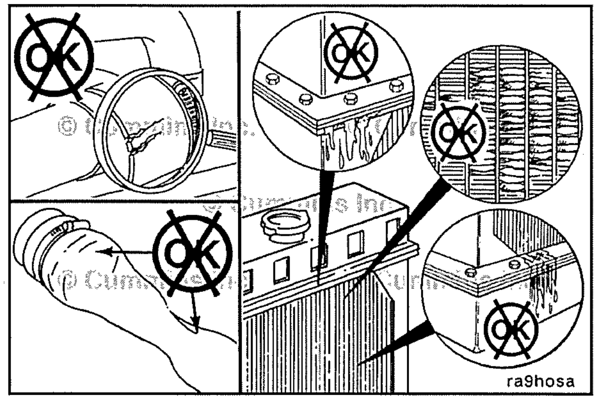
⚠WARNING⚠

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

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



Check for damaged hoses and loose or damaged hose clamps. Replace as required. Check the radiator for leaks, damage, and buildup of dirt. Clean and replace as required.



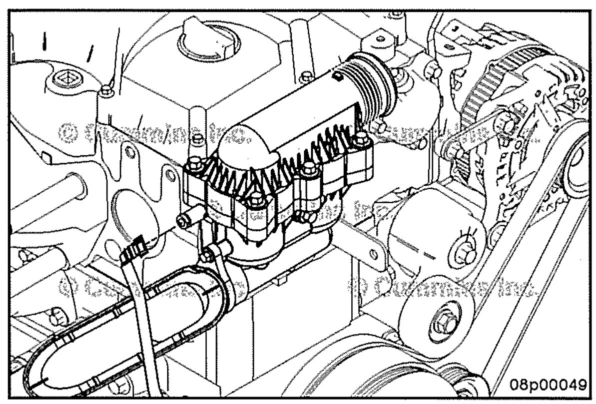
Flush

⚠CAUTION⚠

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

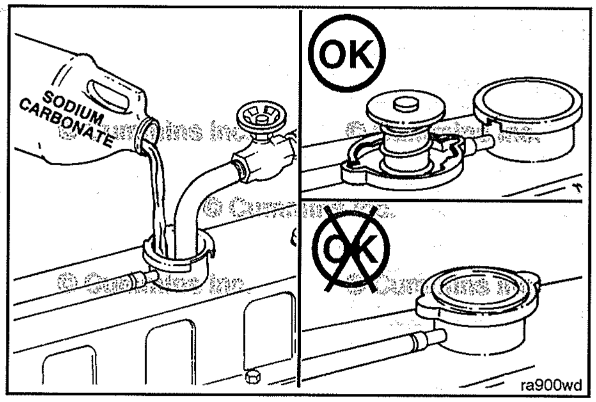
Be sure air is vented during the fill process. A deaeration port is located on the thermostat housing, which connects to the top tank/coolant recovery tank of the cooling system.

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



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

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

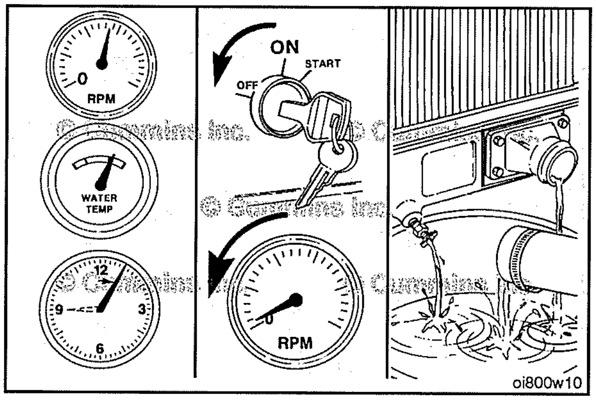


CAUTION

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

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

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

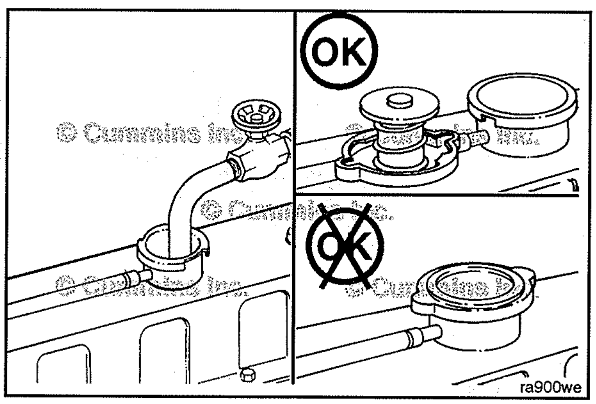


WARNING

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

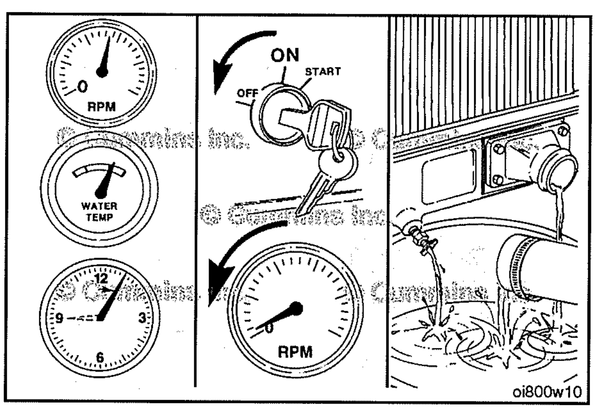
Operate the engine for 5 minutes with the coolant temperature above 80°C [176°F].

Shut the engine OFF, allow to cool to 50° C [120°F], and drain the cooling system.



Fill the cooling system with clean water.

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

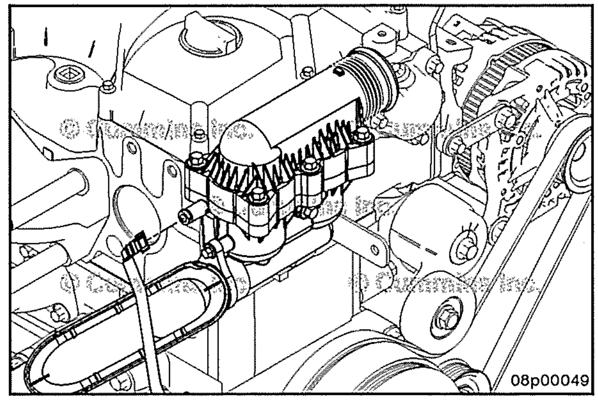


Operate the engine for 5 minutes with the coolant temperature above 80°C [176°F].

Shut the engine OFF, allow to cool to 50° C [120°F], and drain the cooling system.

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

Fill

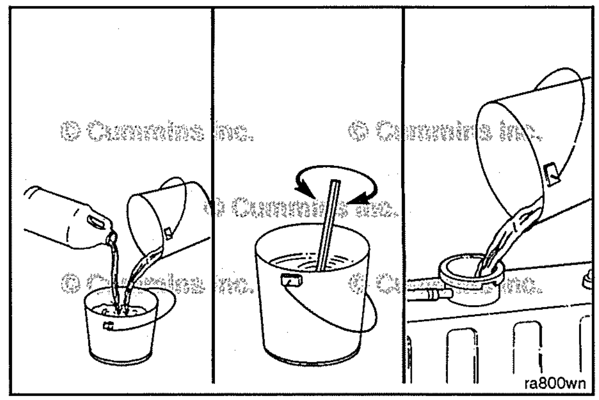


⚠CAUTION⚠

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

To be sure air is vented during the fill process. A deaeration port is located next to the water outlet connection, which connects to the top tank/coolant recovery tank of the cooling system.

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



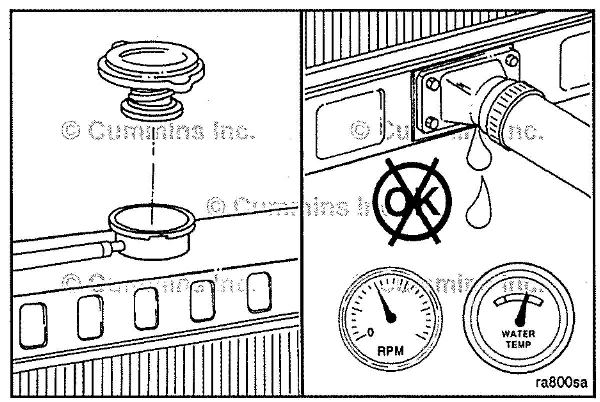
⚠CAUTION⚠

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

Use a mixture of 50-percent water and 50-percent ethylene glycol or propylene glycol antifreeze to fill the cooling system.

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

For cooling system capacity. Refer to Procedure 018-018 in Section V.



⚠WARNING⚠

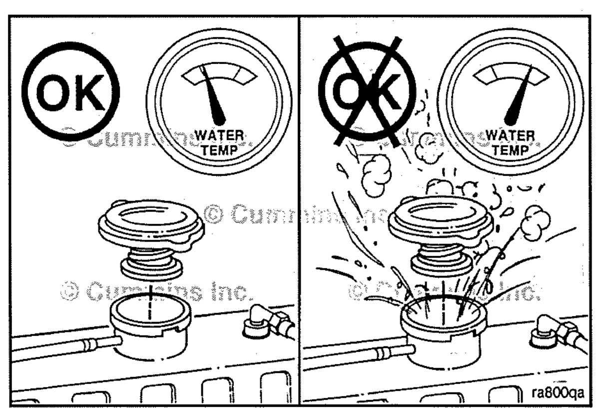
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

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

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

Cooling System - Air or Combustion Gas Test (008-019)

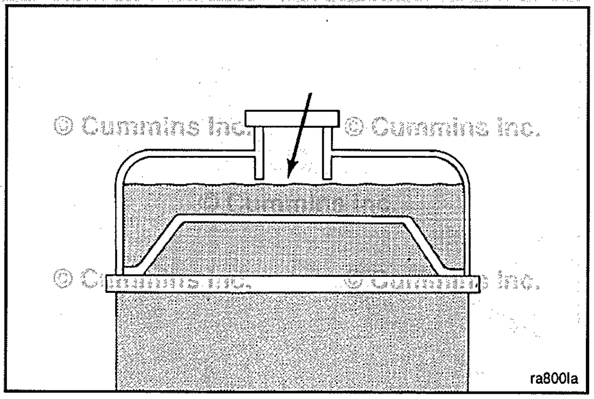
Initial Check



⚠WARNING⚠

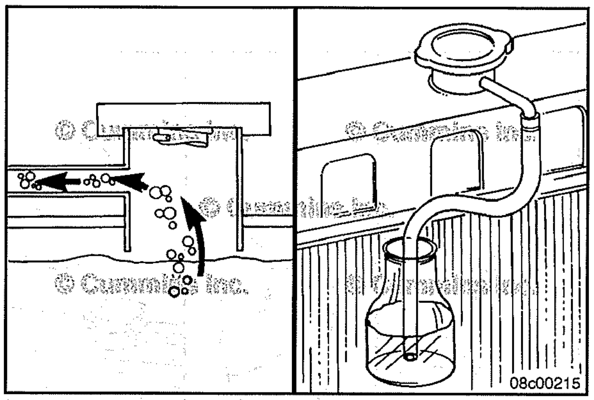
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Allow the engine to cool and remove the radiator cap.



Check the coolant level according to equipment manufacturer service information recommendations and fill, if necessary. Add heavy duty coolant.

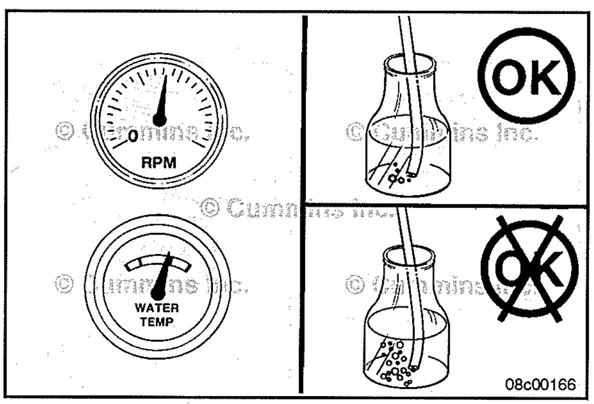
- Refer to Procedure 018-004 in Section V.
- Refer to Cummins® Coolant Requirements and Maintenance, Bulletin 3666132, for a description of heavy duty coolants.



The pressure cap **must** be tightly sealed in the top of the radiator fill neck.

Put the radiator cap back on and attach a rubber hose to the radiator overflow connection.

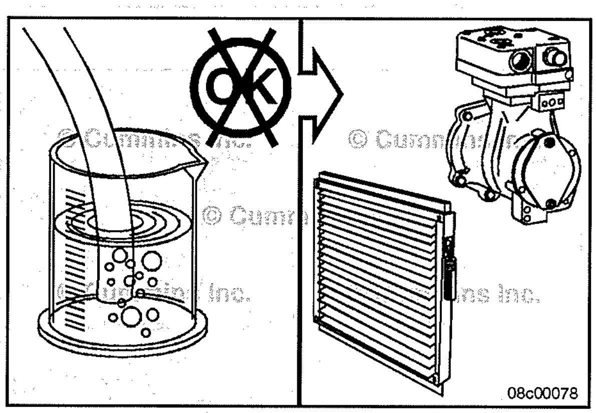
Place the free end of the hose below the water level in a container of water.



The engine coolant temperature **must** be stable to perform this test. An increasing coolant temperature will give a false indication of air due to expansion of the coolant in the system.

Operate the engine at rated rpm until it reaches 82°C [180°F].

Check for a continuous flow of air bubbles from the hose into the water container.

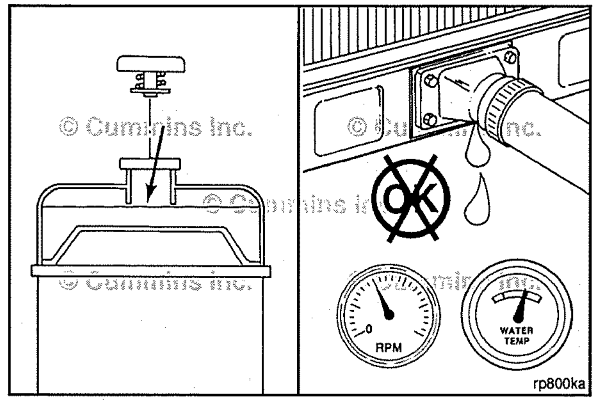


A continuous flow of air bubbles can be caused by one of the following:

- An air compressor cylinder head leak. See the Leak Test - Air Compressor information in this procedure.
- Fan, shutter, or heater air control thermostat valve leaking air. See the Leak Test - Fan, Shutter, or Heater Air Control Valve information in this procedure.
- A cracked cylinder head. Refer to Procedure 002-004 in Section 2.
- A cylinder head gasket combustion leak. See the Leak Test - Overflow Method information in this procedure.

If no air is found in the cooling system, do the following:

- Remove the test equipment.
- Operate the engine until it reaches 80°C [180°F], and check for coolant leaks.

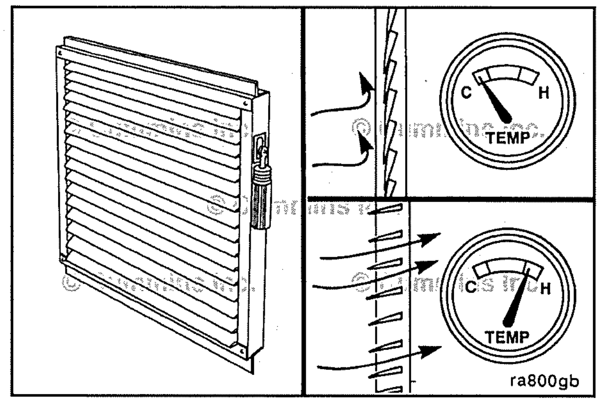


Leak Test

Fan, Shutter, or Heater Air Control Valve

⚠CAUTION⚠

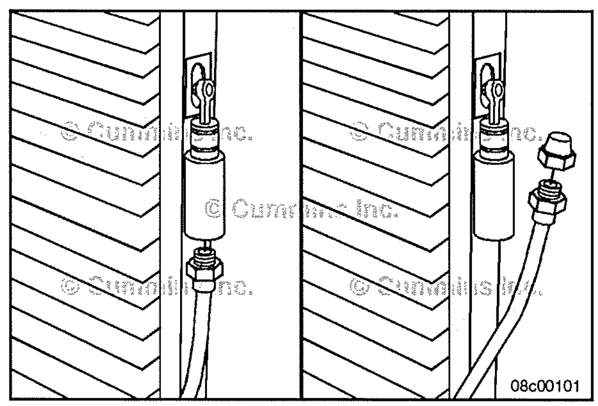
The engine can overheat with the fan control or the shutter air control valve disconnected. Monitor the engine coolant temperature while performing this test. The coolant temperature must not exceed 100°C [212°F] or engine damage can occur.



Disconnect the vehicle air supply hose from the fan, the shutter, and the heater air control valve.

Install a plug into the air supply hose.

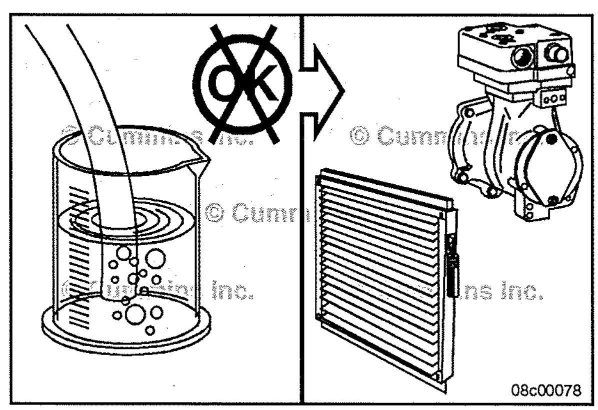
If the vehicle is equipped with more than one air control valve, check **only** one valve at a time.

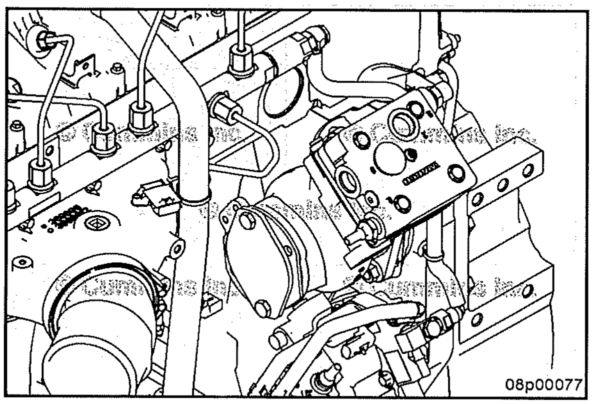


Start the engine and run for 5 minutes before testing for air in the coolant. This will allow any trapped air to purge from the system.

Repeat the test for air in the cooling system, as previously described.

If no air is found in the cooling system with the air control valve(s) isolated, install a new control valve.

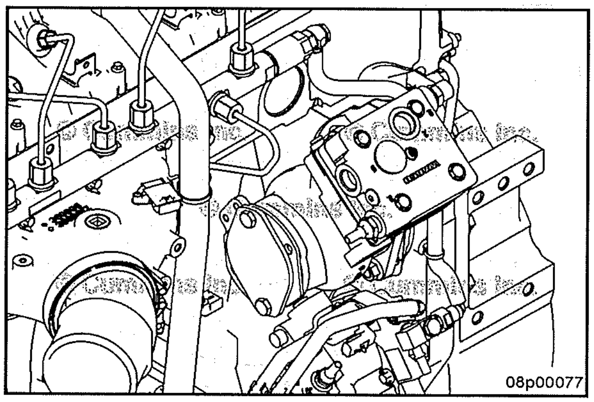




Air Compressor

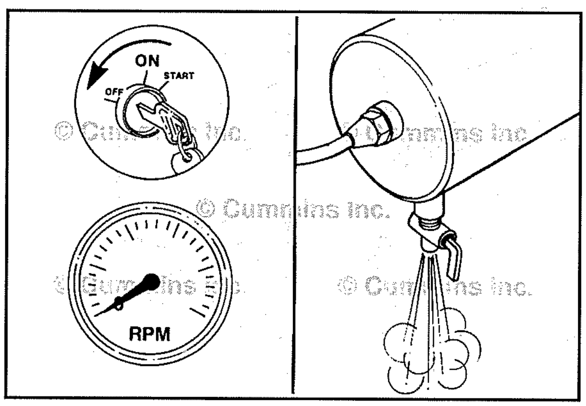
⚠CAUTION⚠

The air compressor discharge line must be disconnected at the compressor to allow the compressor to discharge air to the atmosphere during this next test to prevent the compressor from overheating. Do not run the engine over 5 minutes with components isolated from the cooling system. Component damage can occur.

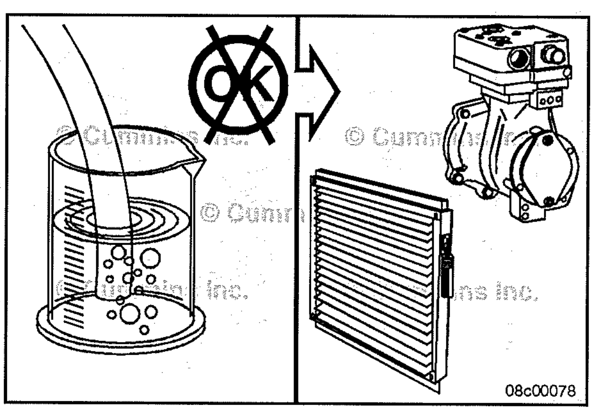


Disconnect the coolant supply and the return tubes from the air compressor.

Use a short piece of hose to connect the tubes together to prevent coolant loss during engine operation.



Drain the air tanks completely to reduce the possibility of air entering the cooling system through the cab heater control valve.



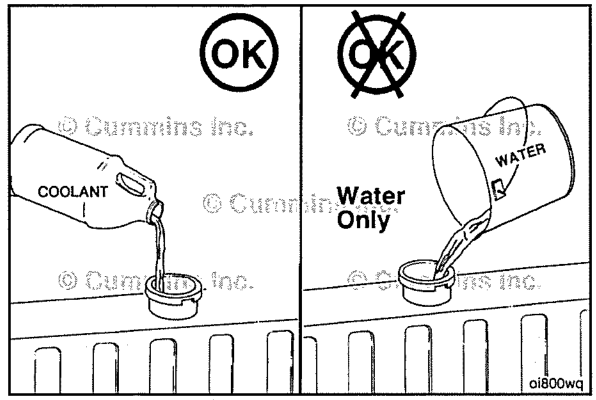
Repeat the test for air in the cooling system as previously described in this procedure.

If no air is found in the cooling system with the air compressor isolated, repair or replace the air compressor.

Combustion Gas Leak

Use combustion gas tester, Part Number 3822985, or equivalent, to test for combustion gases in the cooling system.

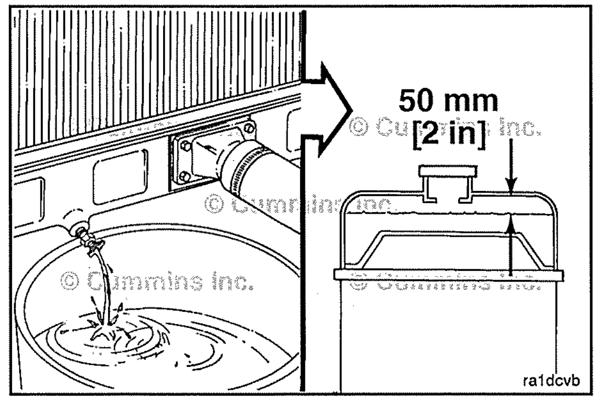
A 50-percent antifreeze and 50-percent water mixture **must** be used in the cooling system when performing the combustion gas leak test.



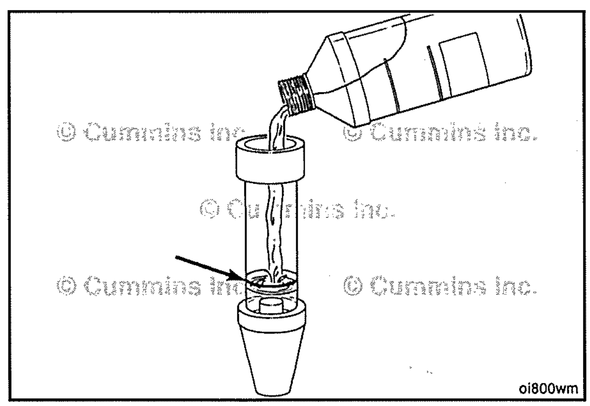
⚠WARNING⚠
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

NOTE: Coolant that gets into the combustion analyzer will stop the color change and render the test ineffective.

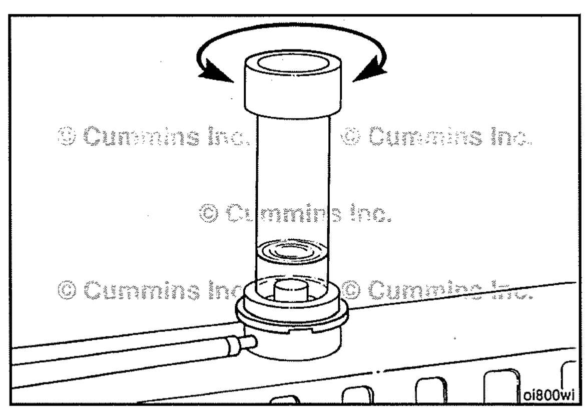
Drain the coolant level down approximately 75 mm [3 in] below the radiator cap seal ledge in the radiator fill neck.

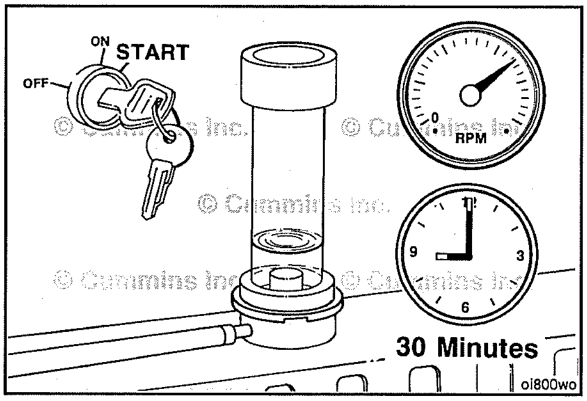


Pour the test fluid into the combustion gas leak test instrument until it is up to the yellow fill line on the instrument.



Insert the rubber tip of the combustion gas leak test instrument into the radiator fill neck. Hold the instrument down firmly and turn back and forth to make sure that an airtight seal is formed between the tester and the radiator fill neck.

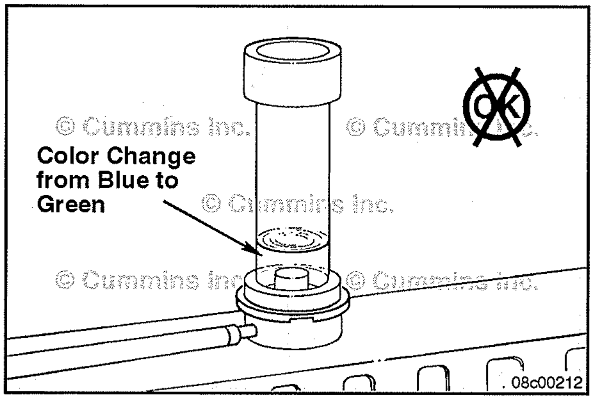




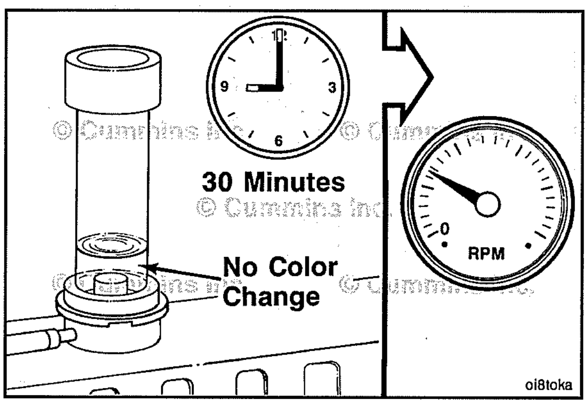
Start the engine and run at high idle for approximately 30 minutes. Monitor the engine temperature and color of the test fluid during engine operation. Do **not** allow the engine temperature to exceed 100°C [212°F] during the test.

A flow of bubbles will occur as the engine warms up and coolant expands.

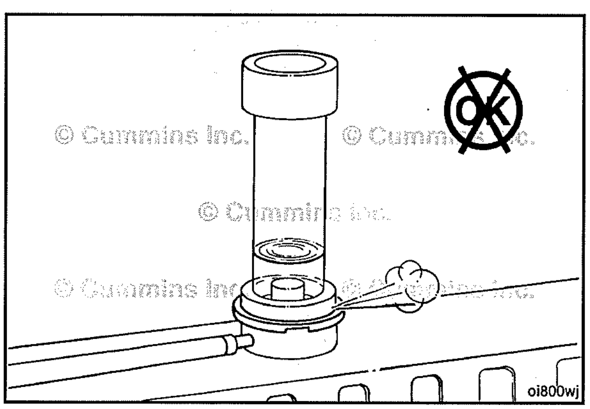
Bubbles in the combustion analyzer is **not** a sign of a combustion leak.



If the color of the test fluid changes from blue to green or yellow any time during the test, combustion gases are leaking into the cooling system. Discontinue the test if the color of the test fluid changes from blue to green or yellow.



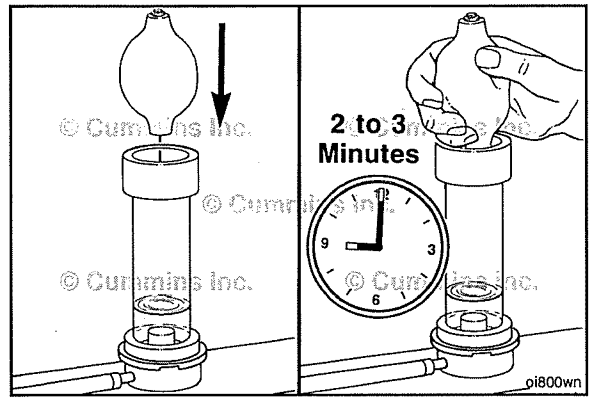
If the color of the test fluid does **not** change from blue to green or yellow during the 30-minute test period, return the engine to low idle.



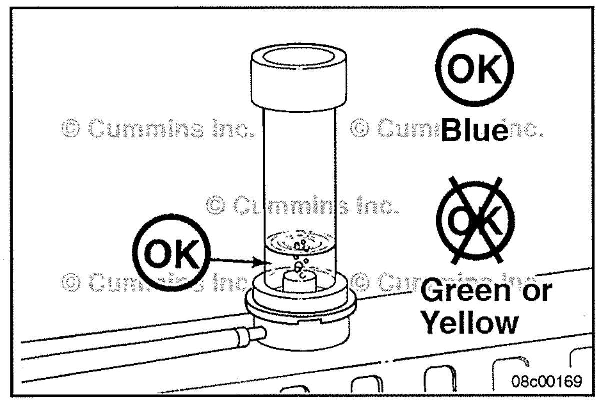
Check the test instrument to make sure it is firmly sealed in the radiator fill neck.

Insert the tip of the rubber ball into the hole in the top of the test instrument. Squeeze the rubber ball 2 to 3 minutes to draw air from the radiator through the test fluid.

If the color of the test fluid remains blue, combustion gases are **not** entering the cooling system. If the color of the test fluid changes from blue to green or yellow, combustion gases are entering the cooling system and further investigation is required to determine the source of the combustion leak.



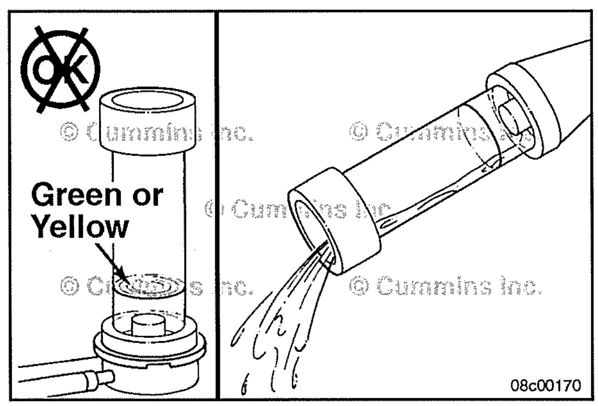
As the cooling system warms up to operating temperature, air will be expelled through the combustion gas tester in the form of bubbles in the test fluid. This is due to normal expansion of the coolant. Do **not** mistake the presence of air bubbles in the tester as combustion gases or air leaks into the cooling system. A change in the color of the test fluid from blue to green or yellow is the **only** indication of combustion gas in the cooling system.



A positive result from the combustion gas leak tester indicates the following:

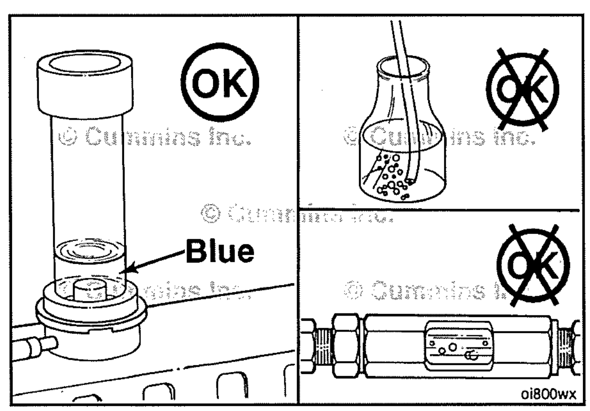
- Injector sleeve leakage. Be sure that the injector hold-down torque is correct. Refer to Procedure 006-026 in Section 6.
- Cylinder liner protrusion is **not** correct. Refer to Procedure 001-028 in Section 1.
- Cylinder head gasket or cylinder head casting leakage. Refer to Procedure 002-004 in Section 2.
- Cracked cylinder liner. Refer to Procedure 001-028 in Section 1.

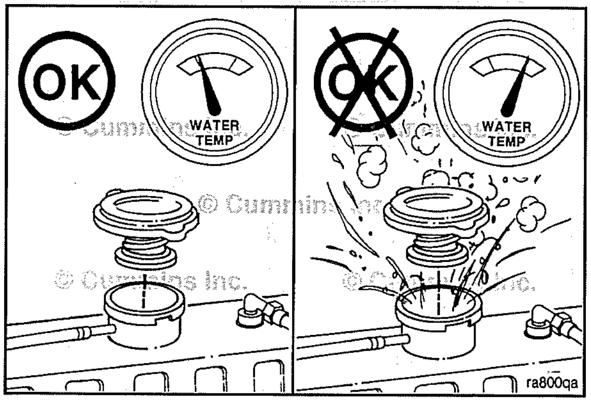
NOTE: Discard the tester fluid if it has indicated positive.



A negative result from the combustion gas leak tester, coupled with a continuous flow of air bubbles from the previous test, indicates the following:

- Defective fan, shutter, or heater air control valve.
- Air compressor head or head gasket leakage.
- Air entrained due to a bad radiator check valve or incorrect fill.



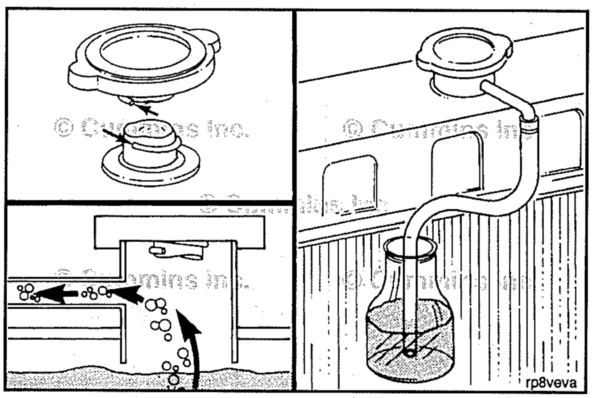


Overflow Method

⚠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.

Allow the engine to cool and remove the radiator cap.

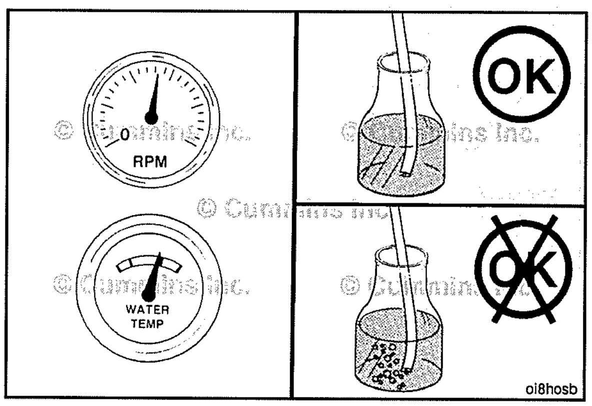


Install a radiator pressure cap that has had the spring and the pressure relief valve removed to allow free flow from the overflow tube.

The pressure cap **must** be tightly sealed in the top of the radiator fill neck.

Attach a rubber hose to the radiator overflow connection.

Put the free end of the hose below the water level in a container of water.



The engine coolant temperature **must** be stable to perform this test. An increasing coolant temperature will give a false indication of air due to expansion of the coolant in the system.

Operate the engine at rated rpm until it reaches a temperature of 82°C [180°F].

Check for a continuous flow of air bubbles from the hose in the water container.

Cooling System Diagnostics (008-020)

General Information

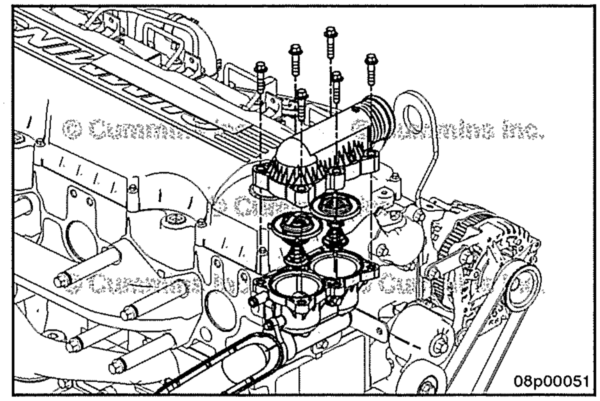
The following procedure covers common troubleshooting steps to help identify:

- Engine overheating causes. See the Initial Check section of this procedure.
- External and internal coolant leaks/loss. See the Test section of this procedure.
- Combustion gas leaks into the cooling system. See the Test section of this procedure.

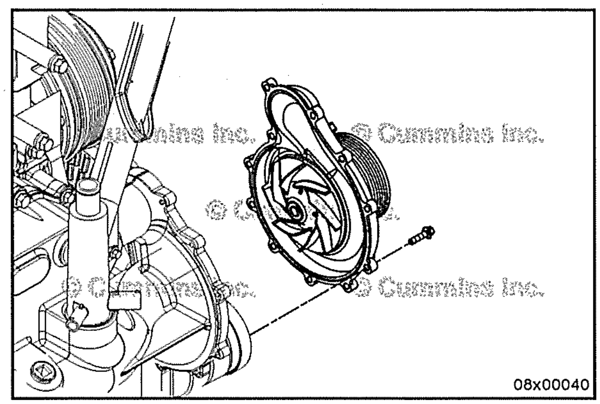
CAUTION

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

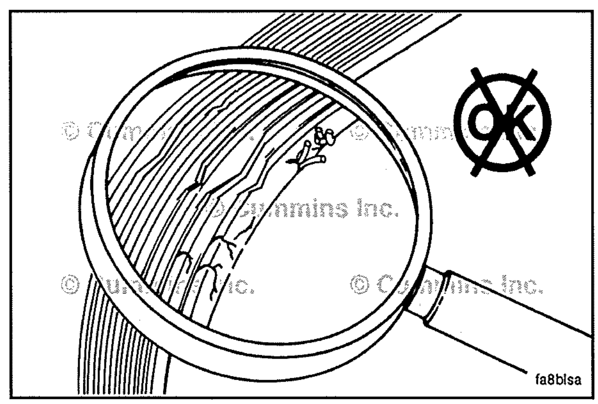
There are two thermostats in this engine. The thermostats open at different coolant temperatures and have different ranges. There are tabs on the thermostat gaskets to ensure they are in the correct location in the thermostat housing. The part number and nominal operating temperature are stamped on the thermostats. Refer to Procedure 008-013 in Section 8 for more information on the coolant thermostats.



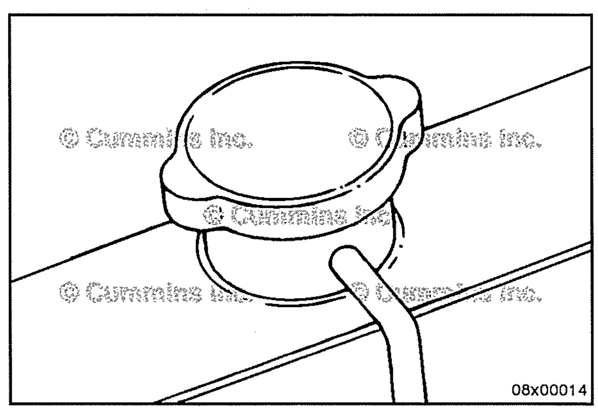
This engine features a cartridge style water pump. A damaged water pump cartridge can lead to an engine overheating condition. Refer to Procedure 008-102 in Section 8 for more information on the water pump cartridge.

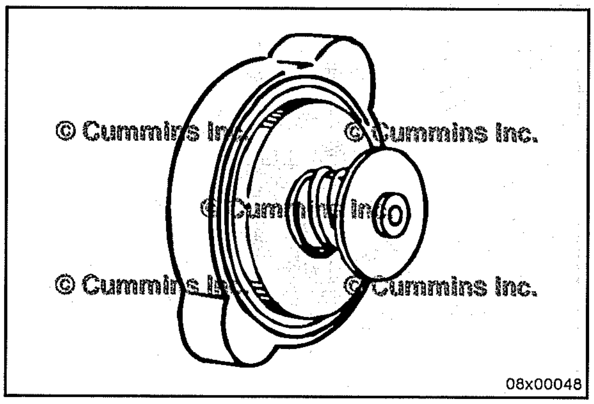


A worn/incorrect belt, belt tensioner, or misaligned pulley can cause a belt to slip or "walk" off. This can reduce water pump and/or cooling fan rotation speeds, resulting in an engine overheating condition. For more information on the cooling fan belt, Refer to Procedure 008-002 in Section 8. For more information on the cooling fan belt tensioner. Refer to Procedure 008-087 in Section 8.



The cooling system is designed to use a pressure cap to prevent the coolant from boiling. See equipment manufacturer service information for pressure cap specifications.



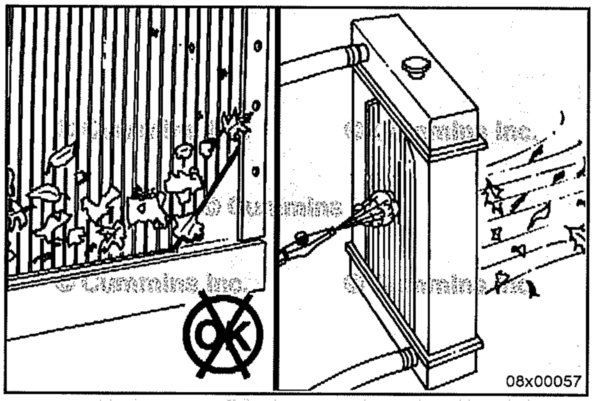


An incorrect or malfunctioning cap can result in the loss of coolant and in an engine overheating condition.

Pressure test the radiator cap. See equipment manufacturer service information for radiator cap test procedures.

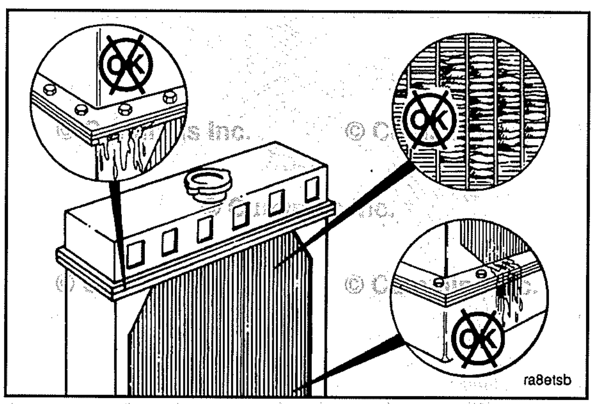
The pressure cap **must** seal within 14 kPa [2 psi] of the value stated on the cap, or it **must** be replaced.

Refer to Procedure 008-047 in Section 8 for more information on the radiator pressure cap.



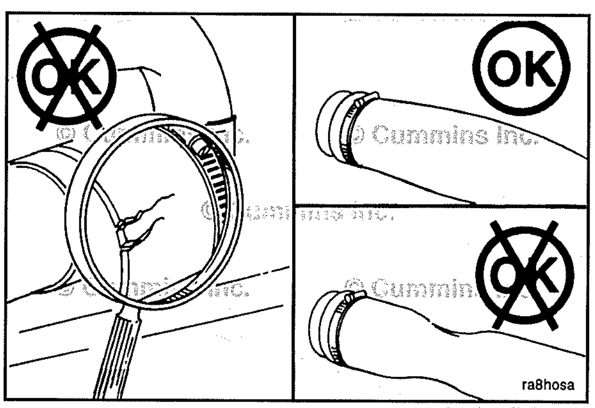
Air forced through the fins of the radiator by a fan cools the coolant pumped through the radiator. Environmental debris (such as paper, straw, lint, and dust) can obstruct the fins and stop the flow of air which reduces the cooling effects of the radiator.

Refer to Procedure 008-042 in Section 8.



The radiator **must** be inspected for bent/broken fins and coolant leaks periodically.

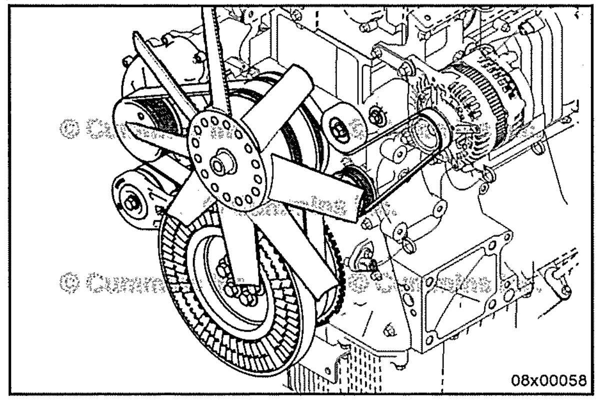
See equipment manufacturer service information for maintenance, removal, or installation of the radiator.



Collapsed or damaged coolant hoses can result in engine heating problems. Make sure to inspect all hoses for cracks, cuts, or collapsing. Replace any damaged hoses.

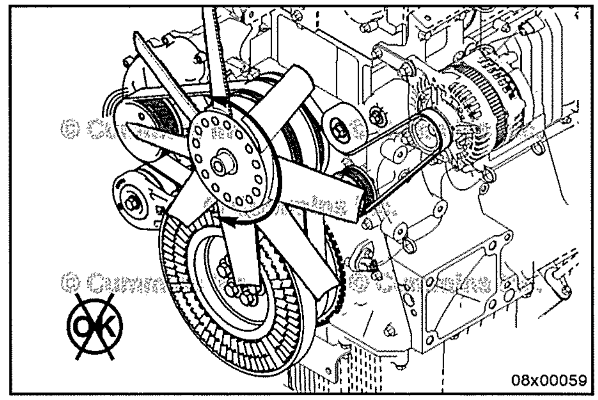
The engine cooling fan is driven by the cooling fan drive belt. Refer to Procedure 008-002 in Section 8 for more details.

The cooling fan is supplied by the OEM and they **must** be contacted for any service related information. This procedure **only** highlights some of the items related to cooling fans.



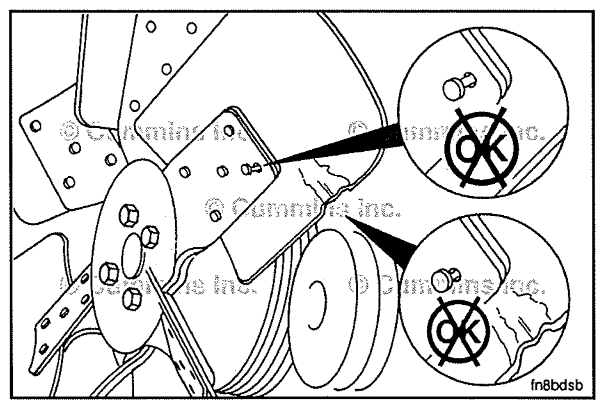
The cooling fan is belt driven. A slipping belt will result in slower fan speed and reduced cooling capabilities. A malfunctioning cooling fan belt tensioner can also be the problem. For more information on the cooling fan belt, Refer to Procedure 008-002 in Section 8. For more information on the cooling fan belt tensioner, Refer to Procedure 008-087 in Section 8.

Check the bearings in the fan hub and other pulleys to make sure they are **not** causing excessive belt vibration and slippage. Refer to Procedure 008-036 in Section 8.

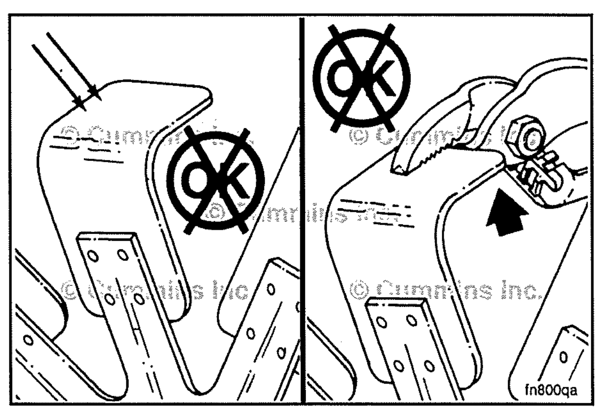


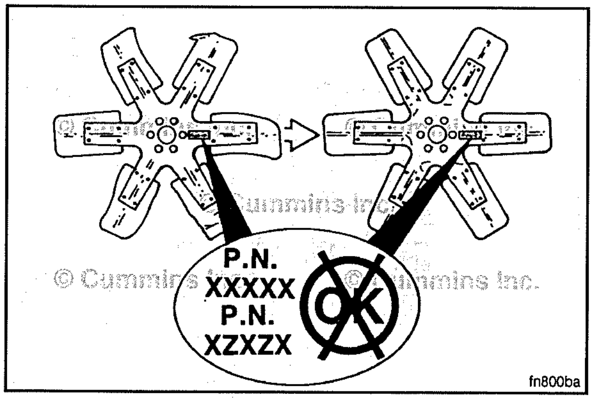
The cooling fan **must** be inspected periodically. Check for cracks, loose rivets, and bent or loose blades.

Check the fan to make sure it is securely mounted. Tighten the capscrews, if necessary.

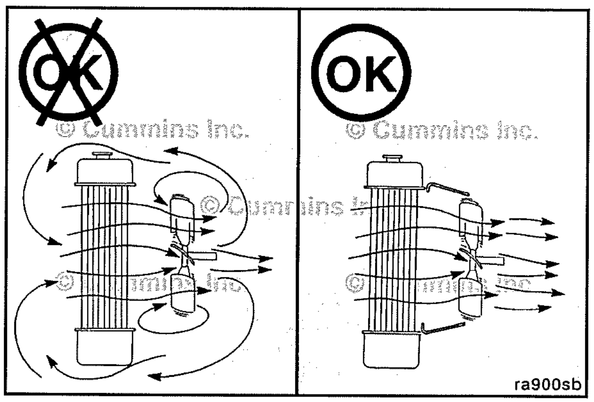


⚠WARNING⚠
Do not straighten a bent fan blade or continue to use a damaged fan. A bent or damaged fan blade can fail during operation and cause personal injury or property damage.

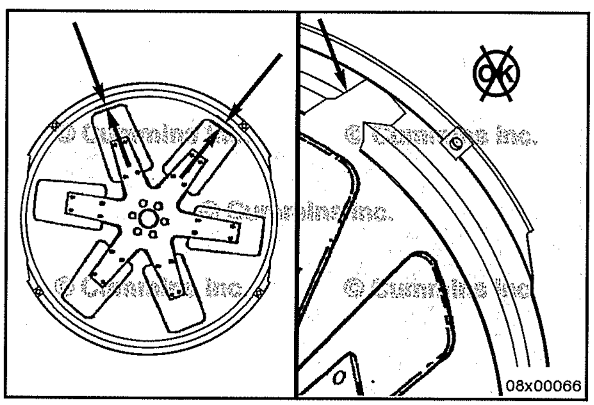




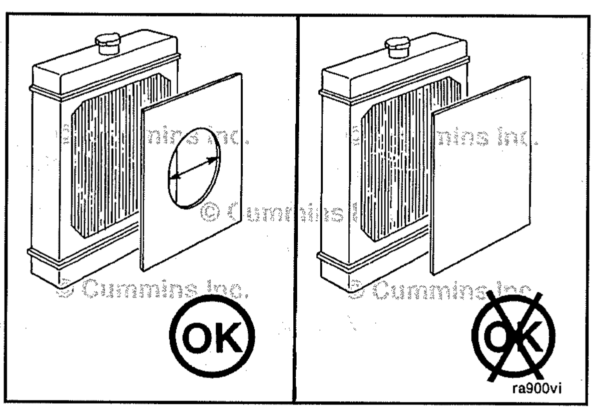
Only replace a damaged cooling fan with an exact equivalent cooling fan. Although same size cooling fans can appear similar, there are differences in the blade pitch and profile.



A fan shroud assembly is used to direct the air flow provided by the cooling fan. A missing or damaged fan shroud will reduce the amount of air flow provided by the cooling fan, and can cause an engine coolant overheating condition.



Check the fan shroud for damage and/or contact with the cooling fan. Replace any damaged components. Refer to Procedure 008-038 in Section 8.



Winter fronts can be used to reduce the engine warm up time and help maintain engine heat in cold climate locations.

The winter fronts **must only** cover part of the frontal area of the cooling system, leaving part of the frontal area open to air flow.

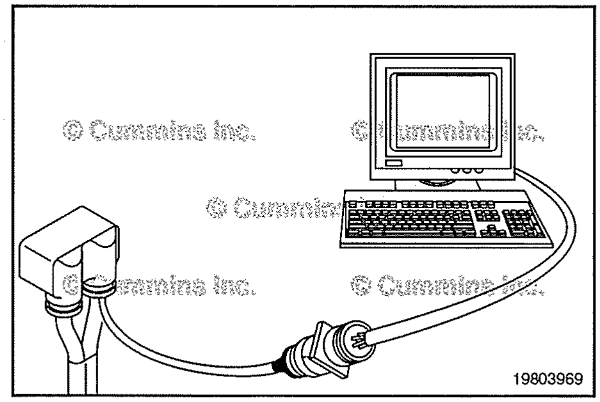
Failure to leave part of the front area open to air flow or leaving the winter fronts installed when ambient temperatures increase can lead to an engine overheating condition.

Initial Check

Connect to the vehicle's data link with INSITE™.

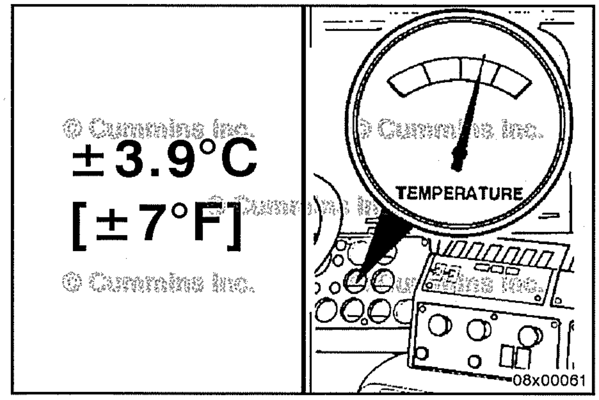
Turn the keyswitch to the ON position.

Monitor the coolant temperature with INSITE™.



If equipped with an in dash coolant temperature gauge, monitor coolant temperature with an electronic service tool and compare the cab temperature gauge reading. Replace the cab temperature gauge if it is **not** within the manufacturer's specifications of the correct reading.

If the manufacturer's specifications are **not** available, replace the gauge if it is **not** within ±3.9°C [±7°F] of the correct reading.



OEMs are free to specify what fan clutch they want to run as long as it meets the Cummins specified cooling requirements.

Check the coolant temperature when the fan is engaged. Compare this value to what is stamped on the fan control.

Cummins Inc. recommends that the fan engage at 96°C [205°F] engine coolant temperature.

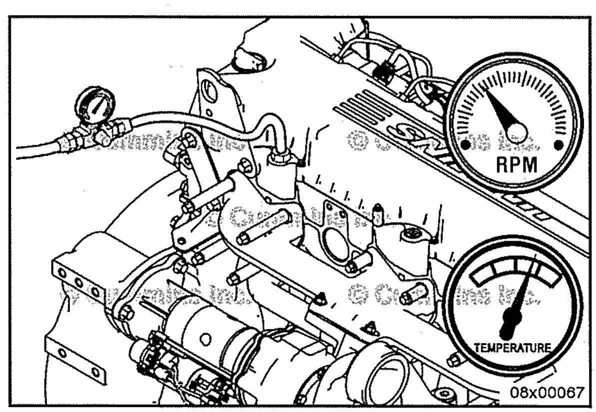
Pressure Test

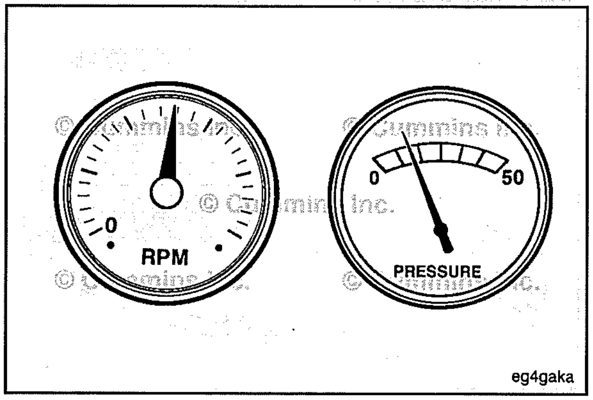
Use a pressure gauge with a maximum capacity of 414 kPa [60 psi].

Measure the coolant pressure at one of the OEM coolant ports on the cylinder head.

Operate the engine until the coolant temperature reaches 90°C [194°F].

NOTE: The thermostats **must** be open.



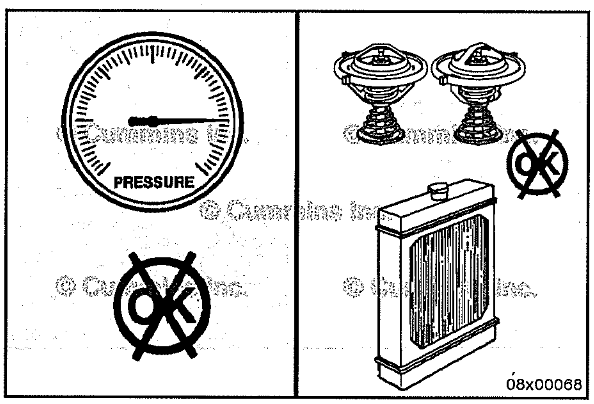


Operate the engine at rated rpm.

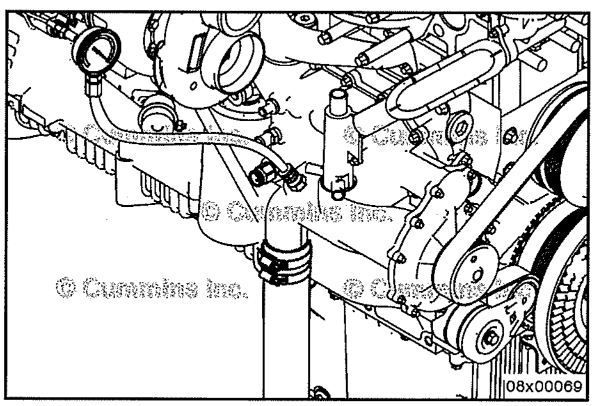
Compare the pressure readings to the following specifications.

Minimum Coolant Pressure at cylinder head			
	kPa		psi
1800 RPM	55	MIN	8
1900 RPM	62	MIN	9
2100 RPM	76	MIN	11

Maximum Coolant Pressure at cylinder head (Cap Removed)			
	kPa		psi
2100 RPM	172	MAX	25



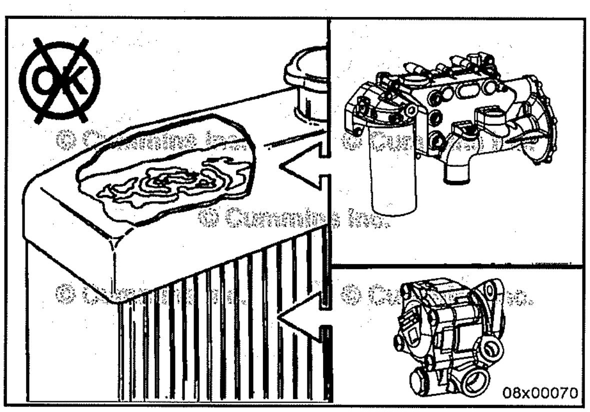
If coolant pressure is higher than specified in the above table with the radiator cap removed, check the thermostat or radiator for a restriction. Refer to Procedure 008-042 in Section 8.



If the coolant pressure is low, install a gauge with a maximum capacity of 69 kPa [10 psi] at the water pump inlet connection.

Operate the engine at rated rpm.

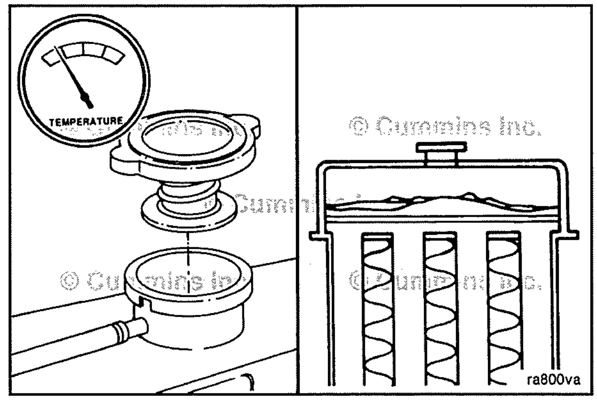
If the gauge reads less than 14 kPa [2 psi] with the radiator cap removed, check radiator and water inlet for restriction.



Leak Test

The operating pressure of the coolant system and the lubricating system can result in the mixing of the fluids if there is a leak between the systems.

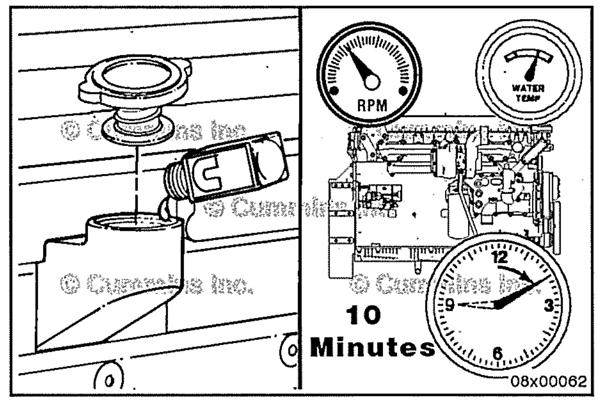
Check the coolant level and fill if necessary. Refer to Procedure 008-018 in Section 8.



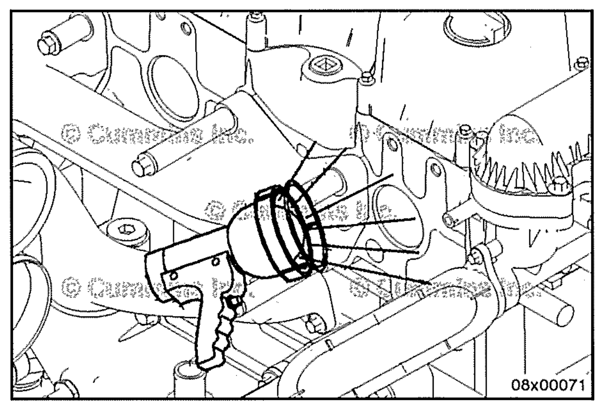
To aid in determining the location of the coolant leak, it may be necessary to add fluorescent tracer, Part Number 3377438, to the cooling system.

Add one unit of fluorescent tracer for each 38 liters [10 gal] of coolant.

Idle the engine for 5 to 10 minutes, or until normal operating temperature is reached, to allow the dye to circulate through the cooling system.



Check for leaks using a high intensity black light, Part Number 3163337, or equivalent, to illuminate the dye.



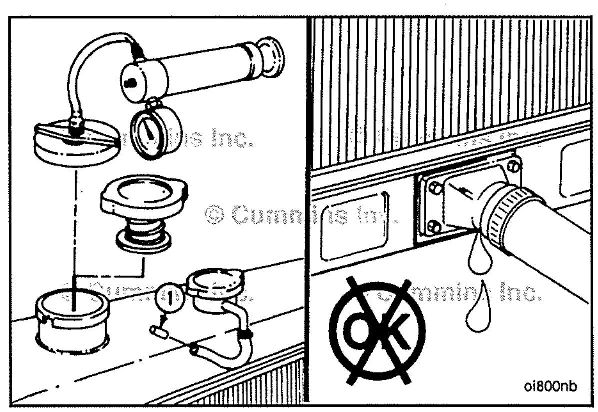
CAUTION

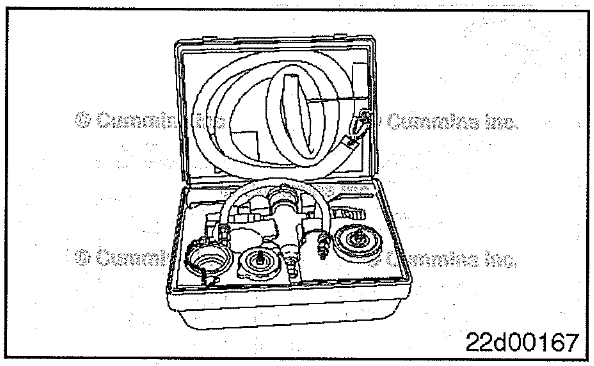
Do not apply more than 138 kPa [20 psi] air pressure to the cooling system. The water pump seal can be damaged.

If the radiator is equipped with a pressure relief valve, plug the overflow line (1).

Install the pressure tester on the radiator fill neck or surge tank, if equipped, and apply air pressure.

Air Pressure 138 kPa [20 psi]

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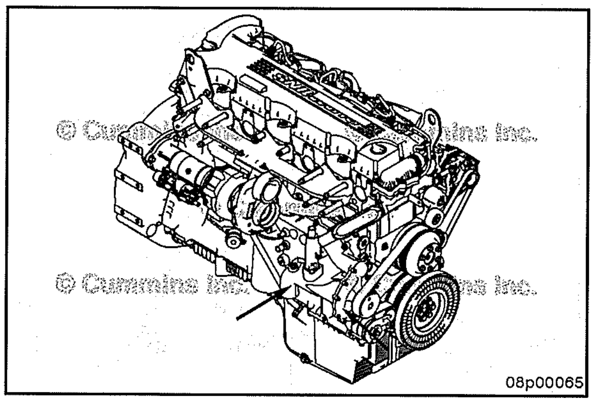
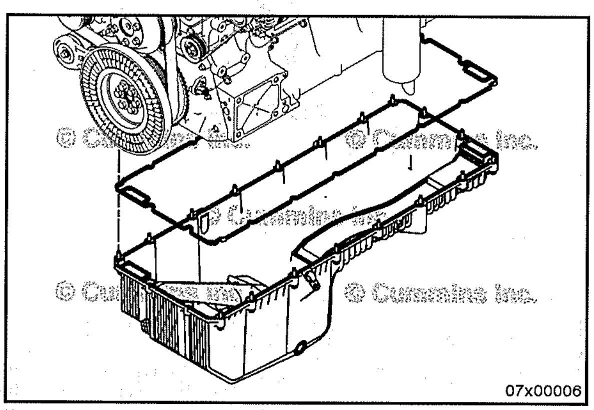
The Coolant Dam™/Pressure Tester service tool, Part Number 3824319, can also be used to pressurize the cooling system. The Coolant Dam™/Pressure Tester uses shop air rather than a hand air pump.


08p00065

For external coolant leaks, inspect the exterior of the engine for coolant leaks and repair if necessary.

Pay close attention to areas around the:

- Lubricating oil cooler housing. Refer to Procedure 007-046 in Section 7.
- Water Bypass Tube. Refer to Procedure 008-005 in Section 8.
- Water pump. Refer to Procedure 008-102 in Section 8.
- Turbocharger. Refer to Procedure 010-033 in Section 10.
- Exhaust Pressure Regulator. Refer to Procedure 011-105 in Section 11.
- Cup plugs. Refer to Procedure 017-002 in Section 17.
- Pipe plugs. Refer to Procedure 017-007 in Section 17.
- AT System. Refer to Procedure 011-084 in Section 11.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For internal coolant leaks, inspect the interior of the engine. It may be necessary to remove the following components to looks for signs of a coolant leak.

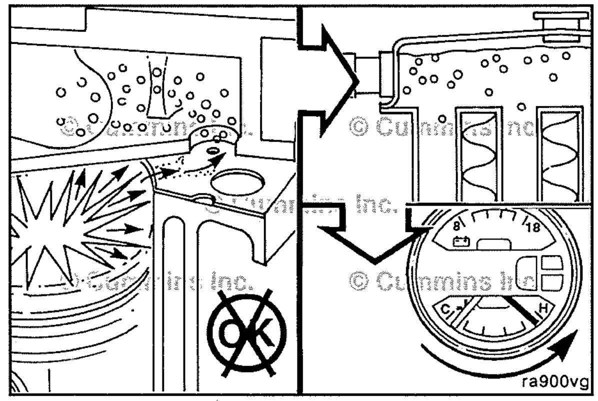
- Rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Lubricating oil pan. Refer to Procedure 007-025 in Section 7.
- Turbo Oil Drain Line. Refer to Procedure 010-045 in Section 10.

Test

Combustion Gas Leak

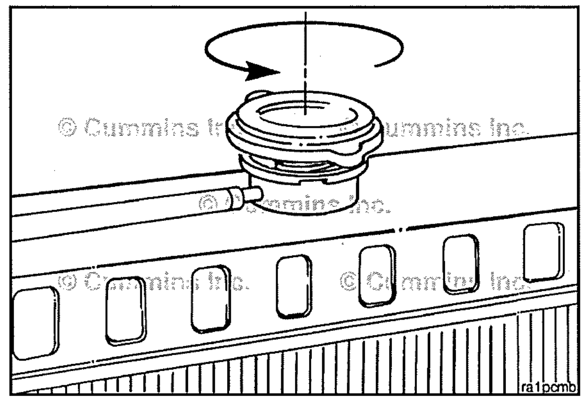
Air in the coolant can result in loss of coolant from the overflow when the aerated coolant is hot. The heated air expands, increasing the pressure in the system, causing the cap to open.

Similarly, coolant can be displaced through the overflow if the head gasket or a crack in the cylinder head leaks compression gases to the cooling system.



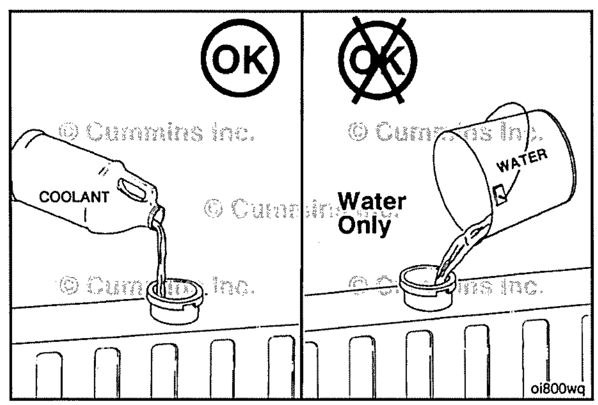
NOTE: All cab heaters and air conditioners **must** be turned off, and the engine fan control **must** be turned to the AUTOMATIC position, if applicable.

Remove the radiator cap and leave it off for the following test.



Use combustion gas tester, Part Number 3822985, or its equivalent, to test for combustion gases in the cooling system.

It is recommended that the cooling system contain a mixture of 50 percent antifreeze and 50 percent water during the combustion gas leak test. The use of water **only** can result in a color change in the test fluid from blue to turquoise or light green during the test. This is **not** an indication of a combustion gas leak.

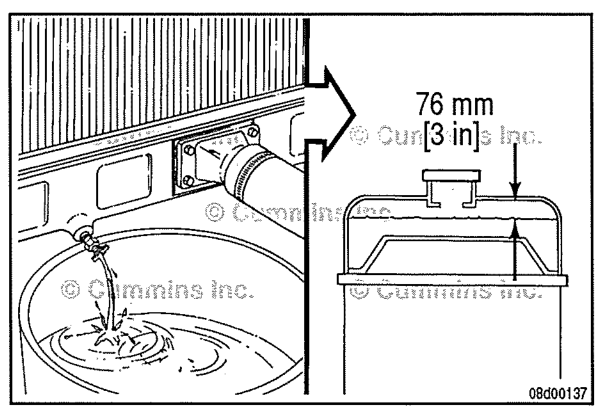


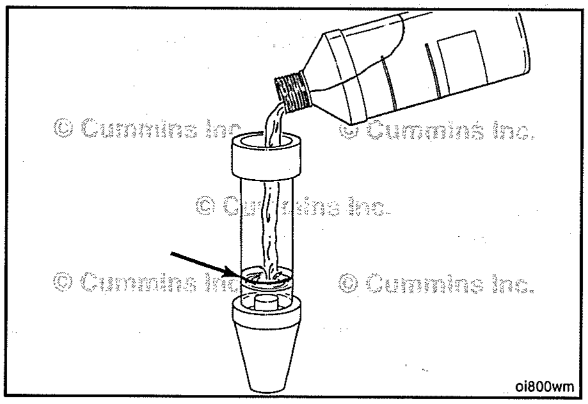
WARNING

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

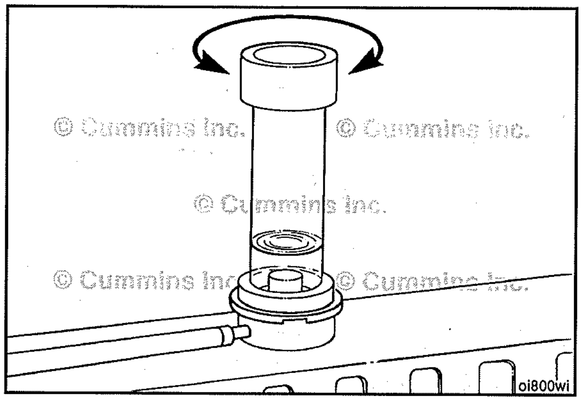
Drain the coolant level down approximately 76 mm [3 in] below the radiator cap seal ledge in the radiator fill neck.

If the coolant is above this point, the coolant can contaminate the test fluid, causing the test to be ineffective.

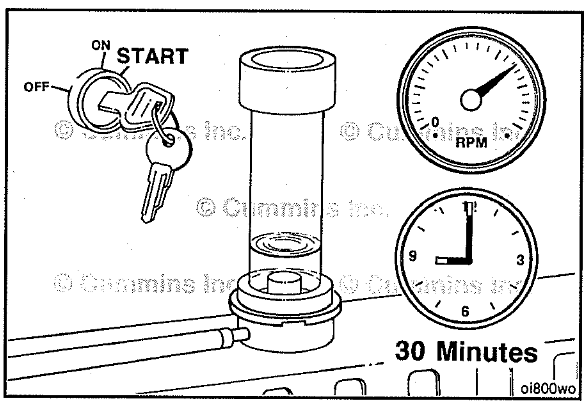




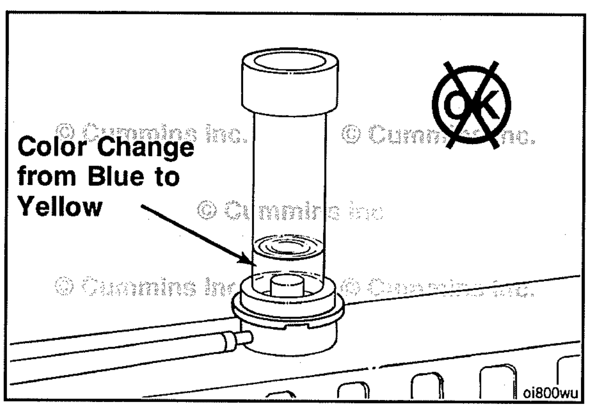
Pour the test fluid into the combustion gas leak test instrument until it is up to the yellow fill line on the instrument.



Insert the rubber tip of the combustion gas leak test instrument into the radiator fill neck. Hold the instrument down firmly and turn back and forth to make certain that an airtight seal is formed between the tester and the radiator fill neck.

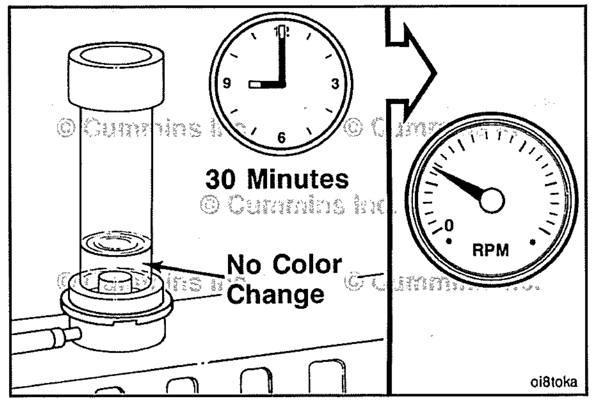


Start the engine and run at high idle for approximately 30 minutes. Monitor the engine temperature and color of the test fluid during engine operation. Do **not** allow the engine temperature to exceed 100°C [212°F] during the test.

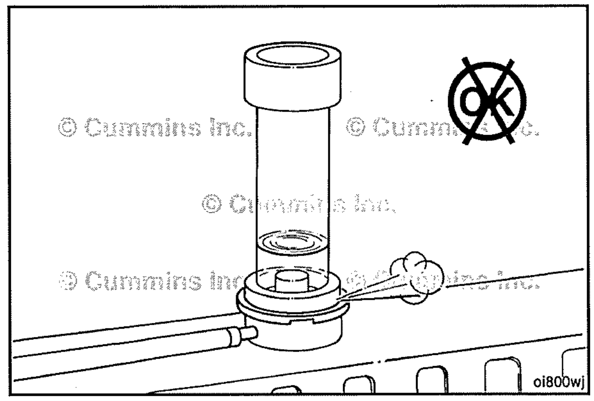


If the color of the test fluid changes from blue to yellow or green anytime during the test, combustion gases are leaking into the cooling system. Discontinue the test if the color of test fluid changes from blue to yellow or green.

If the color of the test fluid does **not** change from blue to yellow or green during the 30-minute test period, return the engine to low idle.

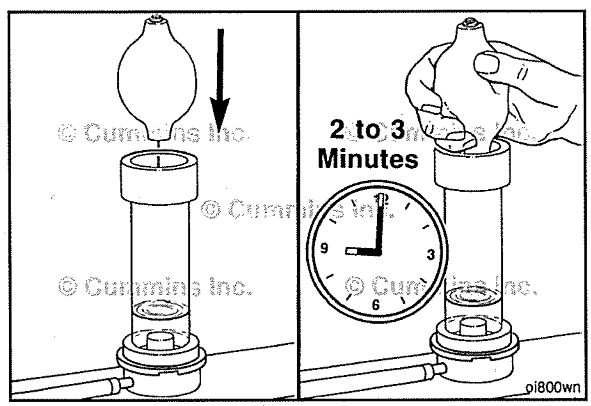


Check the test instrument to make sure it is firmly sealed in the radiator fill neck.

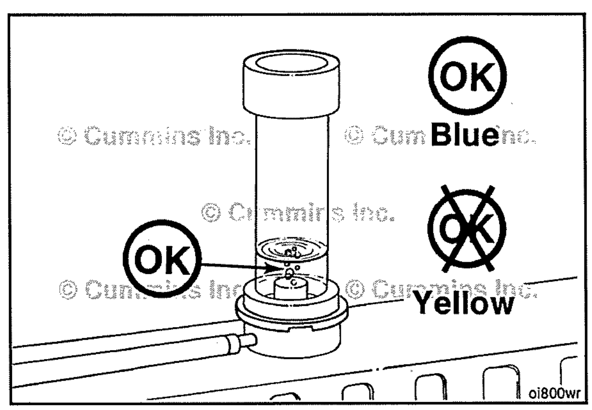


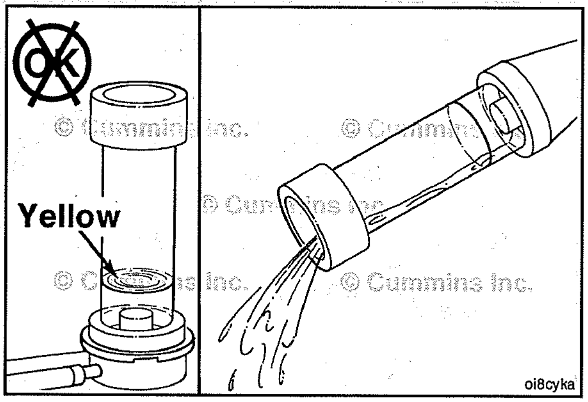
Insert the tip of the rubber ball into the hole in the top of the test instrument. Squeeze the rubber ball 2 to 3 minutes to draw air from the radiator through the test fluid.

If the color of the test fluid remains blue, combustion gases are **not** entering the cooling system. If the color of the test fluid changes from blue to yellow or green, combustion gases are entering the cooling system and further investigation is required to determine the source of the combustion leak.



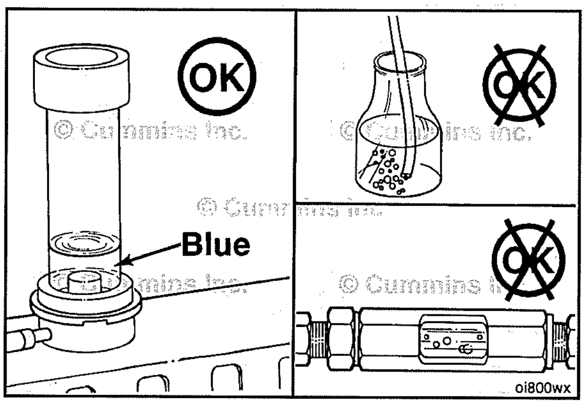
As the cooling system warms up to operating temperature, air will be expelled through the combustion gas tester in the form of bubbles in the test fluid. This is due to normal expansion of the coolant. Do **not** mistake the presence of air bubbles in the tester as combustion gases or air leaks into the cooling system. A change in the color of the test fluid from blue to yellow or green is the **only** indication of combustion gas in the cooling system.





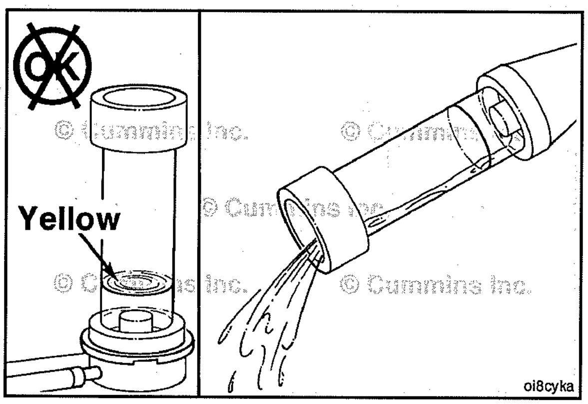
A positive result from the combustion gas leak tester indicates cylinder head gasket or cylinder head casting leakage. Refer to Procedure 002-004 in Section 2.

NOTE: Discard the tester fluid if it has changed color.



A negative result from the combustion gas leak tester, coupled with a continuous flow of air bubbles from the previous test, indicates the following:

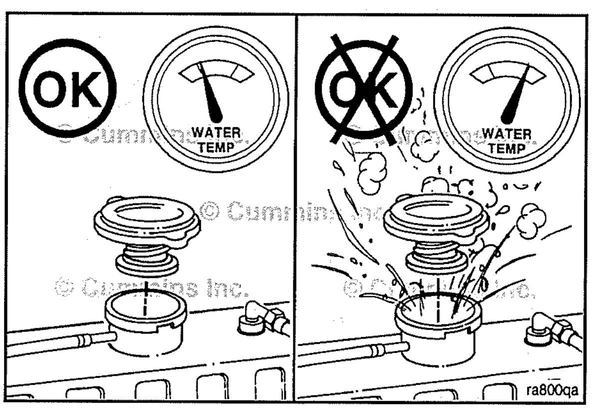
- Defective fan, shutter, or heater air control valve
- Air entrained due to a bad radiator check valve or incorrect fill.



Check the color of fluid in the combustion gas leak tester. A yellow or green color will indicate a combustion leak. A blue color will indicate there is no leak. This information will help isolate the source of air in the cooling system, if any.

NOTE: The test kit is **not** sensitive enough to detect very small combustion gas leaks.

Do **not** rule out combustion gas leaks if the combustion gas leak test does **not** indicate a combustion gas leak.



Overflow Method

⚠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.

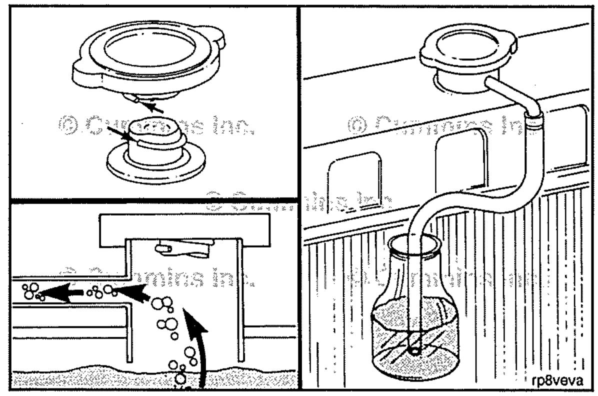
Allow the engine to cool and remove the radiator cap.

Install a radiator pressure cap that has had the spring and the pressure relief valve removed to allow free flow from the overflow tube.

Attach a rubber hose to the radiator overflow connection.

Put the free end of the hose below the water level in a container of water.

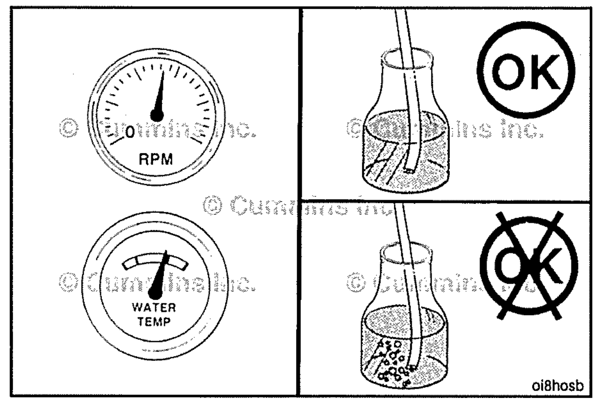
NOTE: The pressure cap **must** be tightly sealed in the top of the radiator fill neck.



Operate the engine at rated rpm until it reaches a temperature of 82°C [180°F].

Check for a continuous flow of air bubbles from the hose in the water container.

NOTE: The engine coolant temperature **must** be stable to perform this test. An increasing coolant temperature will give a false indication of air, due to expansion of the coolant in the system.



Cooling System Service Requirements (008-022)

General Information

Always use good quality, soft water in the coolant mixture. Water added to the cooling system **must** meet the specifications given in the accompanying chart.

Mineral	Problem Cause	Max. Limit
Calcium Magnesium (hardness)	Deposits on Liners/Heads/ Coolers	170 PPM
Chloride	General Corrosion	40 PPM
Sulfate	General Corrosion	100 PPM

lt800kb

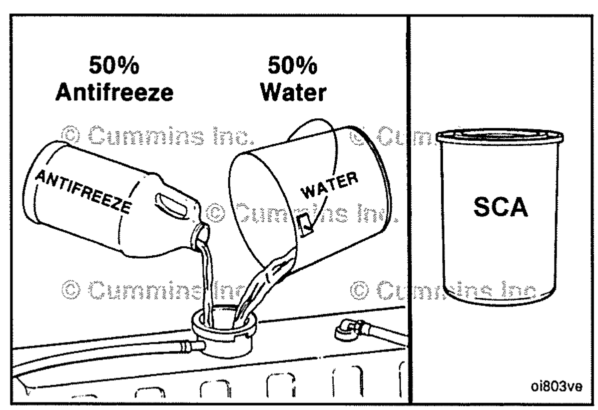
⚠CAUTION⚠

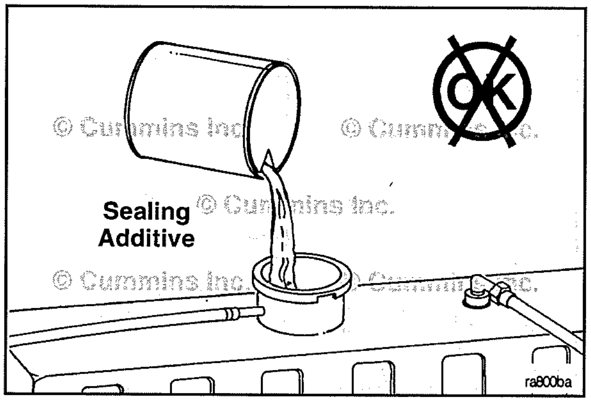
Antifreeze over-concentration reduces protection. Do not use more than 68 percent antifreeze or overheating can result. A mixture of 50 percent antifreeze and 50 percent water is sufficient for freeze protection to -37°C [-34°F]. Engine damage will result.

⚠CAUTION⚠

Do not use a high silicate antifreeze. A silicate-gel (hydro-gel) formation can occur when a cooling system contains an over-concentration of high silicate antifreeze and/or supplemental coolant additives. Engine damage will result.

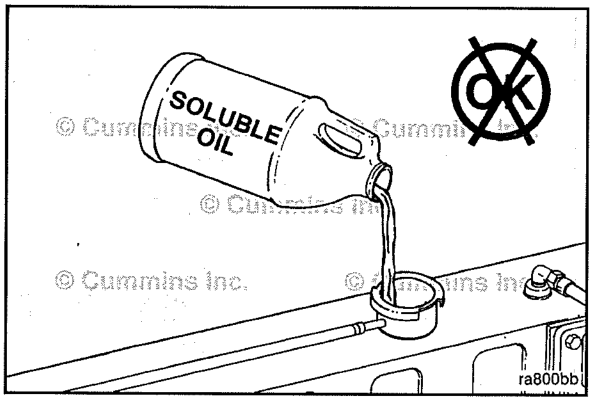
NOTE: Use ethylene glycol antifreeze year-round to provide freeze point and boil-over protection.





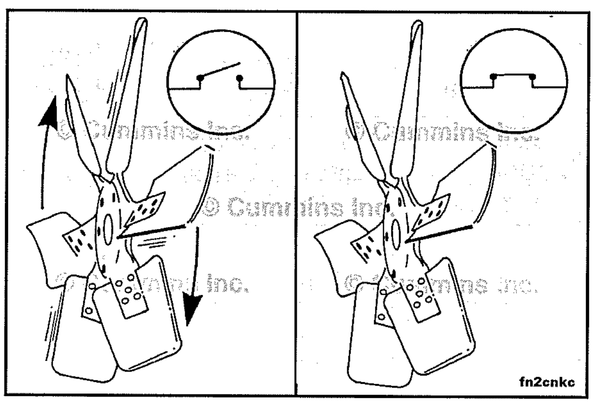
Do **not** use sealing additives in the cooling system. The use of sealing additives will cause the following problems:

- Buildup in coolant low flow areas
- Plugged radiator.



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

- Allow cylinder liner pitting
- Corrode brass and copper
- Damage heat-transfer surfaces
- Damage seals and hoses.



Fan Clutch, Viscous (008-028)

General Information

The fan clutches can be controlled by the electronic control module (ECM). The ECM is programmed to turn the fan on when 0 VDC (normally open switch) is applied to the fan clutch relay, and turn the fan off when battery voltage (normally closed switch) is applied to the fan clutch relay.

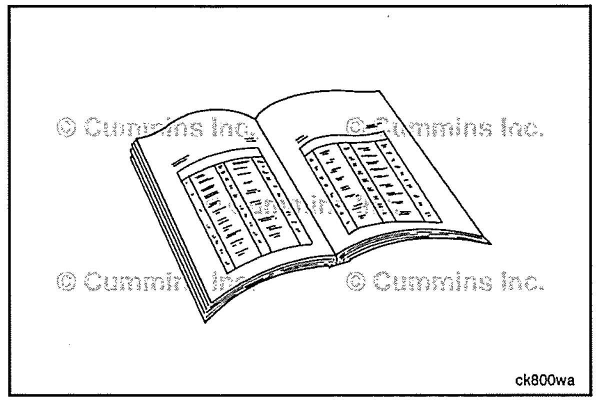
The following fan clutch checks are for fan clutches wired to the electronically controlled fuel system. See the vehicle manufacturer's specifications to determine the installation of the fan clutch.

Viscous fan drives are used as a power-saving device activated by the ECM used to monitor coolant temperature.

When the coolant temperature reaches a specific level, the ECM sends a signal to the actuator which allows viscous fluid to engage the fan drive and increase the fan speed.

See equipment manufacturer service information for troubleshooting.

Preparatory Steps

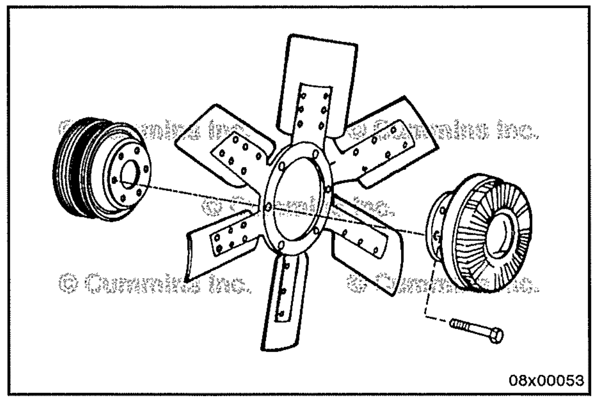

ck800wa

⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the fan drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.

Remove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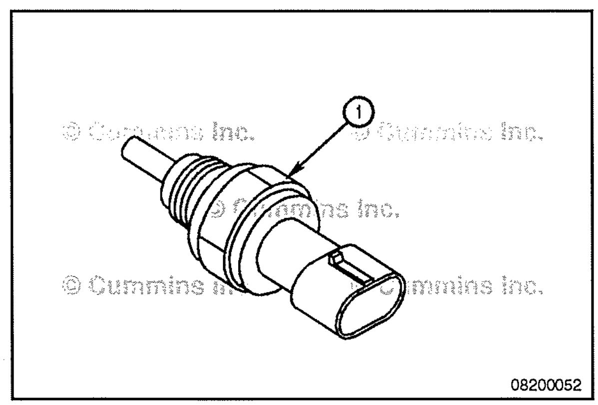
Disconnect the fan clutch connector from the engine harness.

Remove the cooling fan assembly from the fan pulley. See equipment manufacturer service information.

Remove the fan blades from the fan clutch assembly. See equipment manufacturer service information.

Inspect for Reuse



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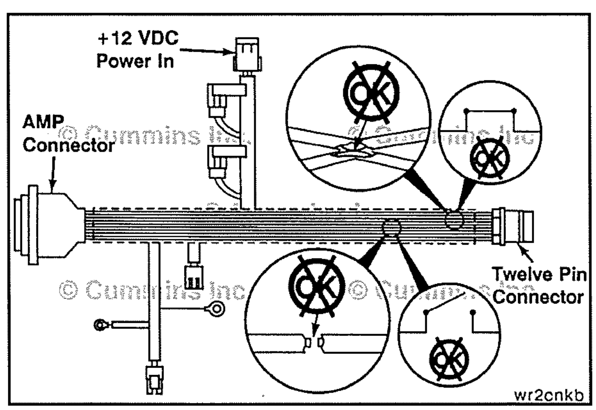
If the fan does **not** operate within the temperature range on the coolant temperature sensor (1), the fan clutch and the controls **must** be checked.



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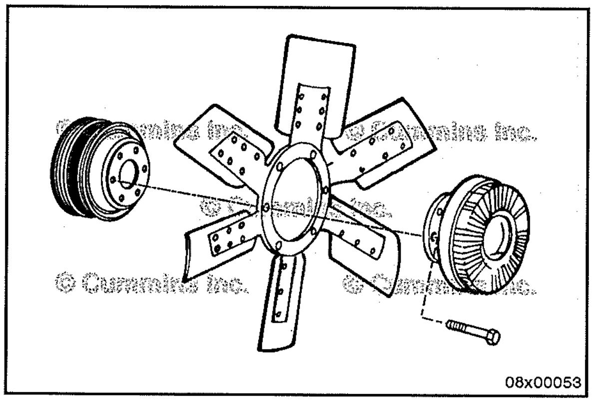
Inspect wires and harnesses to make sure none are broken or shorted. Replace fan clutch if harnesses or wires are broken.



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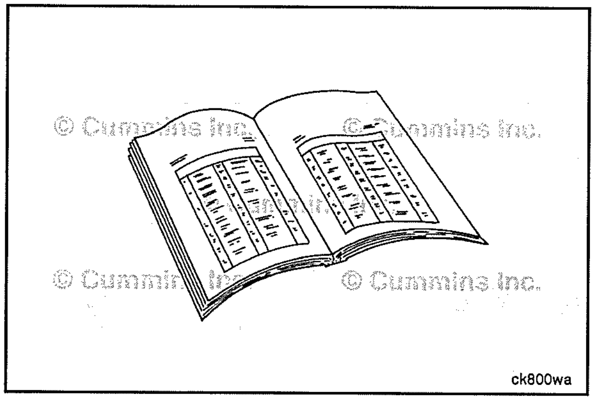
Install

Install the fan blades on the fan clutch assembly. See equipment manufacturer service information for torque specification.

Install the cooling fan assembly onto the fan pulley. Refer to Procedure 008-089 in Section 8.

Connect the fan clutch connector to the engine harness.



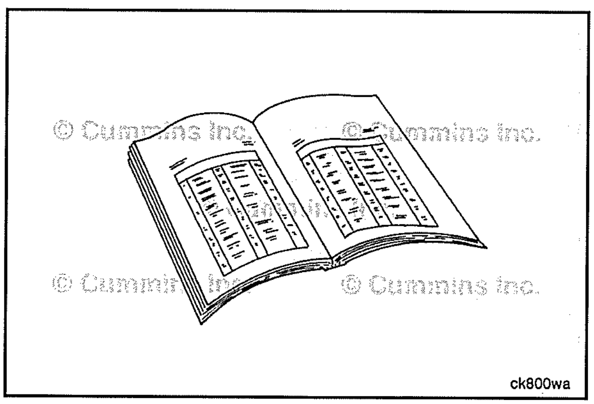
ck800wa

Finishing Steps

WARNING

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

- Install the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for proper operation.



ck800wa

Fan Hub, Belt Driven (008-036)

Preparatory Steps

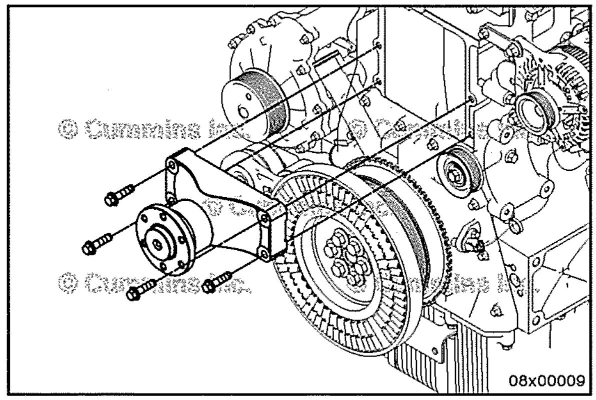
WARNING

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

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the cooling fan. See equipment manufacturer service information for instructions.
- Remove the fan pulley and spacer. Refer to Procedure 008-089 in Section 8.

Remove

Remove the four capscrews and the fan support.



08x00009

Clean and Inspect for Reuse

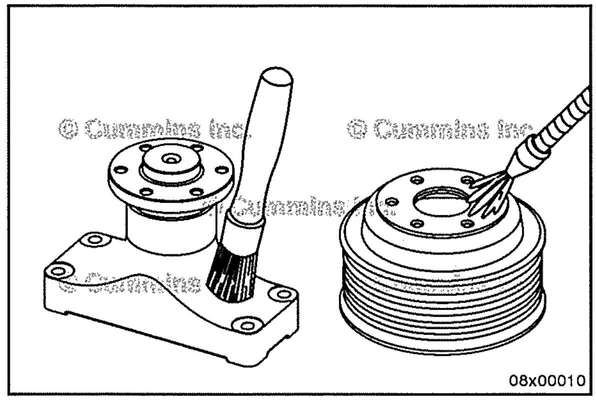
⚠WARNING⚠
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

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

⚠CAUTION⚠
Do not expose the cooling fan drive belt to solvents, acids, or alkaline materials for cleaning. Belt damage can result.

Clean the fan hub and fan pulley with solvent.

Dry with compressed air.



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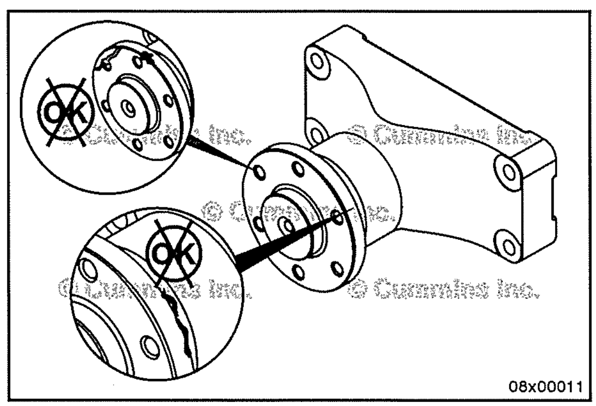
Inspect the fan hub for indications of oil seal leakage.

Inspect the fan hub for cracks or other damage.

Inspect the fan hub chamfer and pulley mating surface for damage.

Replace the fan hub if damage is found.



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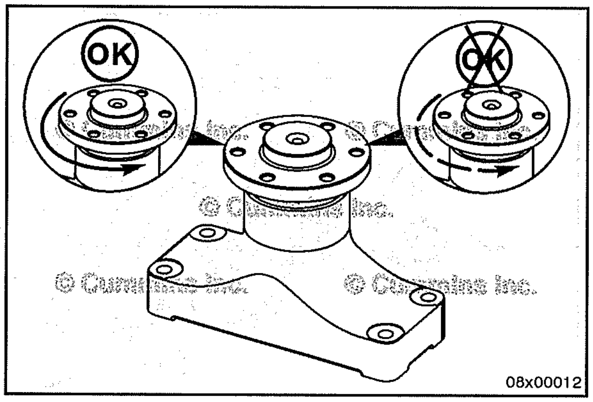
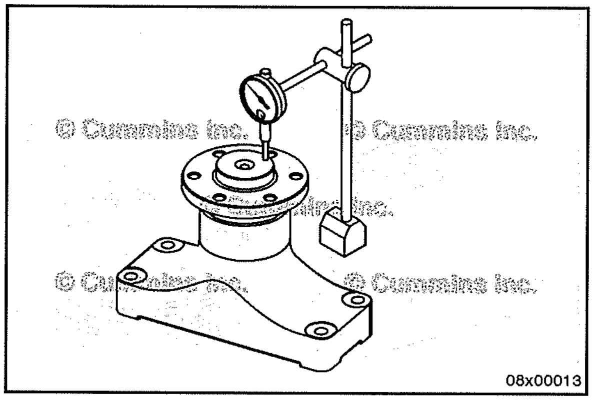


Turn the fan hub by hand to check for freedom of rotation.

The fan hub **must** spin freely without any wobble or excessive end clearance.



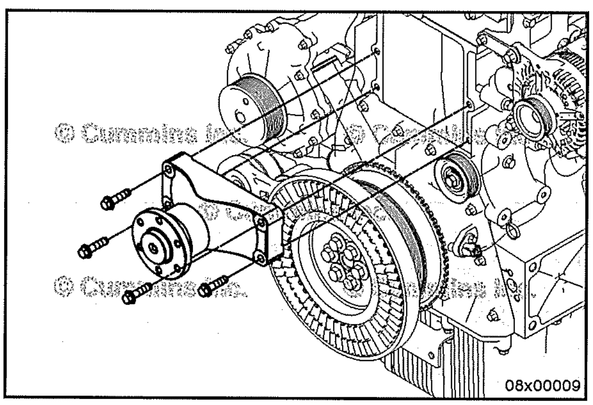
Inspect the fan hub bearing for wear.

The bearing **must** have a minimal amount of side-to-side or end-play movement.

Replace the fan hub if there is more than 0.15 mm [0.006 in] of end play in the fan hub. Measure end play with a dial indicator, service tool Part Number 3376050.

Fan Hub End Play

mm		in
0.15	MAX	0.006

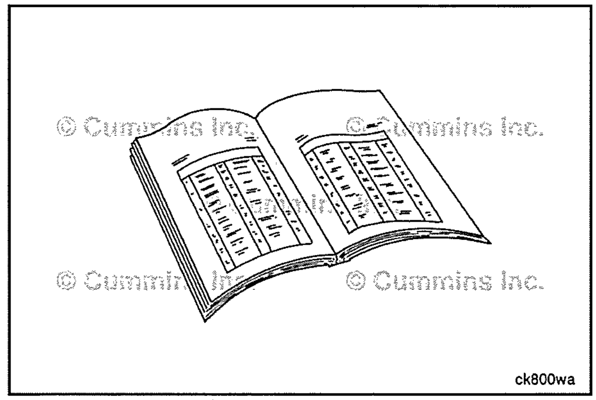


Install

Install the fan hub and four capscrews.

Torque Value: 46 N•m [34 ft-lb]

Finishing Steps



⚠WARNING⚠

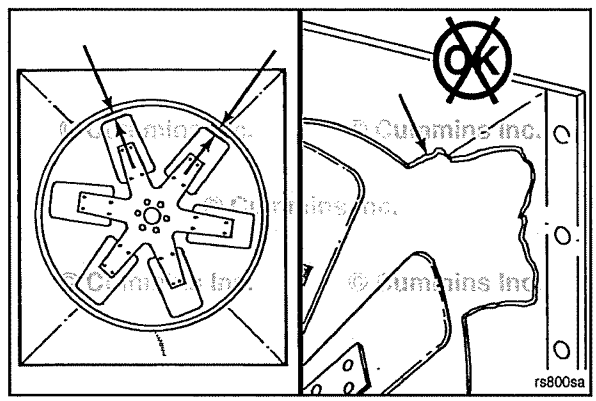
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

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

- Install the fan pulley and spacer. Refer to Procedure 008-089 in Section 8.
- Install the cooling fan. See equipment manufacturer service information.
- Install the drive belt. Refer to Procedure 008-002 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for proper operation.

Fan Shroud Assembly (008-038)

Initial Check

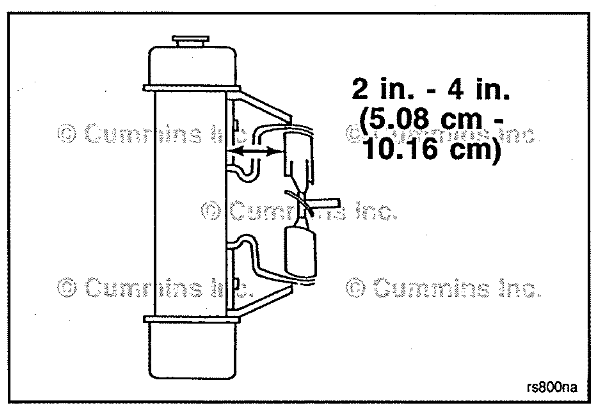


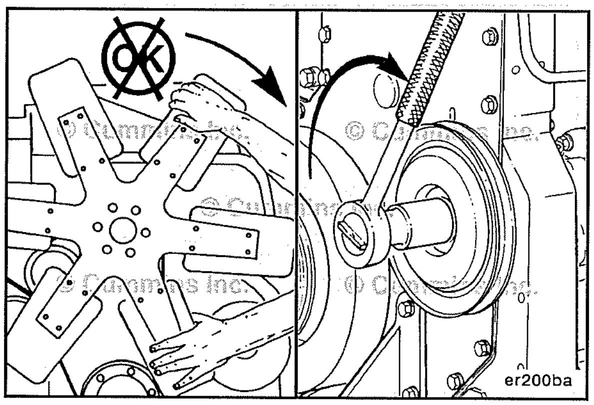
⚠CAUTION⚠

The fan shroud must be installed correctly, be in good condition, and the shroud-to-fan clearance must be within the manufacturer's specifications to allow proper airflow through the radiator to provide adequate engine cooling.

Inspect the fan shroud for proper fan clearance, cracks, air leaks, or other damage. Replace the fan shroud if necessary. See equipment manufacturer service information.

Cummins Inc. recommends the fan clearance be 5.08 to 10.16 cm [2 to 4 in] from the radiator core. Refer to the equipment manufacturer for alternative positions.



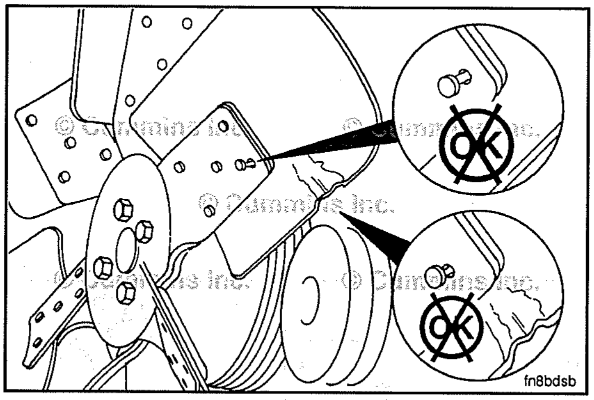


Fan, Cooling (008-040)

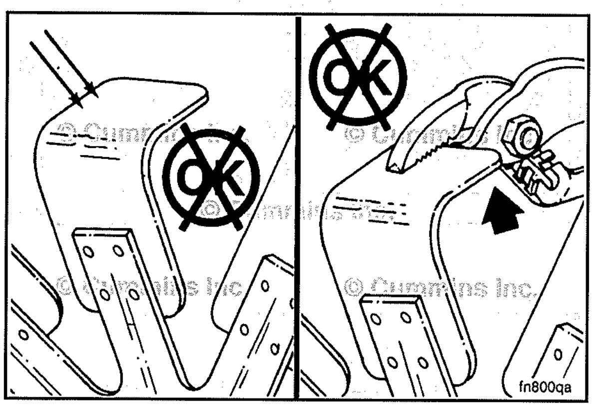
Inspect for Reuse

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.

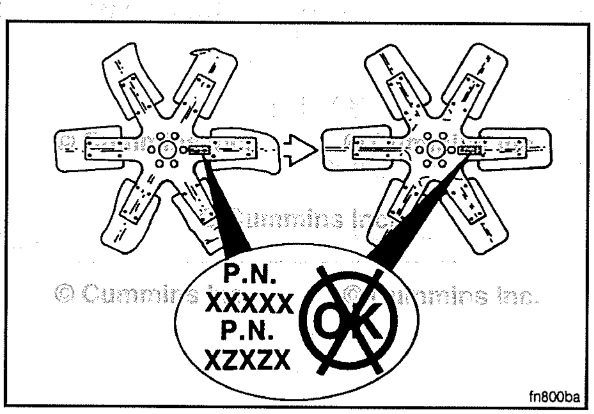


A visual inspection of the cooling fan is required daily. Check for cracks, loose rivets, and bent or loose blades. Check the fan to make sure it is securely mounted. Tighten the capscrews, if necessary.



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.



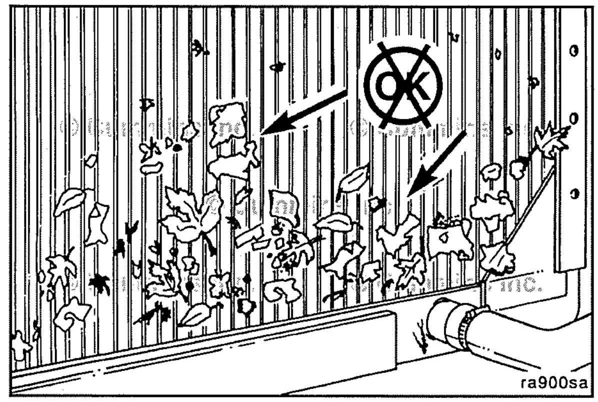
Replace original equipment fan that is damaged with a fan of the identical part number. Cummins Inc. **must** approve any other fan changes to be covered under warranty.

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

Radiator (008-042)

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.

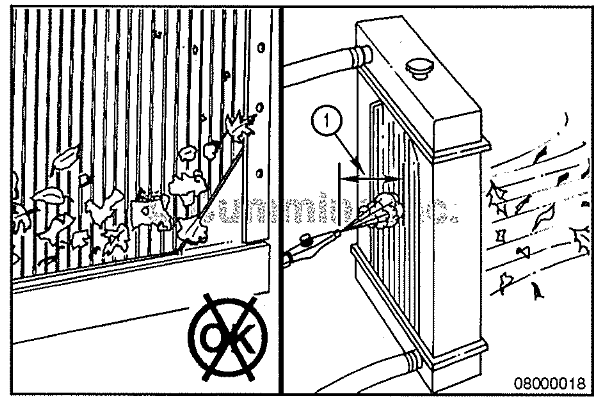
CAUTION

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.

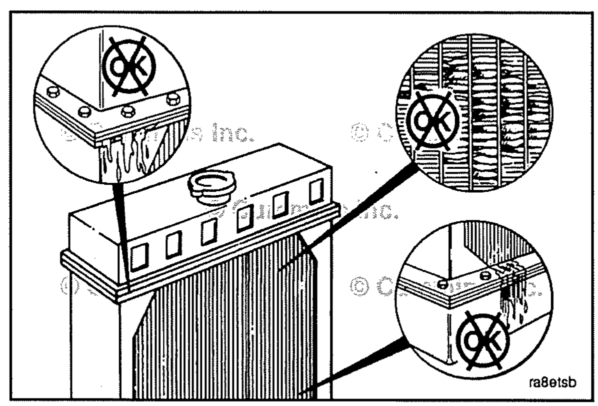
Air Pressure: 552 kPa [80 psi]

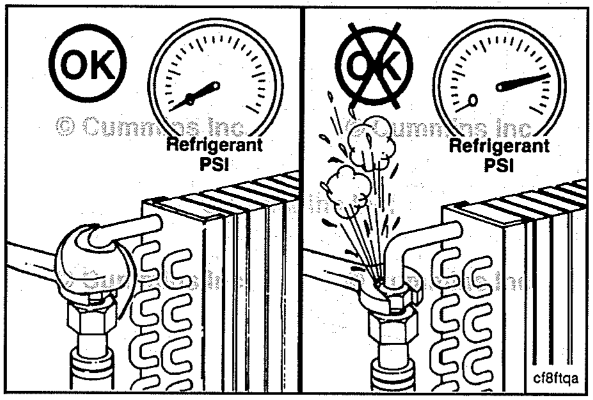


Inspect the radiator for bent or broken fins.

Inspect the radiator core and gasket for leaks.

If the radiator **must** be replaced, see equipment manufacturer service information.

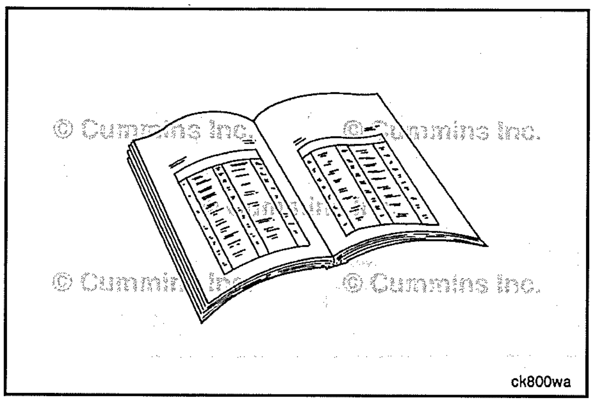




⚠WARNING⚠
If a liquid refrigerant system (air conditioning) is used, wear eye and face protection, and wrap a cloth around the fittings before removing. Liquid refrigerant can cause serious eye and skin injuries.

⚠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.



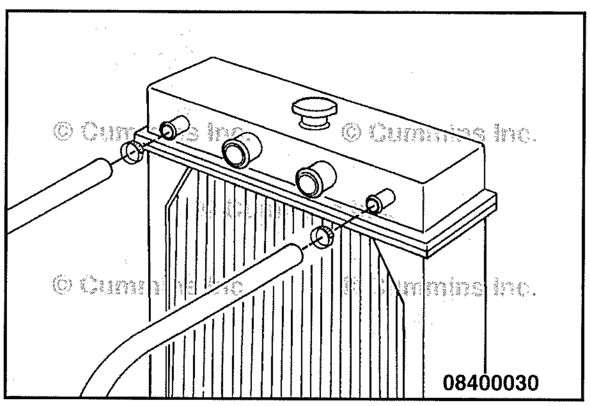
Radiator Hoses (008-045)

Preparatory Steps

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

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

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



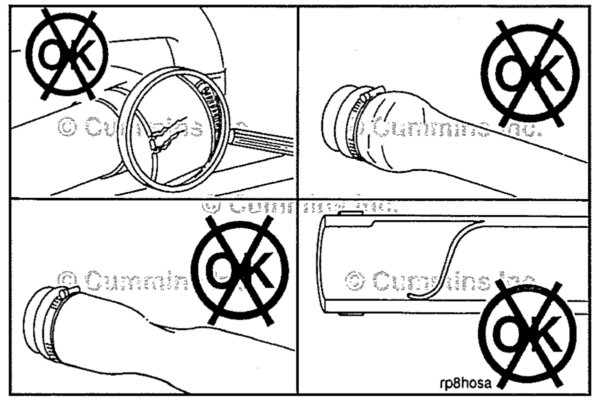
Remove

Remove the radiator hoses.

Inspect for Reuse

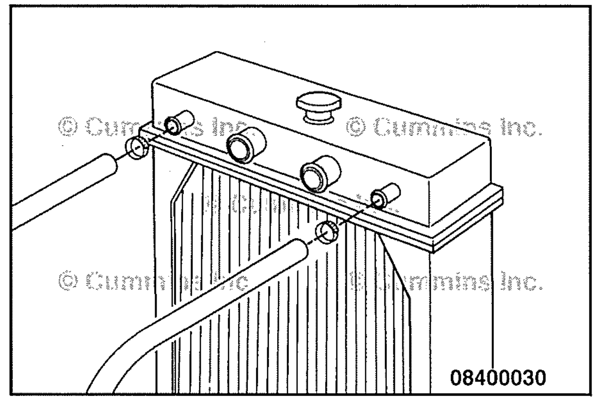
Inspect all hoses for cracks, cuts, or collapsing.

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



Install

Install the radiator hoses. See equipment manufacturer service information for torque values.

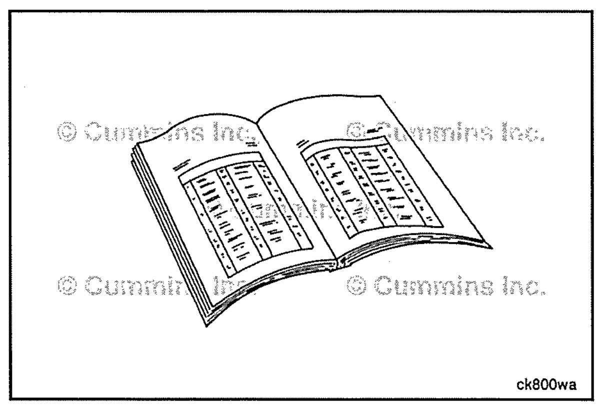


Finishing Steps

WARNING

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

- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine to normal operating temperature and check for leaks.

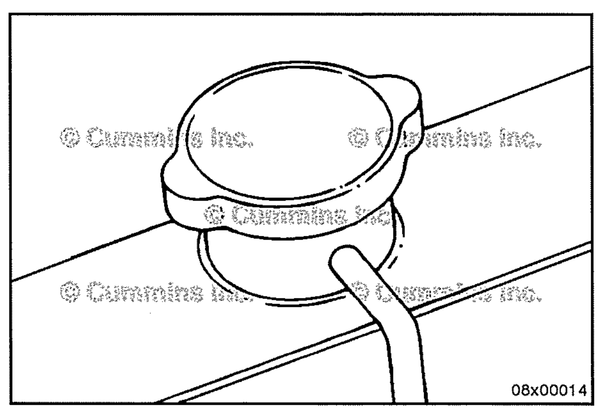


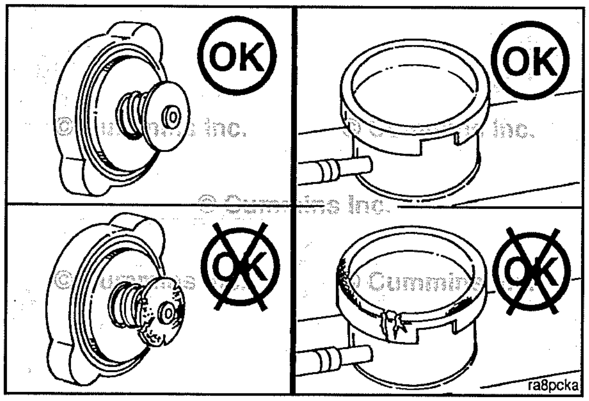
Radiator Pressure Cap (008-047)

General Information

The cooling system is designed to use a pressure cap to prevent boiling of the coolant. See equipment manufacturer service information's cooling system specifications for the correct radiator pressure cap for a specific engine application.

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





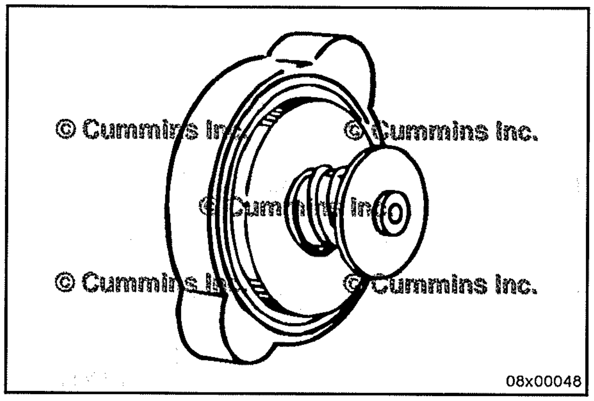
Inspect for Reuse

Make sure the correct radiator pressure cap is being used.

Inspect the rubber seal of the pressure cap for damage.

Inspect the radiator fill neck for cracks or other damage.

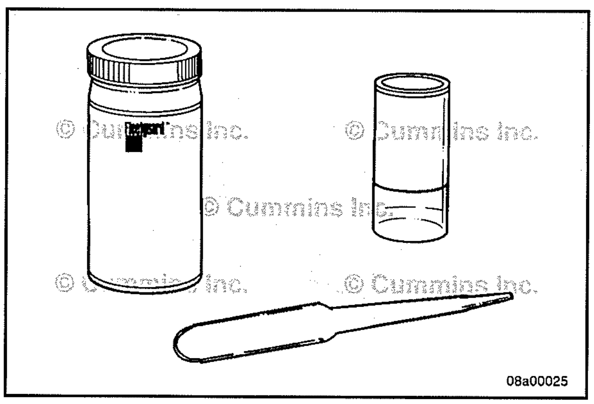
See equipment manufacturer service information for instructions if the fill neck is damaged.



Pressure-test the radiator cap. See equipment manufacturer service information for radiator cap test procedures.

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

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



Supplemental Coolant Additive (SCA) (008-060)

Initial Check

NOTE: Cummins Inc. recommends DCA4 as the Supplemental Coolant Additive. DCA4 is compatible with all permanent-type antifreeze except Methoxy Propanol. If Methoxy Propanol antifreeze is used, reduce the amount of DCA4 by one-third. This will prevent inhibitor loss due to precipitation, caused by chemical incompatibility.

Check the DCA4 concentration level whenever coolant is added to the cooling system between filter changes.

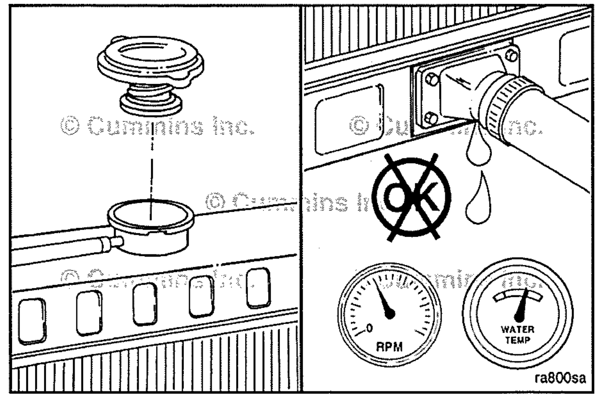
Use Fleetguard® coolant test kit, CC2626, to check the concentration level. Instructions are included with the test kit.

⚠WARNING⚠

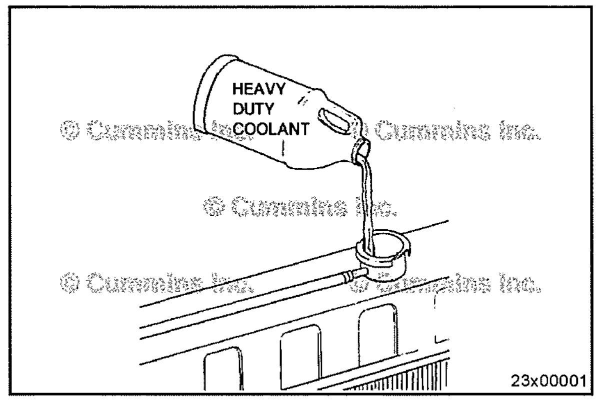
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

Operate the engine and check for coolant leaks.

After the air has been purged from the cooling system, check the coolant level again.



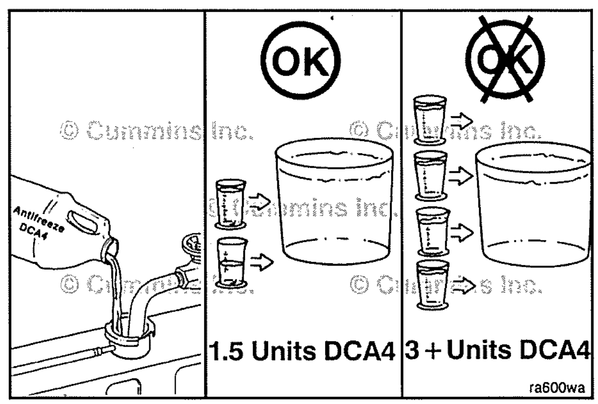
A supplemental coolant additive (DCA4) is used to prevent the buildup of corrosion and scale deposits in the cooling system.



⚠CAUTION⚠

Inadequate concentration of coolant additives can result in liner pitting and system corrosion. Excessive concentration can result in water pump seal leakage.

The recommended concentration level of supplemental coolant additives is 1.5 units per 3.8 liters [1 gal] of coolant. The additive level **must not** drop below 1.2 units or exceed 3 units per 3.8 liters [1 gal] of coolant.

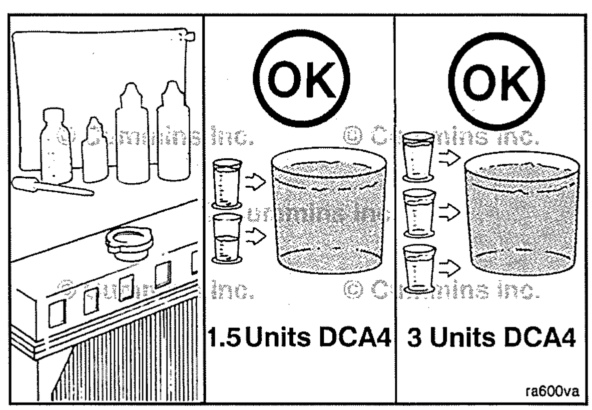


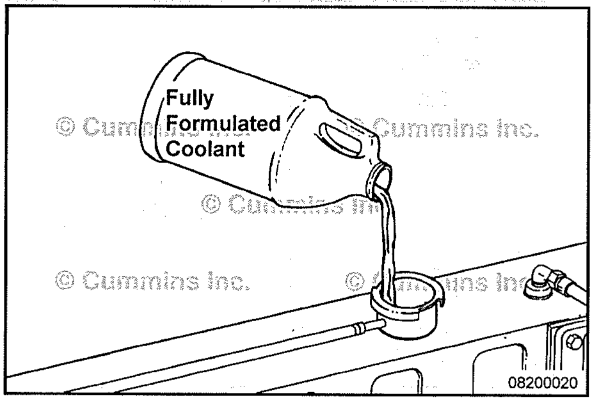
When changing the coolant, the initial DCA4 concentration **must** be between 1.5 units and 3 units per 3.8 liters [1 gal] of coolant (initial charge).

NOTE: The cooling system **must** be clean before adding DCA4.

Use the following procedure for cleaning instructions. Refer to Procedure 008-018 in Section 8.

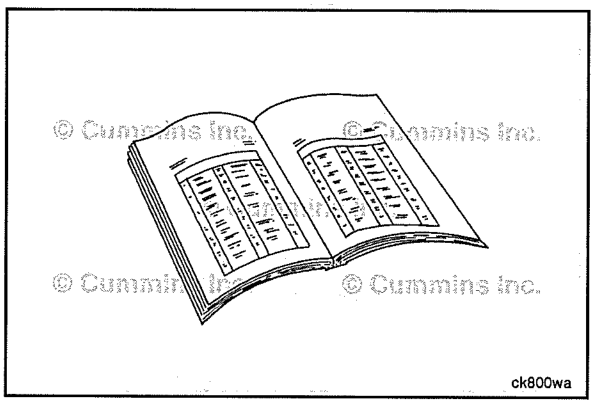
If coolant is added between drain intervals, additional DCA4 will be required unless the added coolant is precharged with additives as described in this section.





If coolant is added between drain intervals, additional SCA or equivalent will be required.

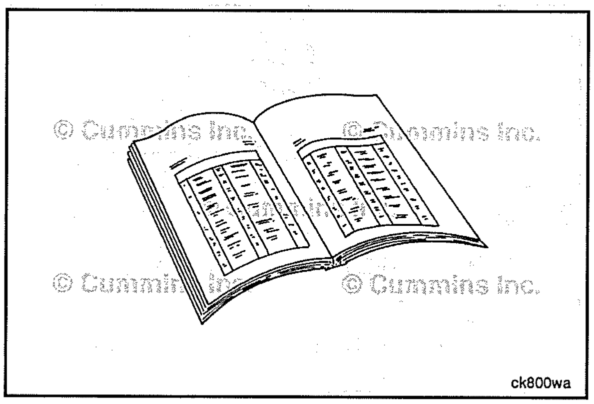
Cummins Inc. recommends using either a 50/50 mixture of high quality water and fully formulated antifreeze, or fully formulated coolant, when filling the cooling system. The fully formulated antifreeze or coolant **must** meet TMC RP 329 or TMC RP 330 specifications. Refer to Cummins® Coolant Requirements and Maintenance, Bulletin 3666132.



Water Manifold (008-061)

General Information

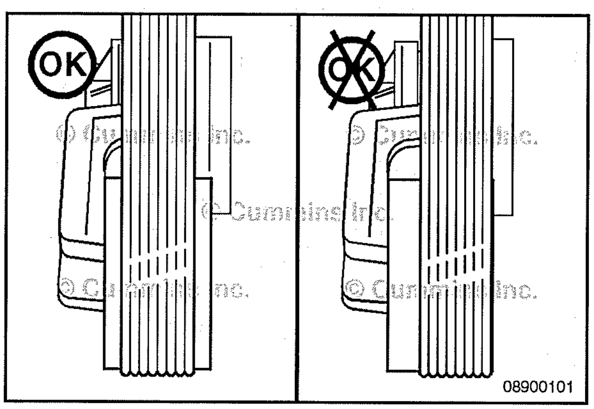
The water manifold on this engine **must** be serviced with the lubricating oil cooler module. Refer to Procedure 007-046 in Section 7.



Water Inlet Connection (008-082)

General Information

The water inlet connection on this engine is part of the lubricating oil cooler module. Refer to Procedure 007-046 in Section 7.



Cooling Fan Belt Tensioner (008-087)

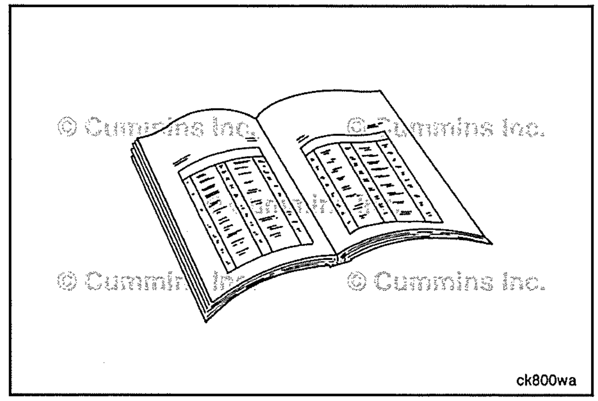
Initial Check

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

Preparatory Steps

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

- Disconnect the batteries. See equipment manufacturer service information.



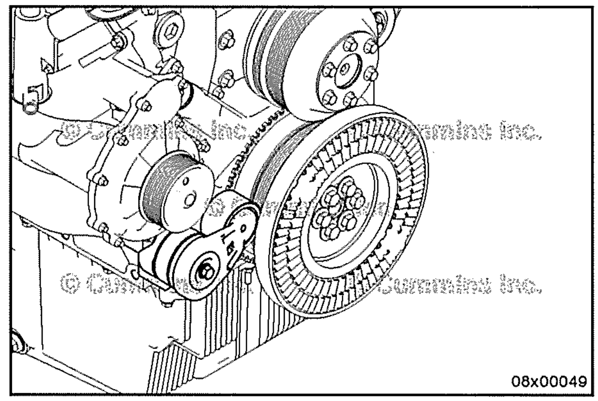
Remove

Remove the drive belt. Refer to Procedure 008-002 in Section 8.

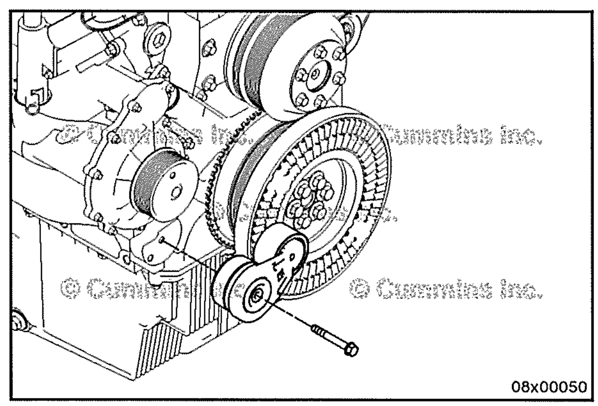
If the belt can be removed without pivoting the tensioner, then the spring in the tensioner has failed. Replace tensioner.

If the tensioner touches its internal stops while unloading the belt, the tensioner has failed. Replace the tensioner.

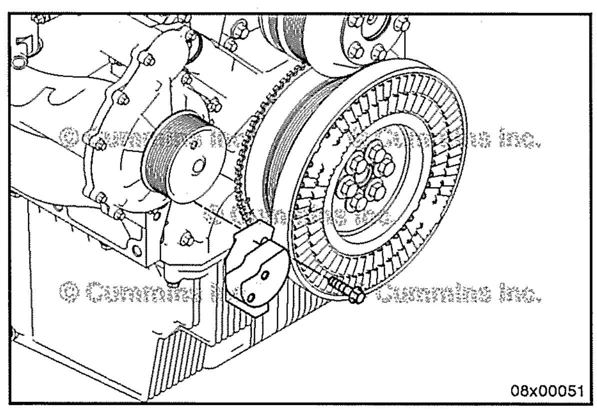
While tensioner is still on the engine, pivot the tensioner through the full range of motion. Tensioner **must** move with resistance from internal spring, if **not** replace tensioner.



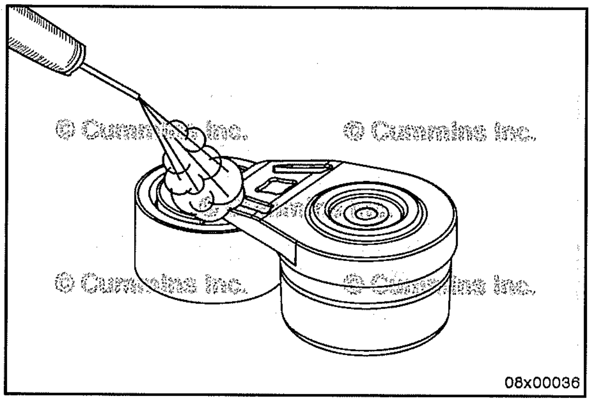
Remove the capscrew and belt tensioner from the bracket.



Remove the capscrews and bracket from engine.



Clean and Inspect for Reuse


08x00036

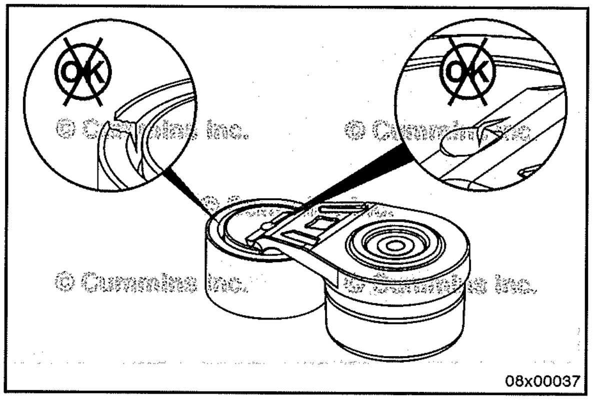
WARNING

The belt tensioner is spring loaded. Do not attempt to disassemble the tensioner. Personal injury can result.

WARNING

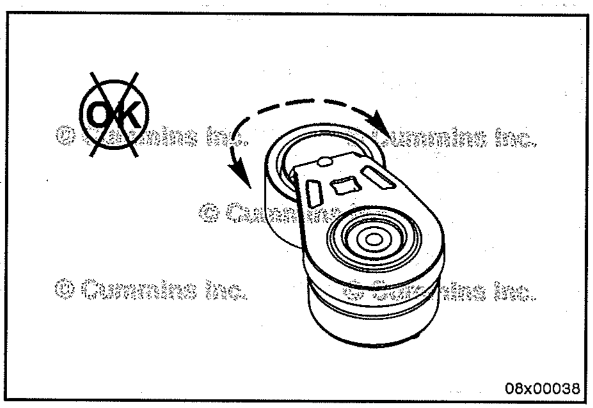
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Check the tensioner for dirt buildup. If tensioner has dirt buildup, remove and use safety solvent to clean belt tensioner.



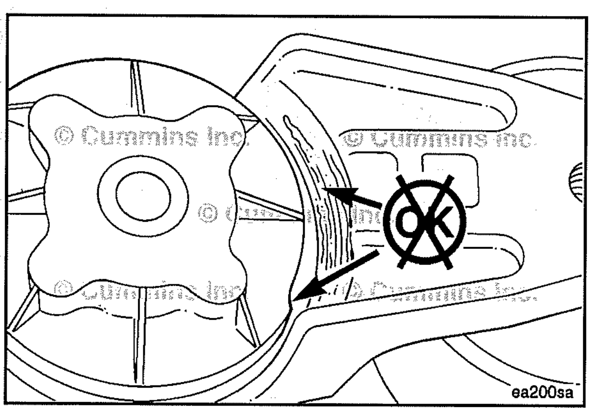
08x00037

Check the belt tensioner pulley and body for cracks. If cracks are found, replace the tensioner.



08x00038

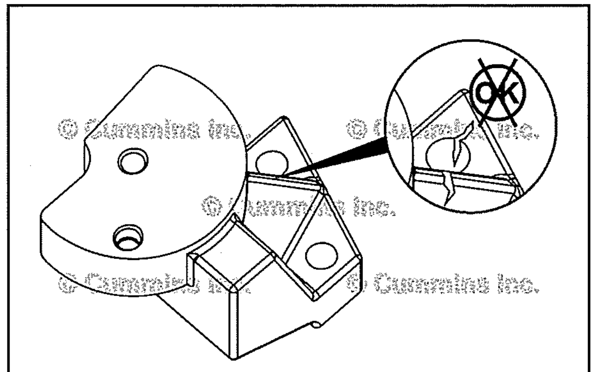
Spin the tensioner pulley. The pulley **must** spin freely. If pulley does **not** spin freely, replace the belt tensioner.



ea200sa

Inspect the belt tensioner for evidence of the tensioner pivoting arm contacting the stationary circular base of the tensioner or the fan shroud bracket. If so, the pivot bushing is excessive worn. Replace the belt tensioner.

Inspect bracket for cracks or damages. Replace if damaged.



08x00039

Install

Install the fan shroud bracket and mounting bracket capscrews.

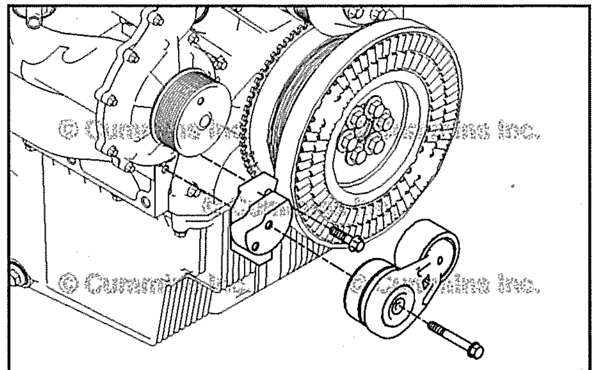
Tighten the capscrew.

Torque Value: 55 N•m [41 ft-lb]

Install the belt tensioner and capscrew.

Tighten the capscrew.

Torque Value: 55 N•m [41 ft-lb]

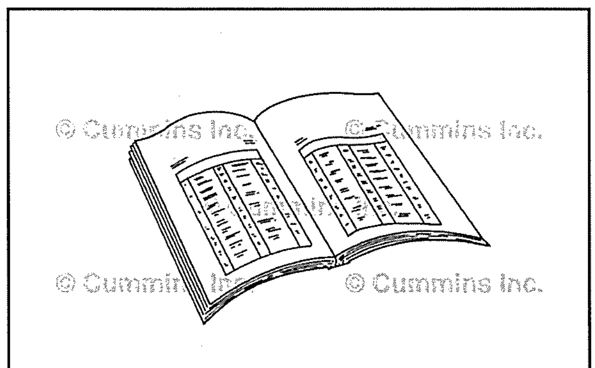

08x00052

Finishing Steps

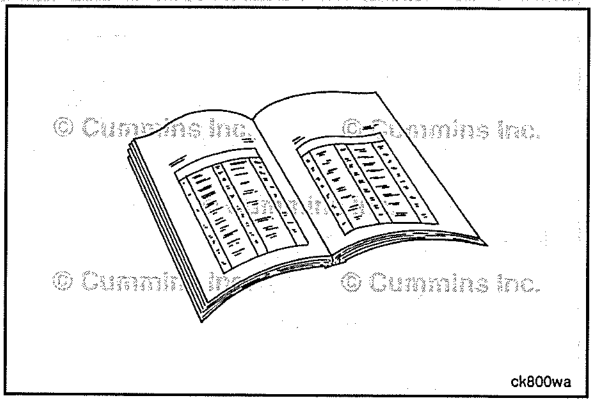
WARNING

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 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for proper operation.


ck800wa

Fan Pulley (008-089)

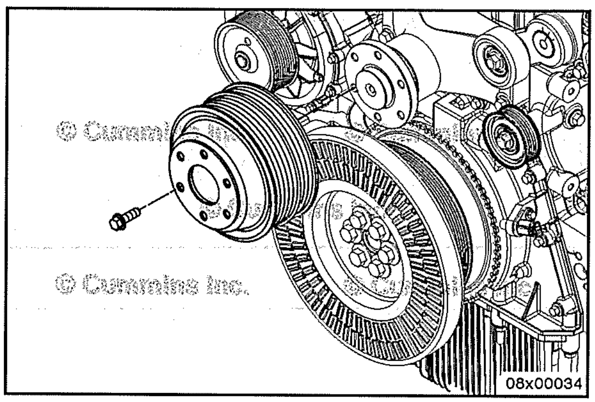


Preparatory Steps

WARNING

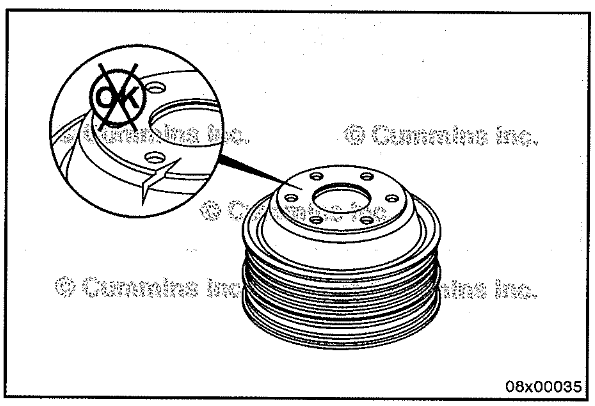
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.



Remove

Remove the cooling fan and fan pulley by loosening the six fan pulley mounting capscrews.



Clean and Inspect for Reuse

Inspect the fan pulley for cracks, excessive wear in the belt grooves, and other damage.

Replace the pulley if damage is found.

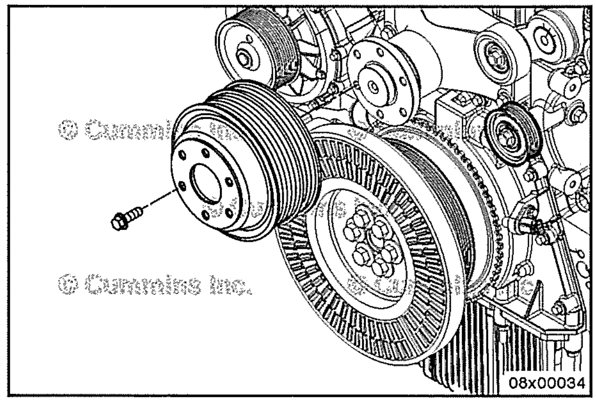
Install

Install the fan pulley on the fan hub.

Install the cooling fan and six mounting capscrews.

Tighten the capscrews in a star pattern.

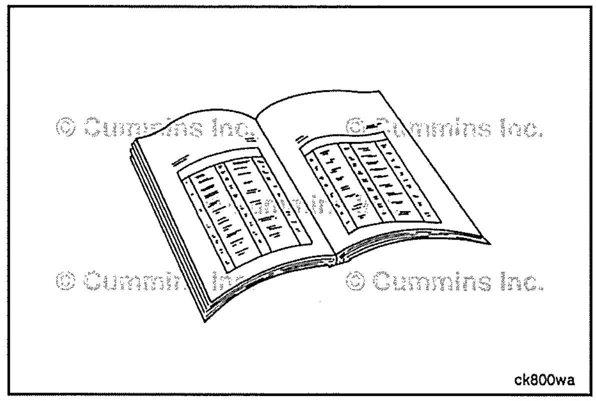
Torque Value: 46 N•m [34 ft-lb]



Finishing Steps

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

- Connect the batteries. See equipment manufacturer service information.
- Install the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Operate the engine and check for proper operation.

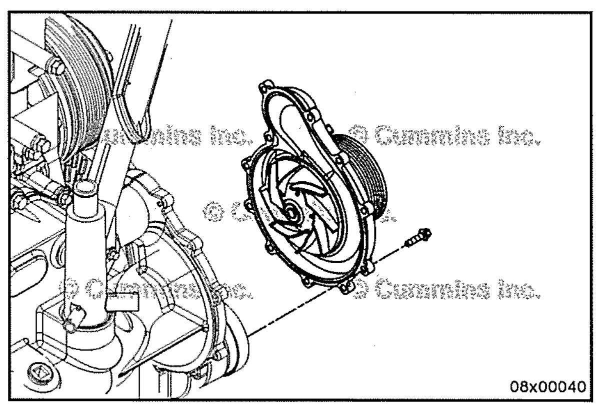


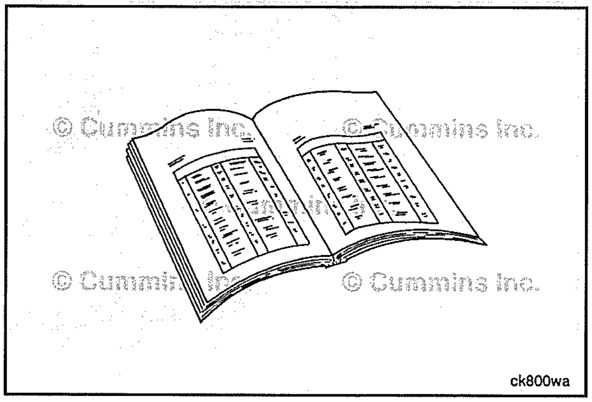
Water Pump Cartridge (008-102)

General Information

This engine features a cartridge style water pump. The housing for the water pump cartridge is integrated into the lubricating oil cooler housing. This procedure **only** includes the water pump cartridge. Refer to Procedure 007-046 in Section 7 for more information on the water pump housing.

The water pump cartridge features a reusable gasket that is **not** serviceable. This gasket is designed to withstand repeated removals and installations. If the gasket is damaged, the water pump cartridge **must** be replaced.





Preparatory Steps

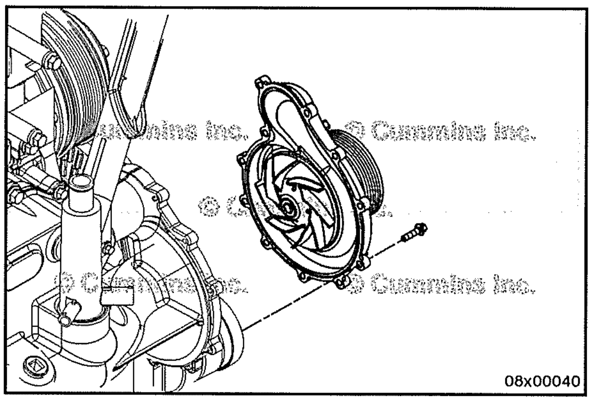
⚠WARNING⚠

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

⚠WARNING⚠

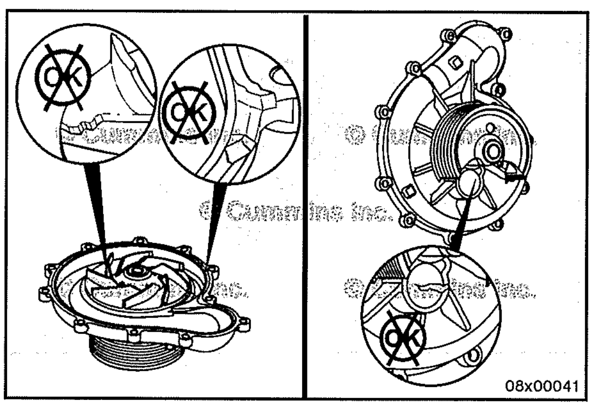
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

- Drain the coolant. Refer to Procedure 008-018 in Section 8.
- Remove the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the cooling fan drive belt tensioner. Refer to Procedure 008-087 in Section 8.



Remove

Remove the eleven mounting capscrews and the water pump cartridge from the front of the engine.



Clean and Inspect for Reuse

Inspect the water pump cartridge impeller for nicks or broken fins.

Inspect the water pump cartridge seal for cuts or other damage that will cause a water pump leak.

If the water pump or seal is damaged, the water pump cartridge **must** be replaced.

Inspect the water pump cartridge weep hole, located behind the water pump pulley on the bottom of the shaft.

If coolant deposits are present the water pump shaft seal is leaking and the water pump cartridge **must** be replaced.

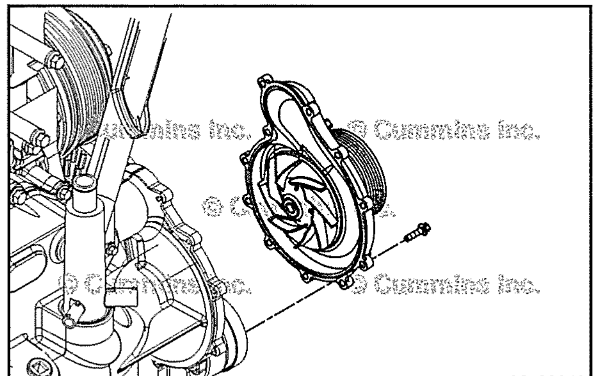
Install

Make sure the water pump mounting surfaces are clean.

Install the water pump cartridge and the mounting capscrews.

Tighten the capscrews evenly.

Torque Value: 7.4 N•m [65 in-lb]

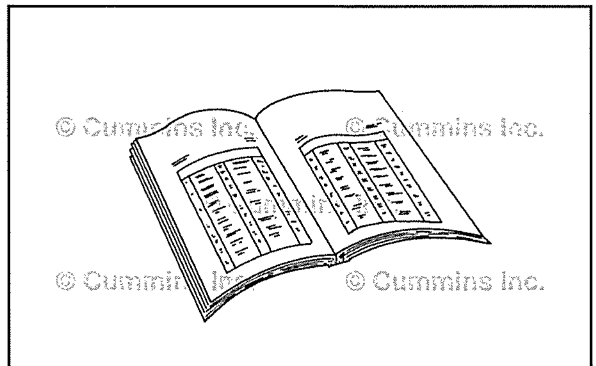


08x00040

Finishing Steps

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

- Install the cooling fan drive belt tensioner. Refer to Procedure 008-087 in Section 8.
- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine and check for leaks.



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Notes

Section 9 - Drive Units - Group 09

Section Contents

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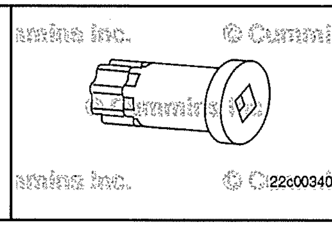
Service Tools

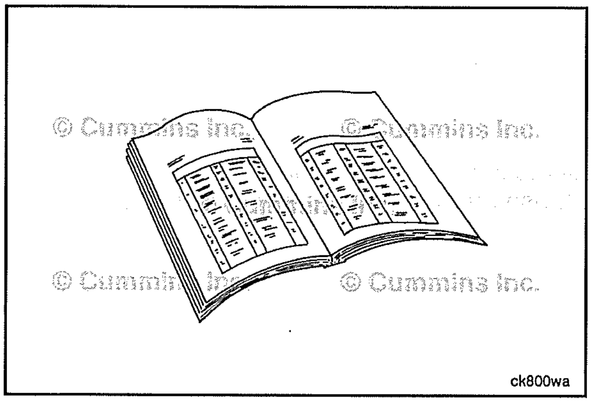
Drive Units

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
4919092	**Engine Barring Tool** Used to bar the engine.	

Hydraulic Pump Drive (009-016)

General Information

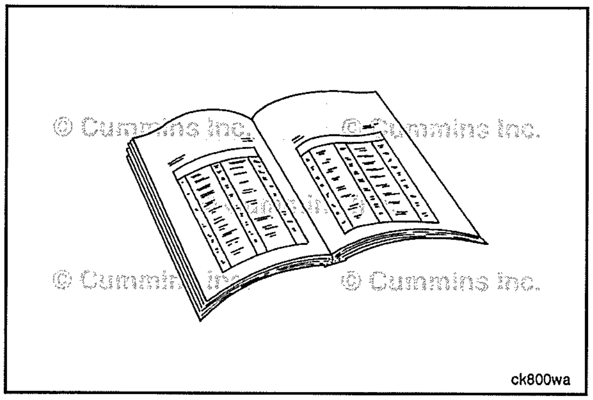


Hydraulic pumps are driven by the engine's gear train through the use of the hydraulic drive adapters. This engine uses an air compressor mounted hydraulic drive adapter.

Hydraulic Drive Adapter

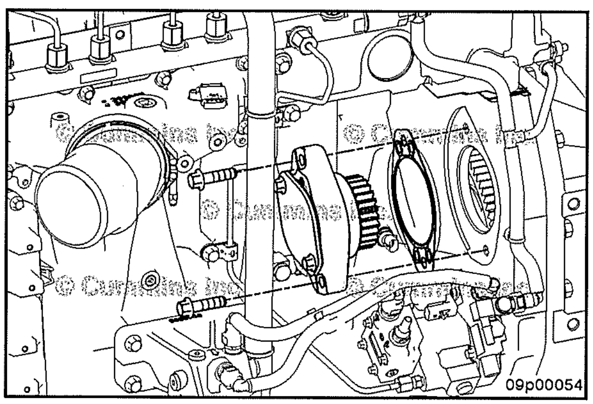
- The most common hydraulic pump used in this location is a power steering pump. The OEM is typically responsible for installing the power steering pump, including selecting the pump's manufacturer and size for the vehicle. See equipment manufacturer service information for installation instructions.

Preparatory Steps



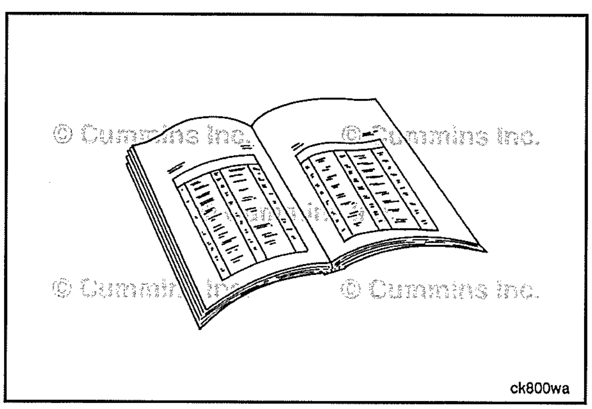
- Disconnect all hydraulic lines from the pump. See equipment manufacturer service information.

Remove



Remove the hydraulic pump. See equipment manufacturer service information.

Clean and Inspect for Reuse



WARNING

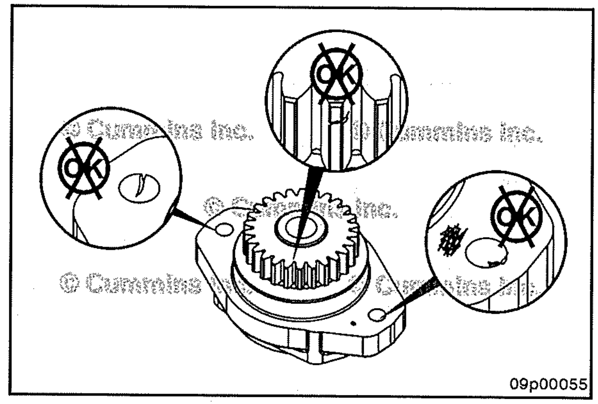
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

Clean the hydraulic pump and coupling. See equipment manufacturer service information for cleaning instructions.

Inspect the components for damage.



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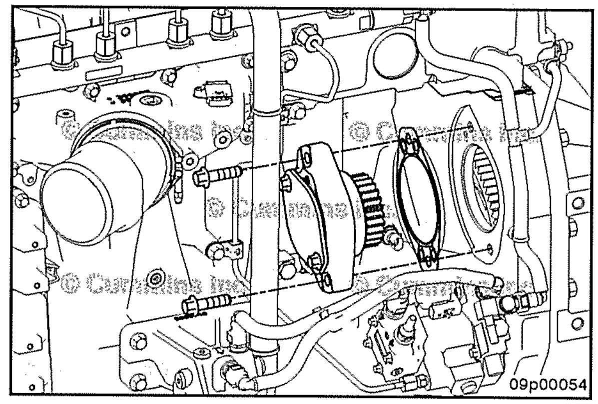
Install

Install the hydraulic pump. See equipment manufacturer service information for installation instructions and torque specifications.



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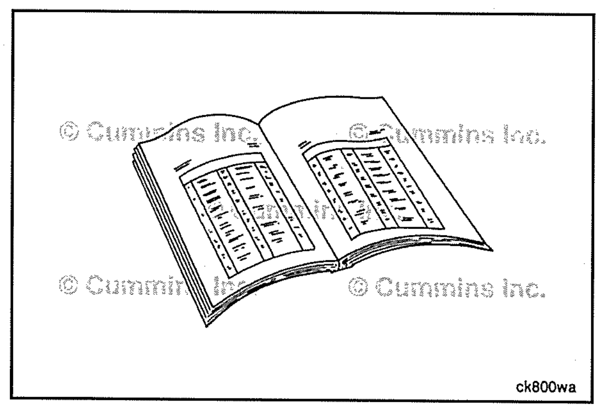
Finishing Steps

- Connect all hydraulic lines to the pump. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks and proper operation.



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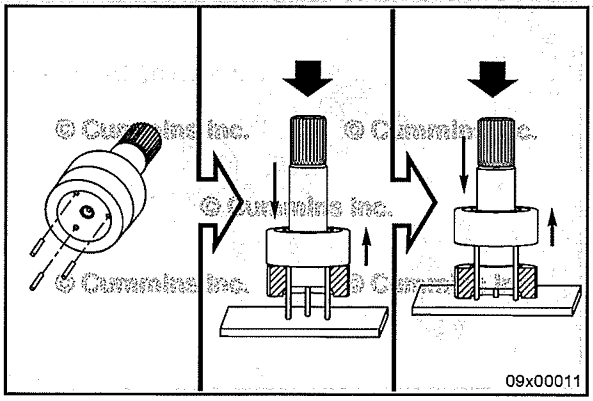


⚠CAUTION⚠

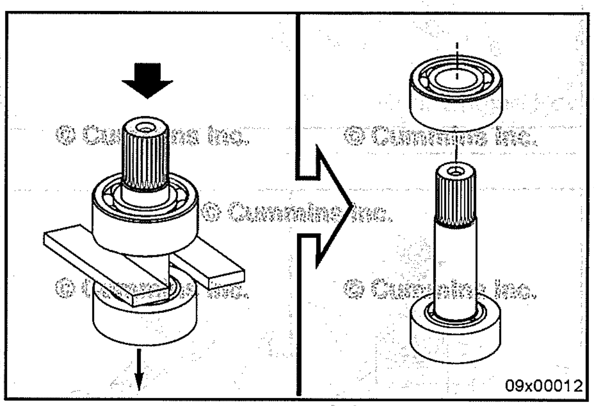
Do not pry on the outer metal ring of the double row bearing between the gear teeth. Damage to the gear teeth or bearing will occur.

- Place three steel pins into the 6-mm drilled holes in the gear end of the accessory drive shaft. The steel pins should be in contact with the inner metal ring of the double row bearing.
- Place the accessory drive shaft with three steel pins into a hydraulic press with the spline end of the accessory drive shaft facing up.
- Press the double row bearing away from the machined diameter surface of the gear by applying pressure to the end of the accessory drive shaft with the splines.

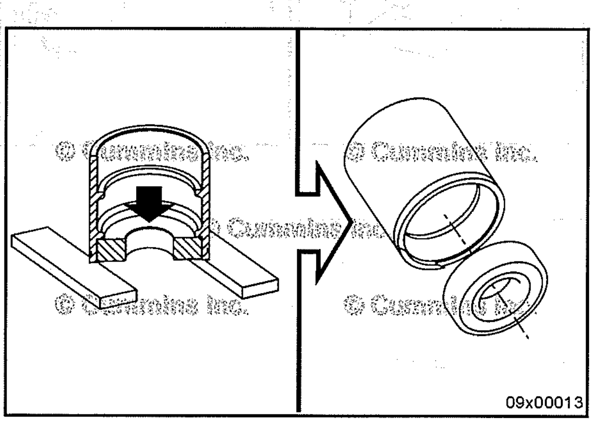
Pin Diameter Requirements

mm		in
4.5	MIN	0.18
5.5	MAX	0.22

NOTE: The minimum pin length is 55 mm [2.17 in].



- Once double row bearing is pressed far enough away from the machined surface of the gear, reposition the accessory drive shaft so that it is supported by the inner and outer metal rings of the double row bearing.
- Continue pressing the double row bearing off the accessory drive shaft applying pressure to the end of the accessory drive shaft with the splines.



⚠CAUTION⚠

There should not be any hammers used during the dis-assembly process. Damage to the bearings and/or accessory drive shaft will occur.

⚠CAUTION⚠

There should not be any heating of the bearing during the dis-assembly process. Damage to the bearings will occur.

- Place PTO housing with single row bearing into hydraulic press with empty bore for double row bearing facing up.
- Press single row bearing out of the PTO housing by applying pressure to the inner metal ring of the single row bearing.

Clean and Inspect for Reuse

⚠WARNING⚠

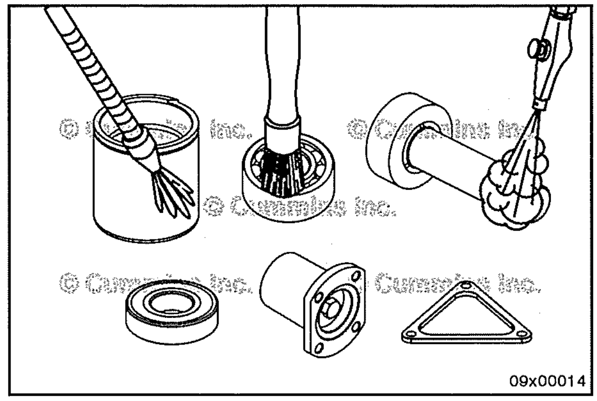
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

⚠WARNING⚠

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

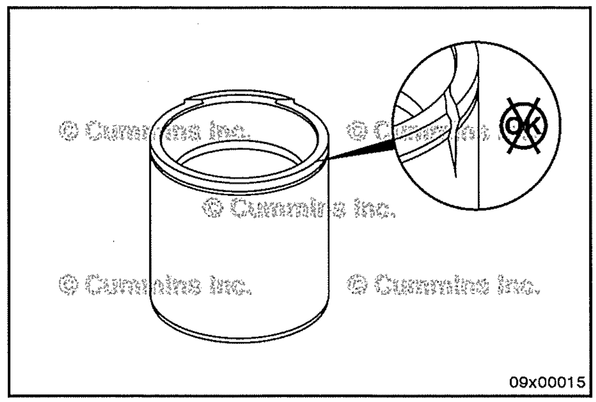
Clean the REPTO housing, output shaft assembly, output flange, and bearings with solvent.

Dry with compressed air.

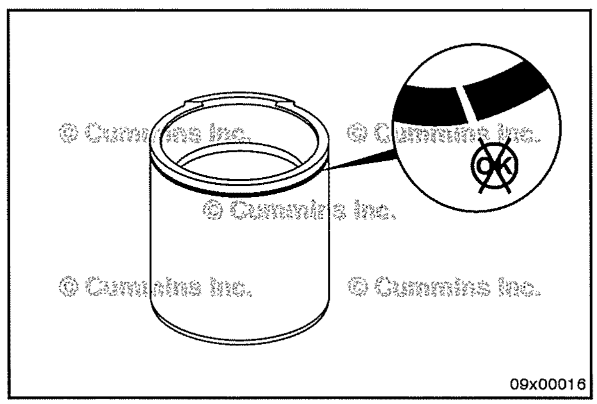


Inspect the REPTO housing for cracks and damage.

Replace the housing if it is cracked or damaged.

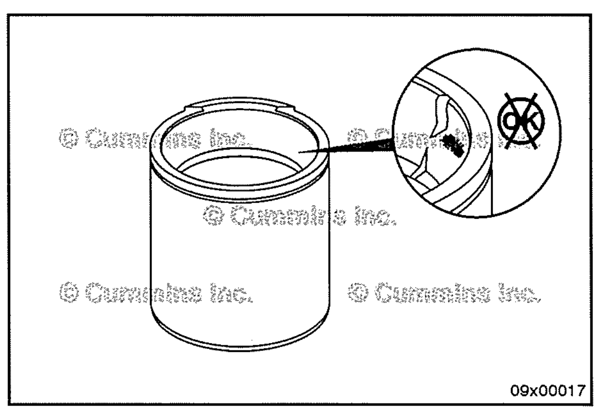


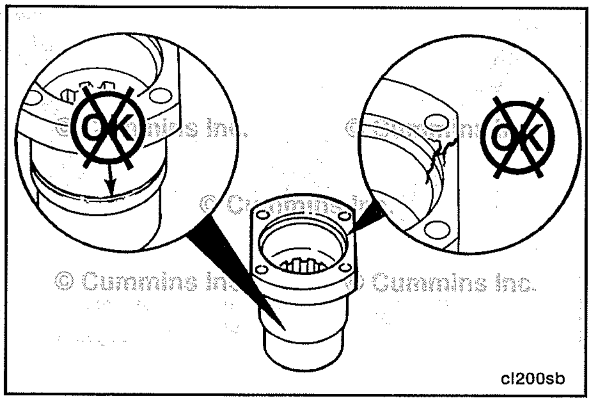
Inspect the O-ring grove and replace the O-ring.



Inspect the inner and outer bearing bores for wear and other damage.

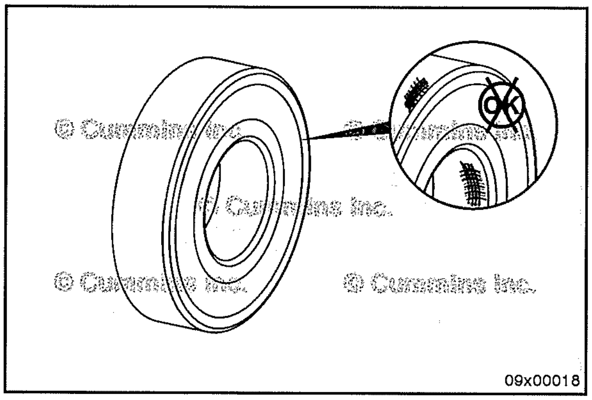
If the bearing bore in the housing are worn or otherwise damaged, replace the whole housing assembly.





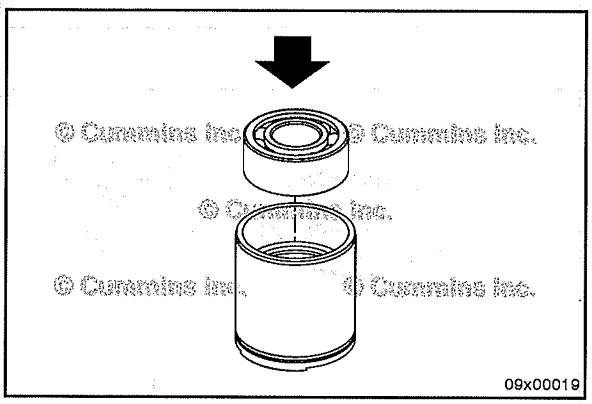
Inspect the output flange for damage.

Replace the flange, if necessary.



Inspect the bearings for wear, leaks, and damage.

If any evidence of these is found, the bearing **must** be replaced.



Assemble

⚠CAUTION⚠

Double row bearing should not be pressed into PTO housing using the inner metal ring alone. Damage to the bearing will occur.

⚠CAUTION⚠

There should not be any hammers used during the assembly process. Damage to the bearings and/or accessory drive shaft will occur.

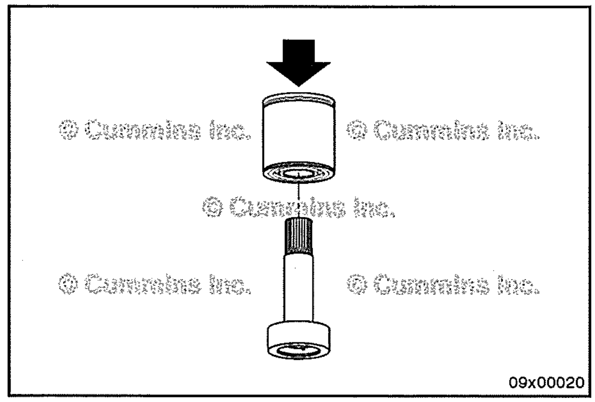
⚠CAUTION⚠

There should not be any heating of the bearing during the assembly process. Damage to the bearings will occur.

Place PTO housing into hydraulic press with bore for double row bearing facing up.

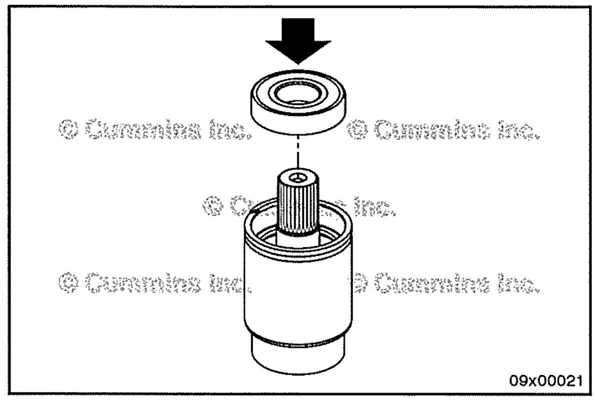
- Press double row bearing into PTO housing bore applying pressure to either the outer metal ring alone or both the outer metal ring and inner metal ring supported together.

⚠CAUTION⚠
PTO housing and double row bearing should not be pressed onto accessory drive shaft using the PTO housing surface. Damage to the bearing will occur.



- Place accessory drive shaft into hydraulic press with splines facing up.
- Press PTO housing and double row bearing onto accessory drive shaft applying pressure to the inner metal ring of the double row bearing using hollow pipe or sleeve.
- Press PTO housing and double row bearing onto accessory drive shaft until inner metal ring of the double row bearing is fully seated and in contact with the machined 66 diameter surface of the gear.

⚠CAUTION⚠
Single row bearing should not be pressed onto accessory drive shaft and into PTO housing using the outer metal ring of the single row bearing alone. Damage to the bearing will occur.

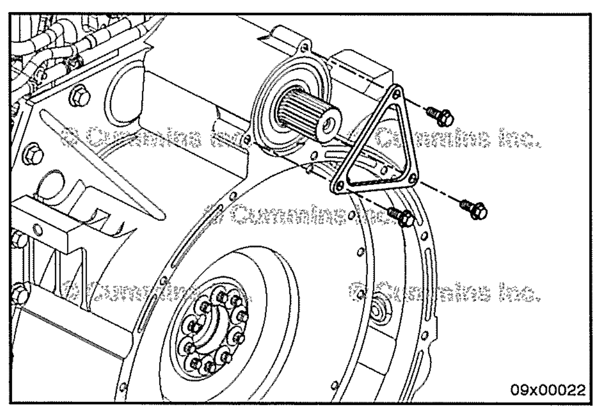


⚠CAUTION⚠
There should not be any hammers used during the assembly process. Damage to the bearings and/or accessory drive shaft will occur.

⚠CAUTION⚠
There should not be any heating of the bearing during the assembly process. Damage to the bearings will occur.

- Place PTO housing with double row bearing and accessory drive shaft into hydraulic press.
- Press single row bearing onto accessory drive shaft and into PTO housing bore by applying pressure with hollow pipe or sleeve to either the inner metal ring alone or both the inner metal ring and outer metal ring supported together.
- Press single row bearing onto accessory drive shaft and into PTO housing bore until outer surface of single row bearing is flush with end of PTO housing.

Install



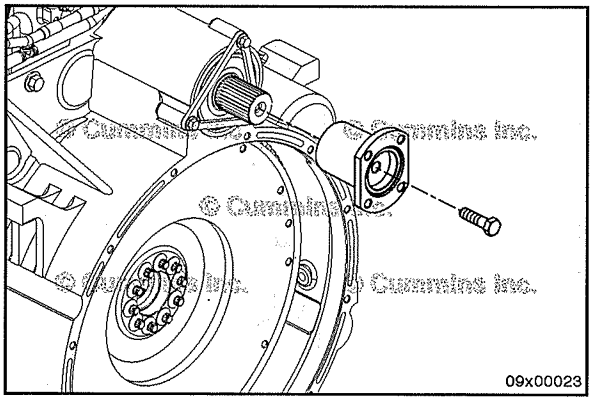
Engage the gears and insert the REPTO assembly into the flywheel housing.

The REPTO assembly **must** be installed with the lip on bottom, so the triangular clamping plate will line up with the mounting screws.

NOTE: Gear timing is **not** required.

Install and torque the REPTO mounting capscrews.

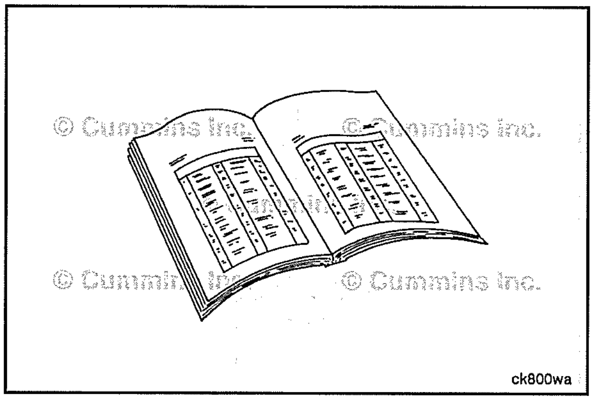
Torque Value: 46 N•m [34 ft-lb]



Install the output flange over the splines of the REPTO gear shaft.

Install and torque the output flange capscrew.

Torque Value: 180 N•m [133 ft-lb]

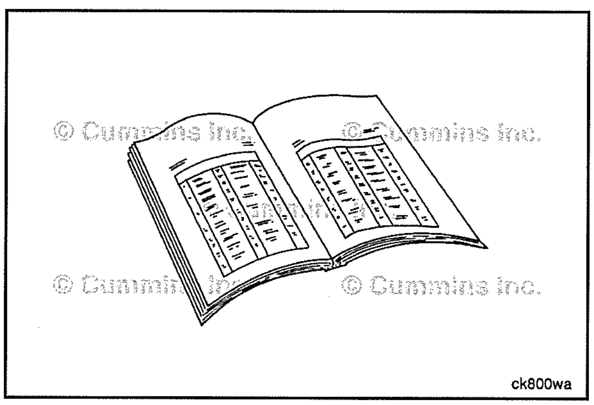


Finishing Steps

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.

- Install the power takeoff (PTO) shaft and OEM components removed to gain access to the REPTO unit. See equipment manufacturer service information.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and the PTO equipment to verify proper operation.



Refrigerant Compressor (009-051)

Preparatory Steps

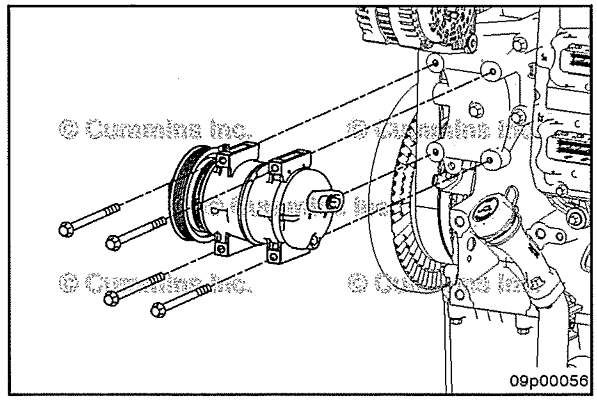
WARNING

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.

NOTE: If the refrigerant compressor is **only** being removed to access other components, refrigerant system depressurization is **not** required. Leave the hoses connected and properly support the refrigerant compressor to other vehicle components.

- Depressurize the refrigerant system, **only** if complete removal of the refrigerant compressor is required. See equipment manufacturer service information.
- Remove the refrigerant lines, if necessary. See equipment manufacturer service information.
- Disconnect the electrical connector, if necessary.
- Remove the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.

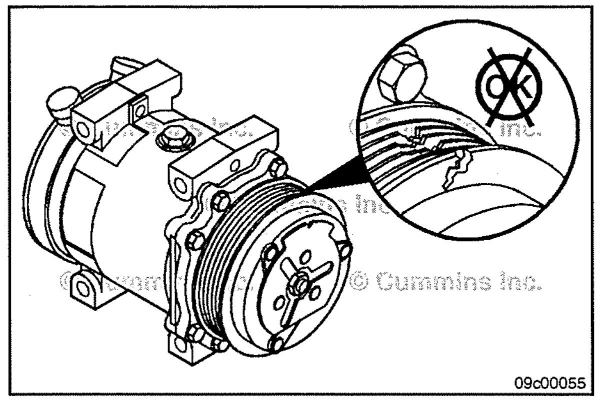
Remove



Remove the four refrigerant compressor mounting capscrews.

Remove the refrigerant compressor. See equipment manufacturer service information.

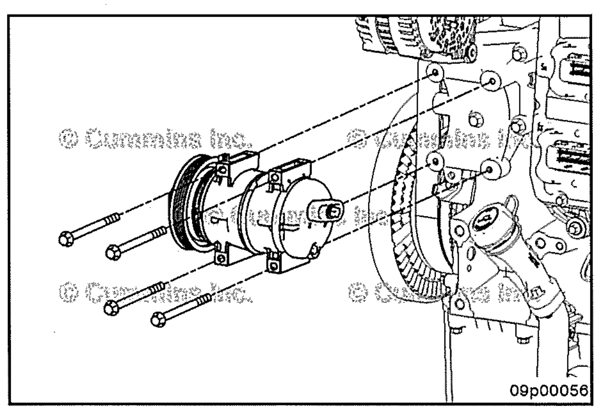
Clean and Inspect for Reuse



Inspect the refrigerant compressor pulley for cracks or broken grooves. Replace the refrigerant compressor if it is damaged.

See equipment manufacturer service information for proper compressor inspection on the various types and configurations available.

Install



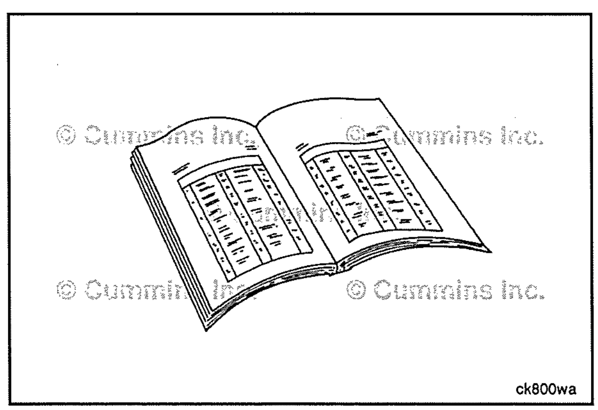
Install the refrigerant compressor. See equipment manufacturer service information.

Install the four mounting capscrews through the refrigerant compressor and refrigerant compressor bracket.

Tighten the capscrews in a crisscross pattern.

Torque Value: 23 N•m [204 in-lb]

Finishing Steps



- Install the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Connect the electrical connector, if disconnected.
- Install the refrigerant lines, if removed. See equipment manufacturer service information.
- Fill the refrigerant system, if depressurized. See equipment manufacturer service information.
- Operate the engine and check for leaks.

Notes

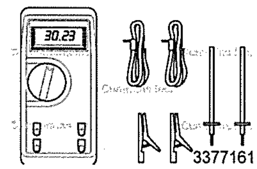
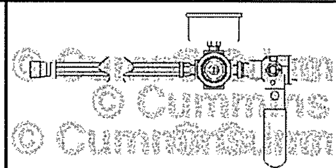
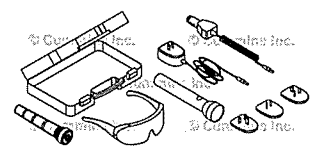
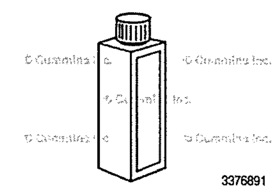
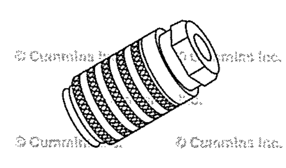
Section 10 - Air Intake System - Group 10

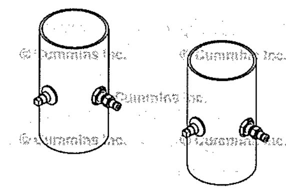
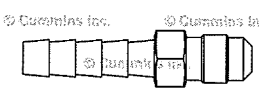
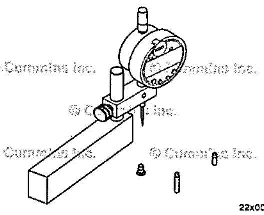
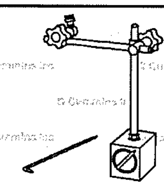
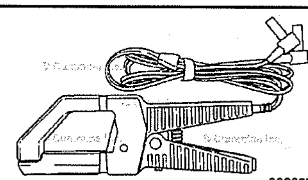
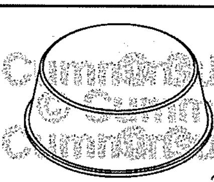
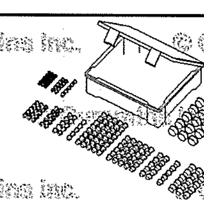
Section Contents

Service Tools

Air Intake System

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3400162	**Digital Multimeter Kit** This tool is used to test various electrical circuits. Includes deluxe multimeter 3164489, pressure adapter 3164491, and immersion probe 3164492. Note: Two of these kits are needed for charge air cooler testing.	
3164231	**Air Pressure Regulator Kit** Used to regulate air pressure.	
2892320	**Leak Test Kit** Used to detect leaks in all engine fluid systems (lubrication, coolant, and fuel) using a cordless "True UV" light that will detect the presence of fluorescent dye additive. The kit is also capable of detecting leaks in air conditioning systems, using the appropriate dye.	
3376891	**Fluorescent Tracer** Added to the oil and used with a black light to find oil leaks.	
2892116	**Penetration Oil** Used to free corroded fasteners and mechanical components.	
3376920	**Female Quick Connect 1/4 NPT**	

Tool No.	Tool Description	Tool Illustration
5298903	**Testing Boot Kit** This kit is used to provide testing ports in the charge air cooler piping. It contains two testing boots Part Number 5298904.	 22x00041
5298595	**Hose Barb Fitting** Used to check operation of turbocharger wastegate actuators.	 22x00030
3164438	**Dial Depth Gauge Assembly Kit** Used for measuring turbocharger axial motion and wastegate actuator movement.	 22x00032
3377399	**Magnetic Base Indicator Holder** Used for measuring wastegate actuator movement.	 22d00102
3824879	**Antiseize Lubricate** This lubricant is an all purpose antiseize lubricant that speeds assembly and disassembly of studs, bolts, capscrews, flanges, and fittings.	 22x00031
3164490	**Clamp-on Current Probe** Used to measure DC currents from 1 to 1000 amps or AC currents from 1 to 1000 amps.	 3823574
4919588	**Air Handling Clean Care Kit for Engine Components** Contains a variety of caps to prevent contamination of engine air handling plumbing during service procedures.	 22c00356
4919073	**Clean Care Kit** Used to cap or plug the turbocharger fittings during service to prevent debris from entering the system.	 22c00376

Air Cleaner Element (010-014)

General Information

⚠CAUTION⚠

Only use the approved Cummins Filtration™ direct flow replacement filter elements to service the air cleaner. Use of improper filters can lead to engine damage.

The direct flow air cleaner uses both primary and secondary air filter elements for Industrial applications. The direct flow air cleaner has been designed for a maximum restriction at 635 mm H_20 [25 in H_20], at which point the filter element(s) require changing. The secondary air filter elements **must** be changed every other time the primary air filter elements are changed. Proper inspection of the secondary air filter elements **must** be performed and the secondary elements changed, if necessary.

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.

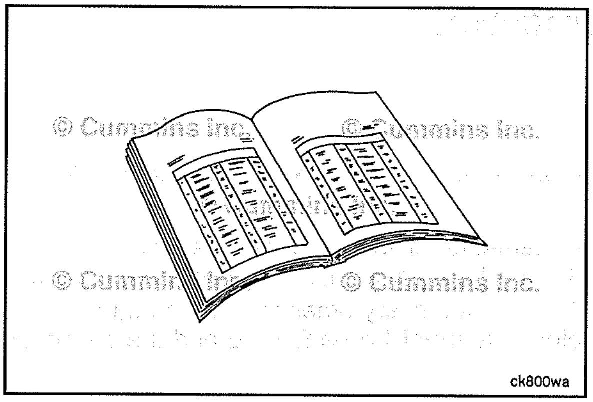
Restriction Indicator Check

- Check the air cleaner restriction by inspecting the restriction indicator located on the outlet end of the air cleaner. A restriction indicator can be purchased separately if one is **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].

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.


ck800wa

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.

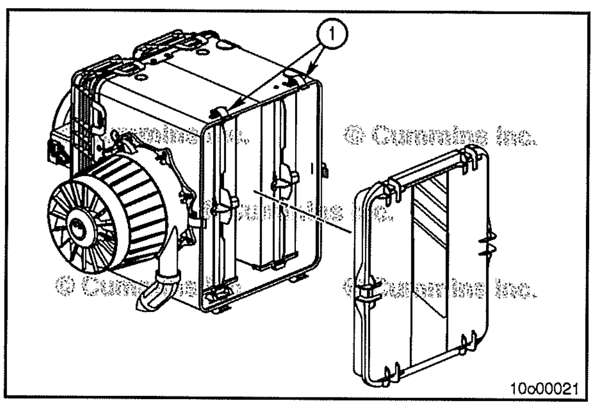
⚠WARNING⚠
Improper practices, carelessness, or ignoring the warnings can cause burns, cuts, mutilation, asphyxiation, or other personal injury or death.

⚠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 batteries. See equipment manufacturer service information.



10o00021

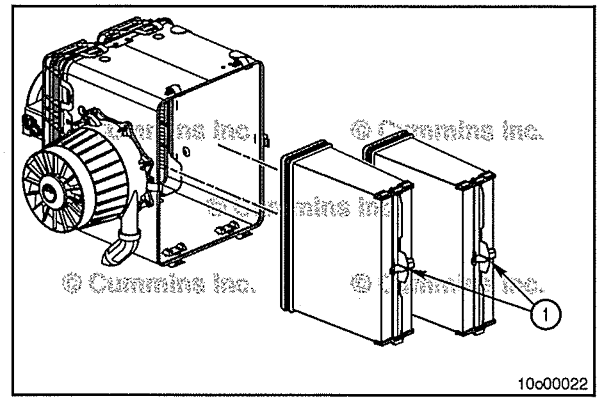
Remove

- To access the filter elements, remove the service door by lifting on the metal clips (1) around the perimeter of the service door.

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

The direct flow primary filter elements have a built-in handle (1) for easy removal. Grasp the handle in the center of the element and pull the filter element outward.

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



CAUTION

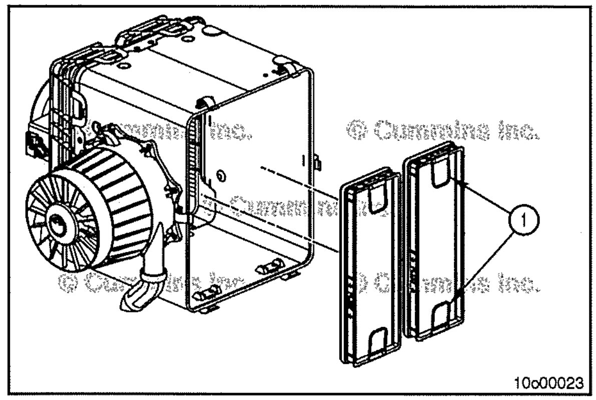
Take caution when removing the secondary elements. Any loose debris can fall into the air intake plumbing leading directly to the engine. Clean the area around the secondary filter elements and replace the secondary filters promptly to avoid engine contamination ingestion.

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 elements **must** be changed every other time the primary elements are changed. Proper inspection of the secondary elements **must** be performed and the elements changed, if necessary.

The secondary elements are removed by pulling on the plastic ring tab (1) on the inside face of the filter element.

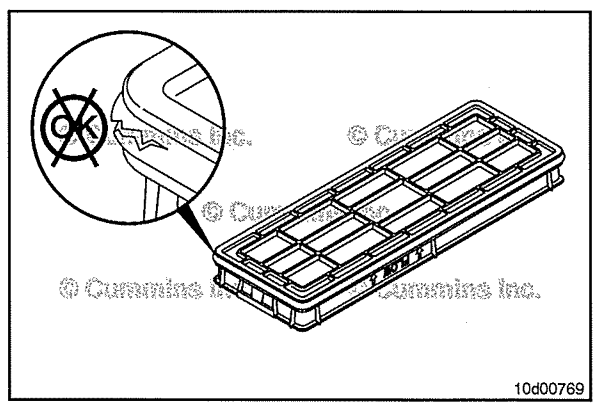


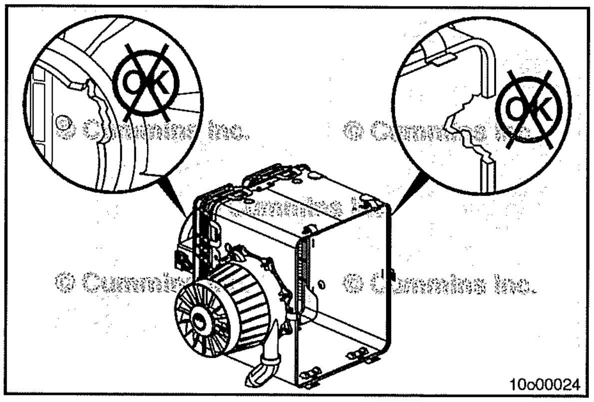
Inspect for Reuse

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

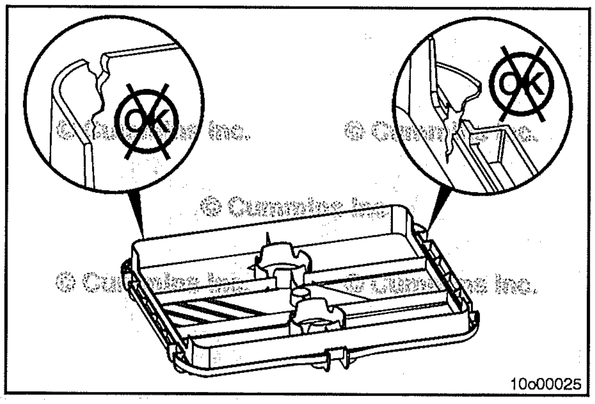
- Inspect the gasket around the base of the filter element. If the gasket exhibits damage, replace the entire filter element assembly.
- Inspect the filter media for any tears or excessive wear. Replace the entire filter element assembly if the filter media is **not** intact. The filter media rows may **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.

NOTE: The secondary elements **must** be changed every other time the primary elements are changed. Proper inspection of the secondary elements **must** be performed and the elements changed, if necessary.

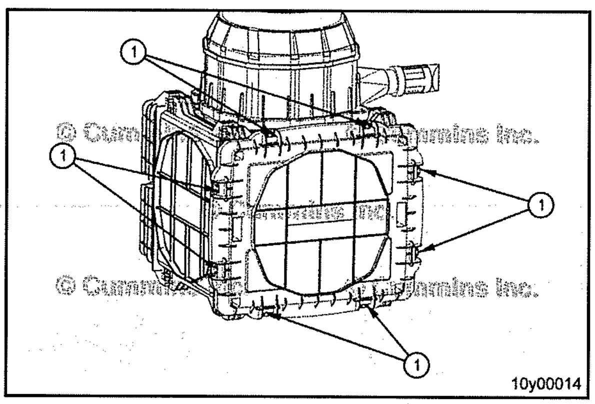




- Inspect the direct flow housing for damage, cracks, or areas where air can bypass the filter elements. Replace the direct flow housing if damage is found.

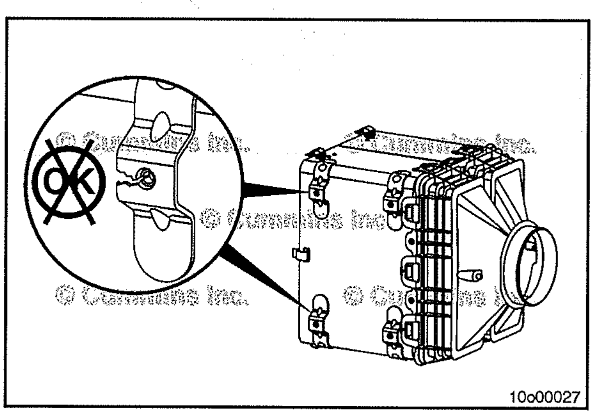


- Inspect the service door and gasket for damage. Replace the service door and gasket if damage is found.



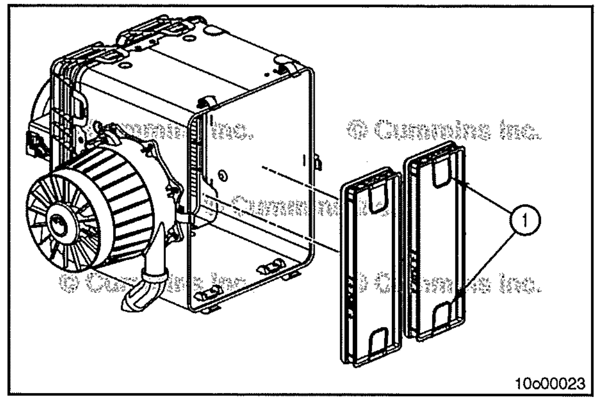
- Inspect the six clips (1) on the housing which are used to hold the service door. If any of the clips are damaged, broken, or missing, the direct flow housing **must** be replaced.

These clips are vital to keeping the service door locked in place during operation. If one of the clips is **not** properly engaged, it can allow the service door and air filters to become unseated during operation and potentially allow debris past the air filter elements.



- Make sure the direct flow air filter housing is properly mounted. Do **not** operate the equipment if the housing is loose or improperly mounted.
- Inspect the mounting tabs on the side of the housing for damage. Replace the housing if damage is found. Replace any missing mounting hardware.

Install



CAUTION

Only use the approved Cummins Filtration™ aftermarket direct flow replacement filter elements to service the air cleaner. Use of improper filters can lead to engine damage.

CAUTION

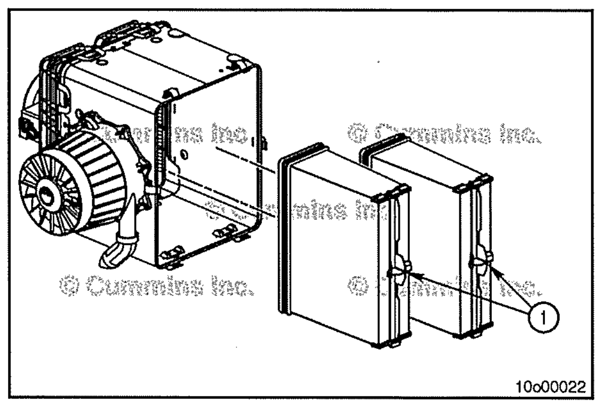
Make sure any cloth or tools used during the removal process are not left in the filter housing (before installing the filter elements) or engine damage can occur.

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

Secondary Elements

- Insert the elements so the orientation of the plastic removal rings (1) are facing the inside of the housing and are accessible for the next service interval.
- Push the secondary elements into the back of the housing so all surfaces are seated inside the housing.
- Apply pressure to all four corners to make sure the elements are secure within the housing.

The secondary filter elements include an o-ring that is glued to the filter elements to provide an airtight seal.

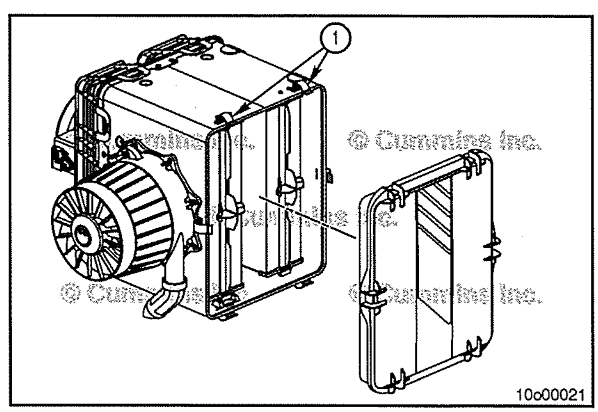


Service Tip: Before installing a new primary filter element, use a marker to note on the element handle if a new secondary element **must** be installed at the next primary element service event.

Primary Filter Element

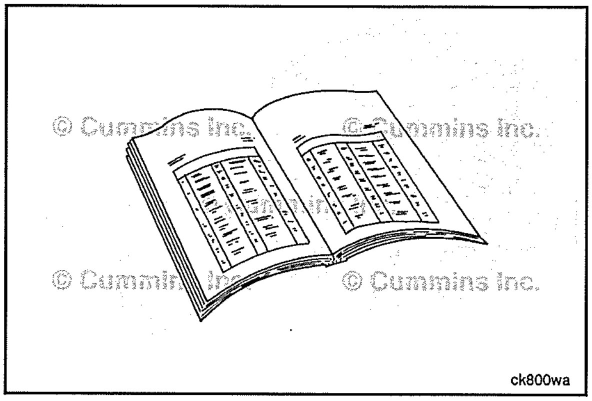
- Place new primary filter elements in the housing so the o-rings are toward the secondary elements.
- Push the primary elements into the housing so all surfaces are seated inside the housing.
- Apply pressure to the two tabs (1) on the side of the primary elements to make sure the elements are secure within the housing. The tabs on the filter **must** seat between the locating tabs inside the housing.

The primary filter element also includes an o-ring that is glued to the filter element to provide an airtight seal.



- Install the service door and fasten the metal clips (1) around the perimeter of the service door.

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

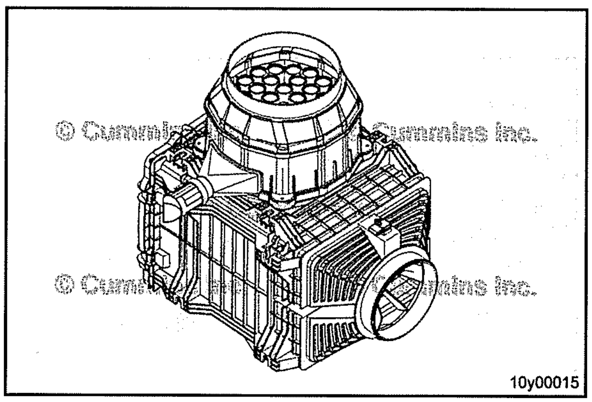
⚠WARNING⚠

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 elements are **not** fully seated into the housing.

NOTE: The direct flow filter elements are completely disposable.

- Install the service door by latching to the housing.
- Reset the restriction indicator by pushing the reset button.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and listen for a noise that could indicate an air leak. Use the following procedure to locate any air leaks in the air system. Refer to Procedure 010-024 in Section 10.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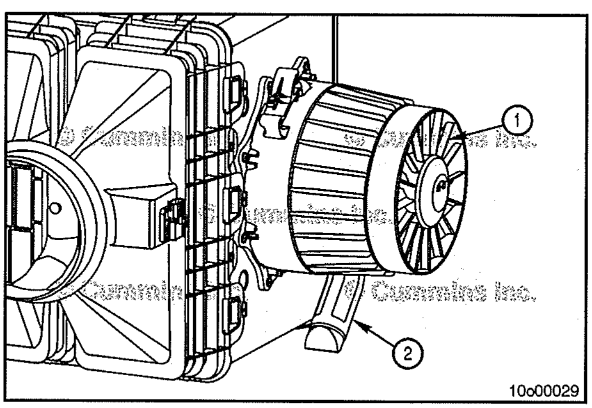
Air Cleaner Precleaner (010-015)

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:

- Vortex style precleaner with dust ejection valve
- Vortex style with aspiration
- Radial fin precleaner with dust ejection valve
- Non-captive style precleaner
- Radial fin precleaner with aspiration.



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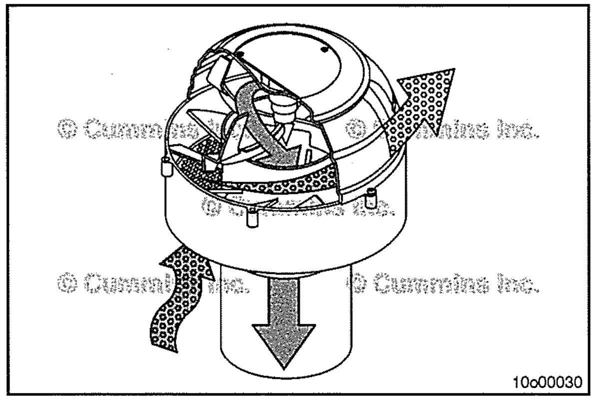
A vortex style precleaner with dust ejection valve removes debris from the intake air by using fins (1) to create centrifugal motion in the intake air stream.

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. Refer to Procedure 010-146 in Section 10.

Non-captive style precleaners work similarly to radial fin 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 radial fin precleaner with dust ejection valve and can create higher intake restriction.



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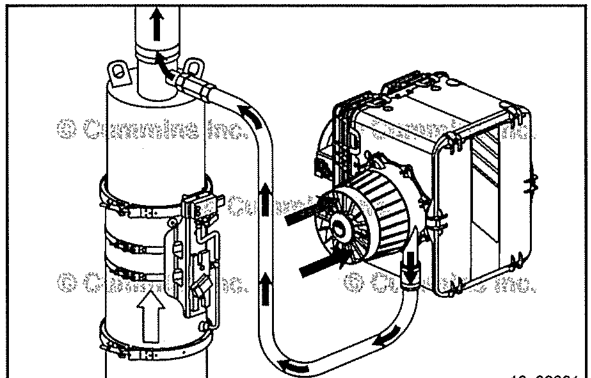
Vortex style precleaning with exhaust aspiration is used for applications that are exposed to extremely dirty and dusty environments, such as agricultural equipment.

An exhaust aspirator uses exhaust flow to create suction. The suction tube from the aspirator is plumbed to the radial fin 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.

NOTE: Other aspiration options are available.



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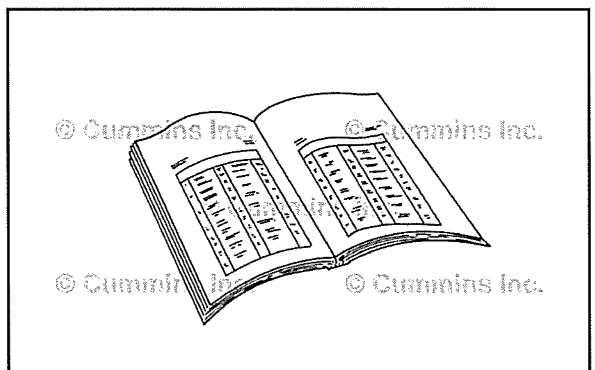
Air Inlet Connection (010-022)

General Information

The air inlet connection connects the turbocharger air inlet to the OEM air inlet piping.



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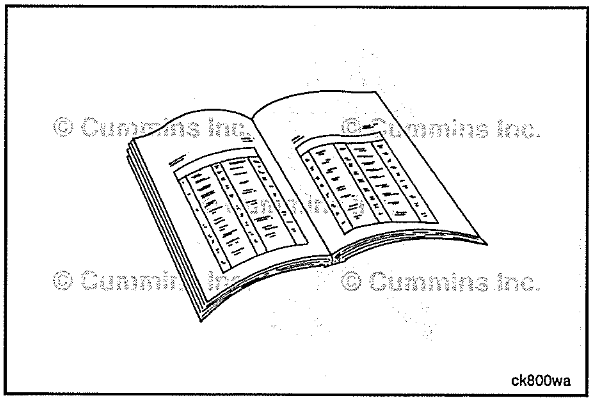
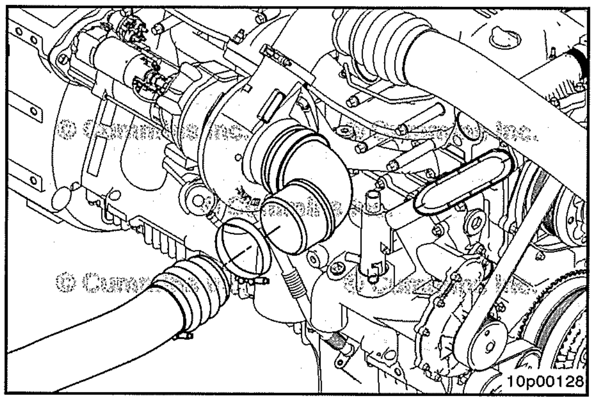


Preparatory Steps

⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.



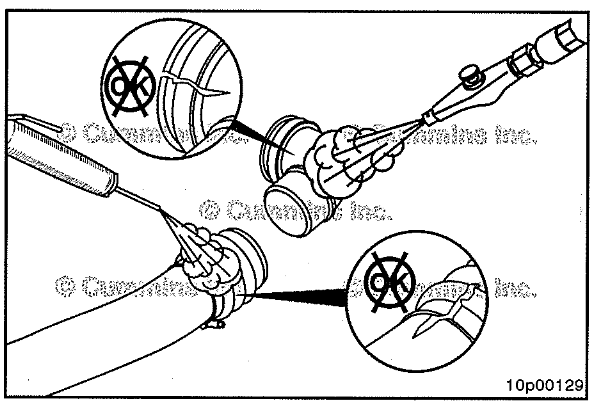
Remove

NOTE: Brush away all loose dirt from around the area of the air handling connections to avoid contamination of the interior of the engine.

Loosen the clamps which hold the air inlet connection to the turbocharger air inlet and the OEM air inlet piping.

Remove the air inlet connection.

Use protective caps from the Air Handling Clean Care Kit, Part Number 4919588, to cover open points on the plumbing and engine.



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⚠

Use skin and eye protection when handling caustic solutions 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 piping and connections with solvent or hot soapy water.

Dry with compressed air.

Check the piping and connections for cracks, holes, and worn sections.

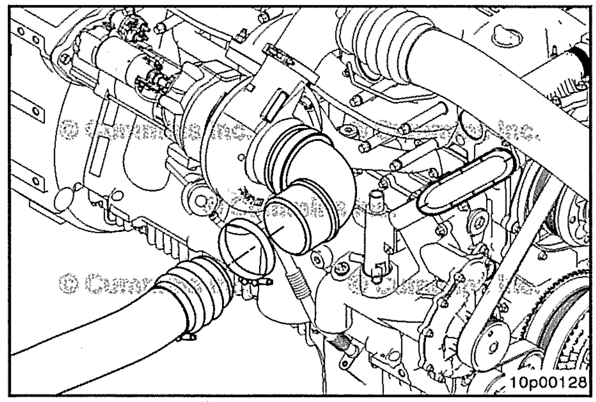
If any damage is found, replace the damaged components.

Install

Install the air inlet piping and connections.

Tighten the attaching clamps.

Torque Value: 8 N•m [71 in-lb]

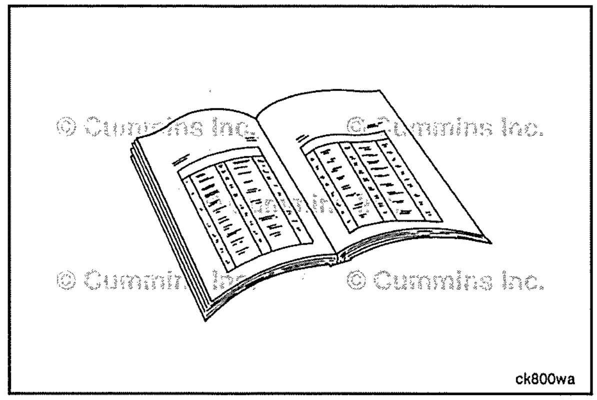


Finishing Steps

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 batteries. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks.



Air Leaks, Air Intake and Exhaust Systems (010-024)

Initial Check

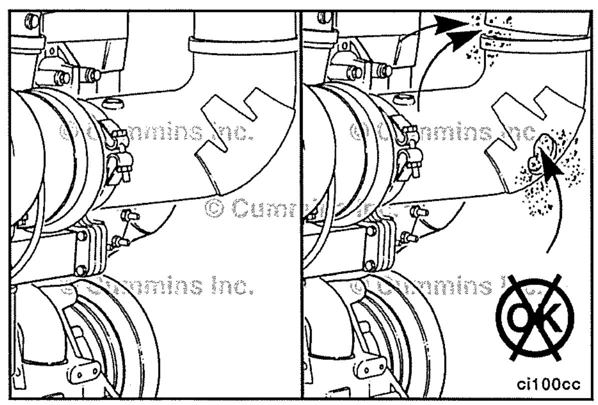
CAUTION

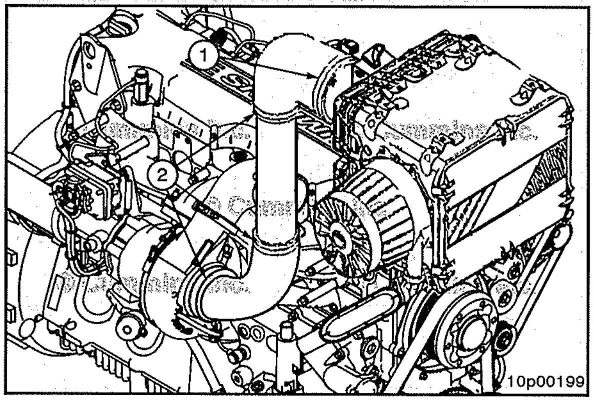
Engine intake air must be filtered to prevent dirt and debris from entering the engine. If intake air piping is damaged or loose, unfiltered air will enter the engine and cause premature wear.

Inspect for loose clamps or damage between the intake air piping, air cleaner, turbocharger, charge-air cooler, and intake manifold.

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

Replace any damaged pipes and tighten any loose clamps.





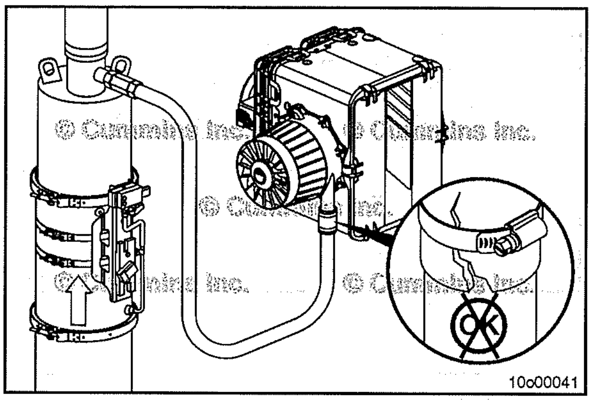
Inspect the intake piping between the direct flow air filter housing and the turbocharger for wear points and damage to piping, loose clamps, or punctures that can allow unfiltered intake air into the engine.

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

Torque Value:
Intake Piping at Direct Flow Air Filter Housing (1) 4.5 N•m [40 in-lb]

Torque Value:
All Other Intake Piping (2) 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.

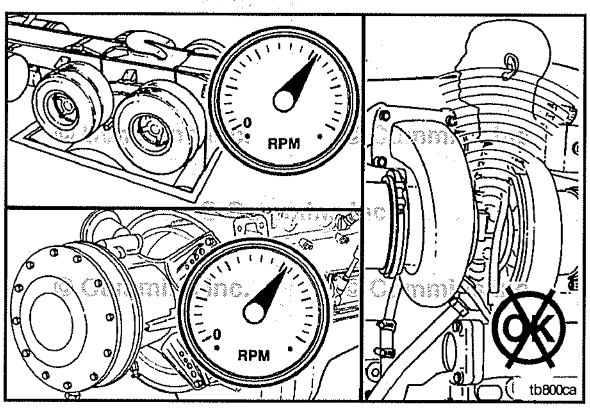


If equipped, inspect the exhaust aspirator piping for leaks, cracks, or loose connections.

Tighten the clamps, if necessary.

See equipment manufacturer service information for the correct torque value.

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 early or frequent air filter plugging.



Excessive back pressure can cause exhaust leaks. Verify the exhaust back pressure is within specified limits. Refer to Procedure 011-009 in Section 11.

Operate the engine at full throttle and maximum load, and check for air leaks. Listen for a whistling noise caused by high-pressure air leaks.

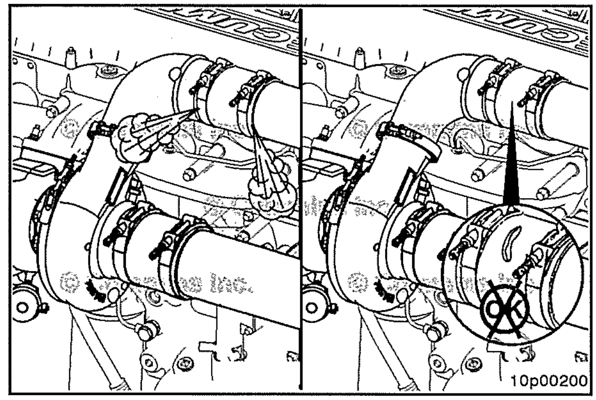
⚠CAUTION⚠

Do not use air tools to remove or install the nut on the V-band clamp. Use of these tools can seriously damage the threads or the bolt and cause the clamp to not be able to be reused.

The noise can be caused by an air leak from the following:

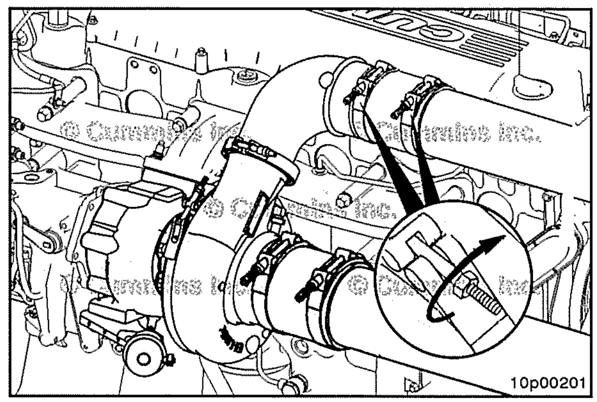
- Turbocharger to charge-air cooler elbow connection
    - Inspect the connection and o-ring for damage.
    - Tighten the band clamps. See equipment manufacturer service information or the following torque value.

Torque Value: 11 N•m [97 in-lb]



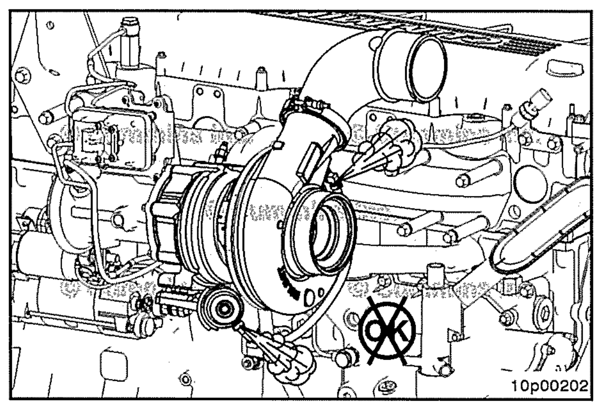
- Any charge-air cooler piping or connecting hose.
    - Inspect the hose and piping for damage.
    - Tighten the band clamps. See equipment manufacturer service information or the following torque value.

Torque Value: 11 N•m [97 in-lb]



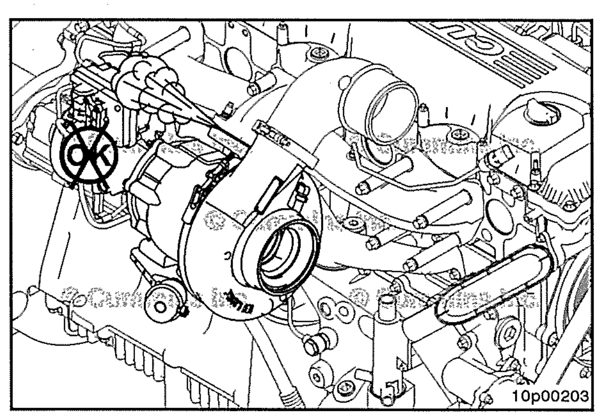
Air leak noise can be caused by a loose connection in the turbocharger wastegate system.

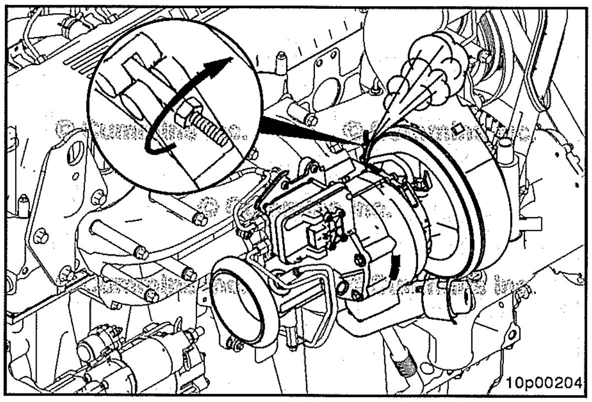
Inspect the turbocharger actuator air line and connections. Refer to Procedure 010-118 in Section 10.



Air leak noise can be caused by an air leak from the turbocharger-to-exhaust manifold mounting gasket.

Inspect for signs of leakage, such as soot streaks which may appear yellowish, brown, or black. If signs of leakage are present, replace the turbocharger mounting gasket. Refer to Procedure 010-033 in Section 10.

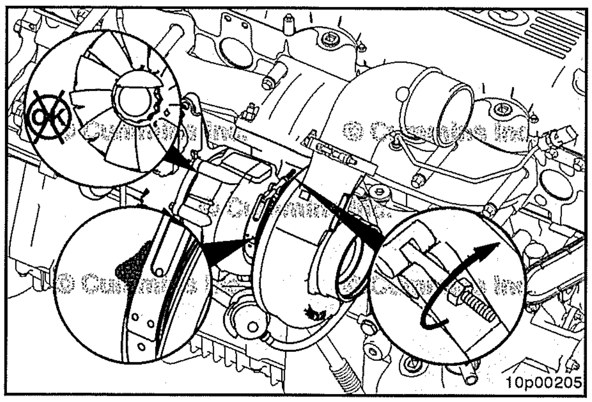




Air leak noise can be caused by an air leak from the turbocharger compressor housing. Air leaks from the turbocharger compressor housing are acceptable. It is possible for even a brand new turbocharger to have an air leak at this location.

Be sure the compressor housing clamp is tightened to the following torque.

Torque Value: 8.5 N•m [75 in-lb]



Air leak noise can be caused by an air leak from the turbine housing sealing surface.

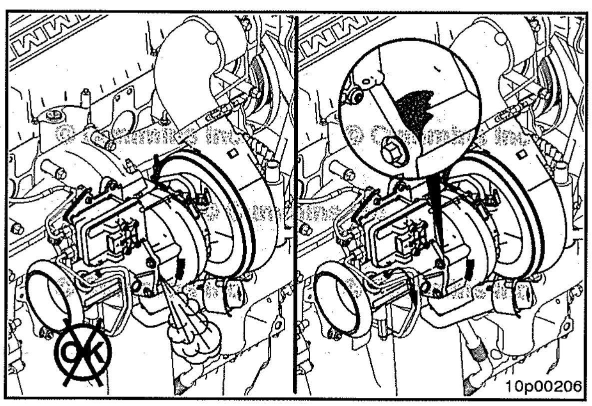
It is acceptable to see soot streaks appearing yellowish, brown, or black coming from the turbine housing sealing surface.

If soot streaks are found check the turbocharger turbine wheel for damage. If turbine wheel damage is found the turbocharger **must** be replaced. Refer to Procedure 010-033 in Section 10.

If no turbine wheel damage is found, make sure the turbine housing clamp is tight.

Torque Value: 11 N•m [97 in-lb]

If no turbine wheel damage is found, the turbocharger can be used.



Air leak noise can be caused by an air leak from the turbine outlet sealing surface.

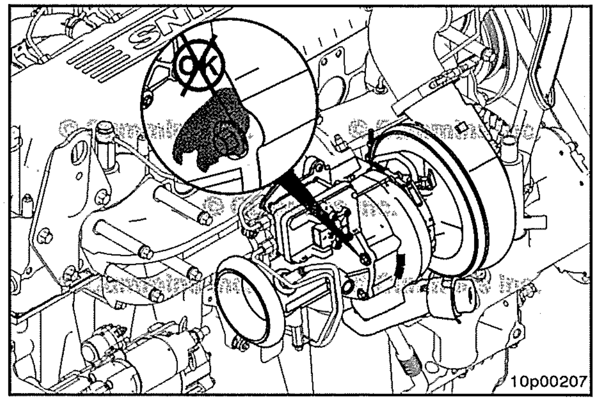
It is acceptable to see soot streaks appearing yellowish, brown, or black coming from the turbine outlet sealing surface.

It is **not** acceptable to see exhaust coming from the turbine outlet sealing surface.

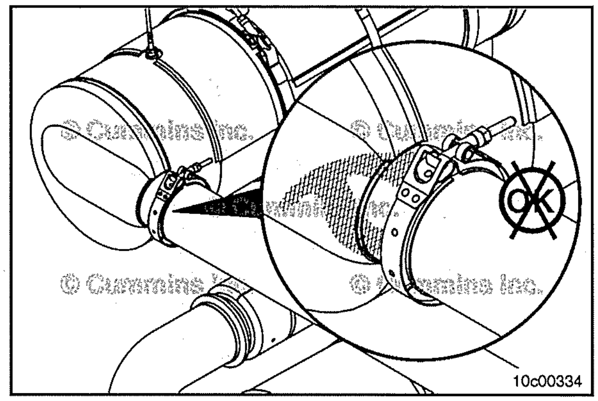
If visible exhaust coming from the turbine outlet sealing surface, tighten the turbine outlet cap screws. Refer to Procedure 011-105 in Section 11.

Check again for a visible exhaust leak. If a leak is visible, remove and replace the turbocharger. Refer to Procedure 010-033 in Section 10.

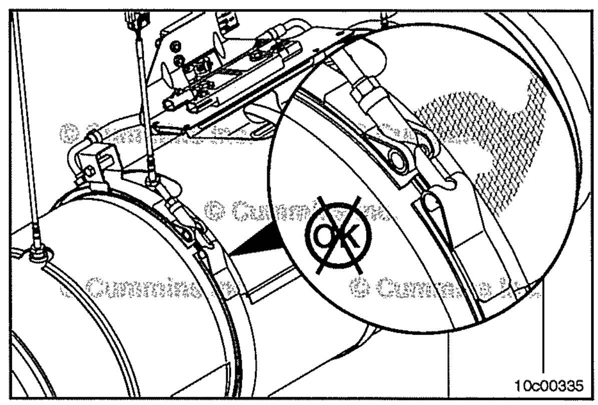
- Check the exhaust pressure regulator.
  - Inspect for visible soot streaks at the V-band joint.
  - If soot streaks are found, tighten the V-band clamp. Refer to Procedure 011-105 in Section 11.
  - Operate the engine at full throttle and check for leakage at full throttle condition.
  - If a leak is still present, remove and replace the gasket with a new gasket and a new V-band clamp.



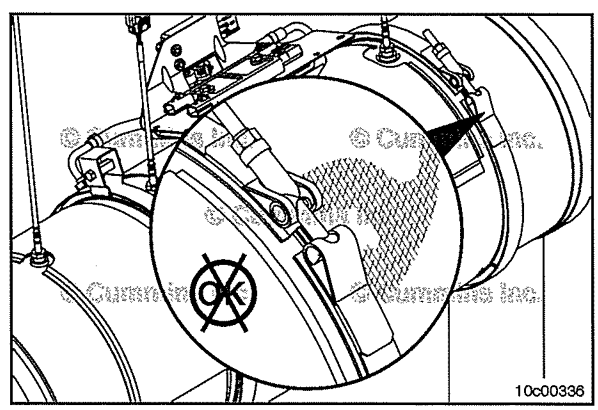
- Check the aftertreatment inlet connection.
  - Inspect for visible soot streaks at the Torca™ clamp or V-band clamp joint. Also inspect for loose or damaged insulation wrapping, if applicable.
  - If soot streaks are found, tighten the V-band or Torca™ clamp. Refer to Procedure 011-041 in Section 11.
  - Operate the engine at full throttle and check for leakage at full throttle condition.
  - If a leak is still present, remove and replace the clamp with a new Torca™ clamp or V-band clamp.

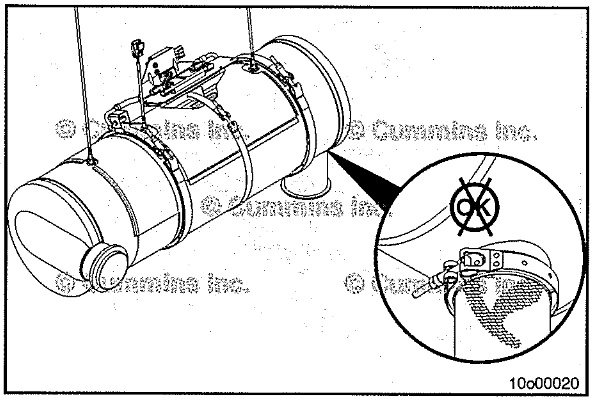


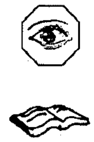
- Check the catalyst to aftertreatment particulate filter connection.
  - Inspect for visible soot streaks at the V-band joint.
  - If soot streaks are found, check for fault codes relating to high differential pressure in the aftertreatment system. If no fault codes are found, tighten the V-band clamp. Refer to Procedure 011-049 in Section 11.
  - Operate the engine at full throttle and check for leakage at full throttle condition.
  - If a leak is still present, remove and replace the gasket with a new gasket and V-band clamp.



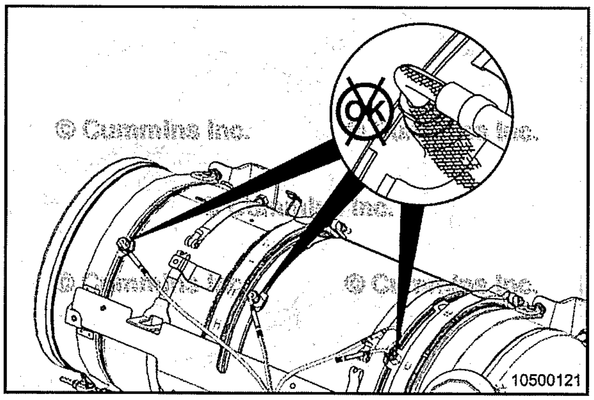
- Check the aftertreatment diesel particulate filter to outlet connection.
  - Inspect for visible soot streaks at the V-band joint.
  - If soot streaks are found, check for fault codes relating to high differential pressure in the aftertreatment system. If no fault codes are found, tighten the V-band clamp. Refer to Procedure 011-041 in Section 11.
  - Operate the engine at full throttle and check for leakage at full throttle condition.
  - If a leak is still present, remove and replace with a new gasket and V-band clamp.

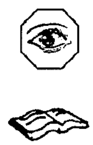






- Check the aftertreatment outlet connection.
  - Inspect for visible soot streaks at the V-band joint.
  - If soot streaks are found, check for fault codes relating to high differential pressure in the aftertreatment system. If no fault codes are found, tighten the V-band clamp. Refer to Procedure 011-041 in Section 11.
  - Operate the engine at full throttle and check for leakage at full throttle condition.
  - If a leak is still present, remove and replace with a new gasket and V-band clamp.



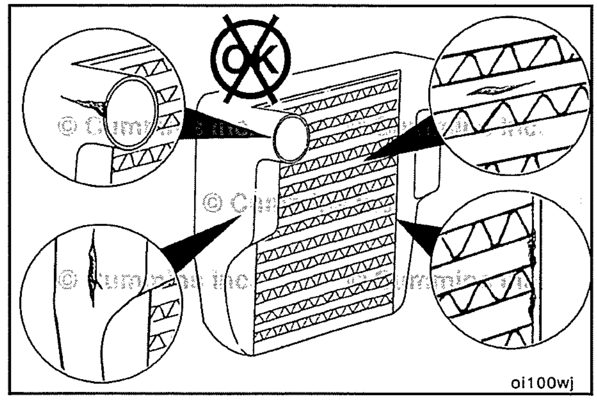


- Check the aftertreatment diesel particulate filter differential pressure sensor tube connections.
  - Inspect for visible soot streaks at the threaded bosses or hose connections.
  - If soot streaks are found at the threaded boss, loosen the differential pressure sensor tube nut, apply a coating of anti-seize compound, and tighten the differential pressure sensor tube nut. Refer to Procedure 011-047 in Section 11.
  - If soot streaks are found at the hose connections, remove and connect the hose. Refer to Procedure 011-047 in Section 11.
- Operate the engine at full throttle and check for leakage at full throttle condition.
  - If a leak is still present at the threaded boss, remove and replace the differential pressure sensor tube.
  - If a leak is still present at the hose connection, replace the differential pressure sensor tube or differential pressure sensor, depending on which component the hose is permanently attached to.
  - If damage resulted in coolant, oil, excessive fuel or excessive black smoke entering the exhaust system, the aftertreatment system **must** be inspected.
    - Use the followig procedure to check the aftertreatment seletive catalytic reduction (SCR). Refer to Procedure 014-015 in Section 14.
    - Use the followig procedure to check the aftertreatment diesel particulate filter (DPF). Refer to Procedure 014-016 in Section 14.

Charge-Air Cooler (010-027)

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.

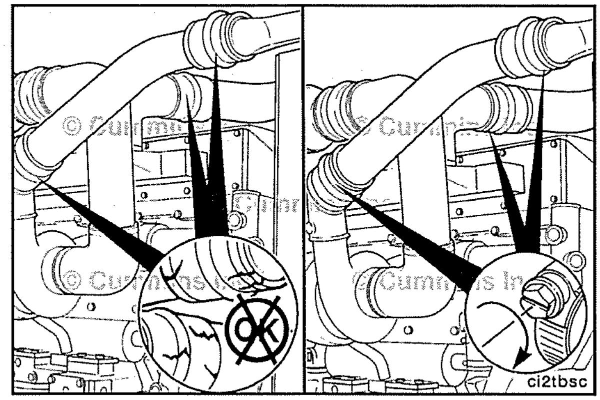


oi100wj

Charge-Air Piping (010-028)

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.



ci2tbsc

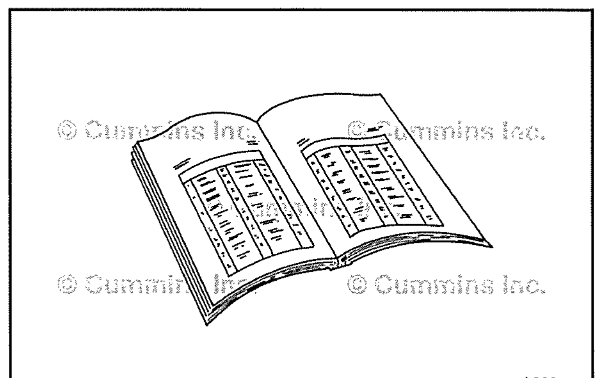
Cold Starting Aid (010-029)

Preparatory Steps

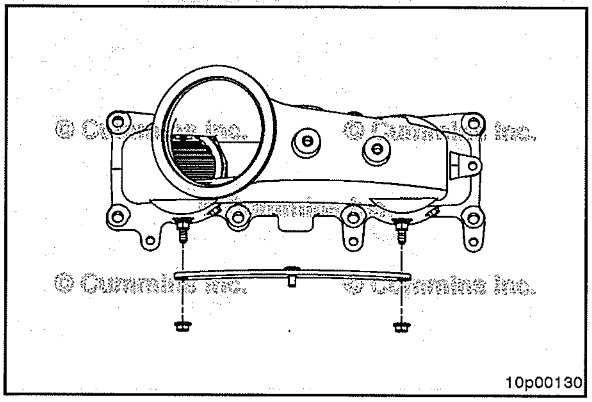
⚠WARNING⚠

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

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Remove the charge air piping. See equipment manufacturer service information.
- Disconnect the cold starting aid wiring. See equipment manufacturer service information.
- Remove the air intake connection. Refer to Procedure 010-080 in Section 10.



ck800wa



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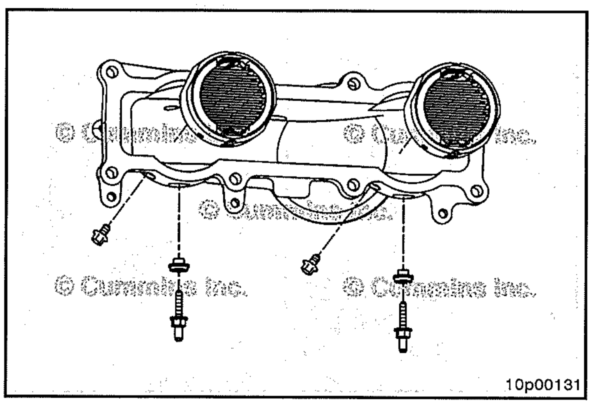
Remove

Remove the two electrical connection nuts.

Remove the electrical connection.



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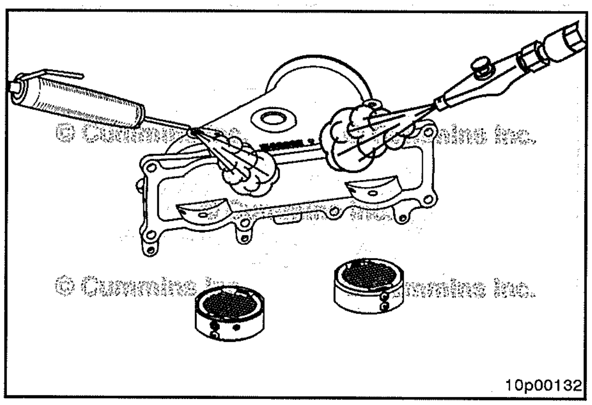
Remove electrical supply studs and spacers.

Remove ground capscrews.

Remove the cylindrical cold starting aid assemblies from the air intake connection.



10p00132

Clean and Inspect for Reuse

WARNING

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

WARNING

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

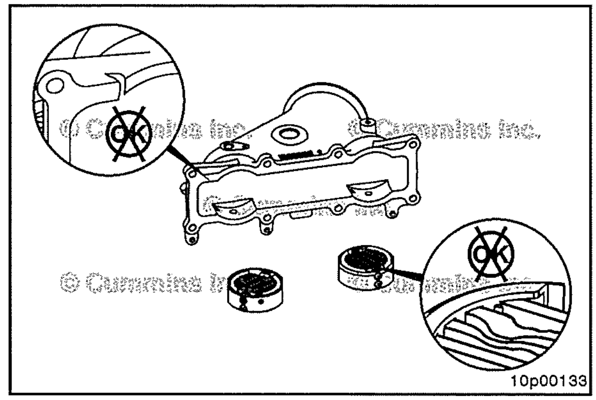
Use heavy tape from the Air Handling Clean Care Kit, Part Number 4919588, to cover open points on the plumbing and engine.

Steam clean the air intake connection. Refer to Procedure 010-080 in Section 10.

Steam clean the cold starting aids, and electrical connection. Dry with compressed air.

Inspect the cold starting aid and air intake connection sealing surfaces for cracks or other damage.

Replace any damaged components.

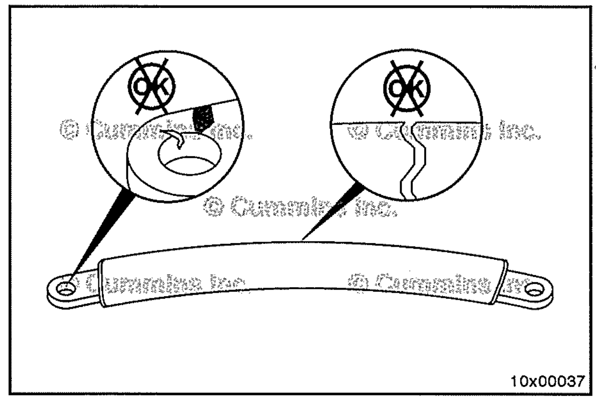


Inspect the electrical connection insulation and connector for damage.

Replace the electrical connection if damage is found.

Inspect the electrical connection of signs of corrosion, If corrosion is found remove all traces of corrosion.

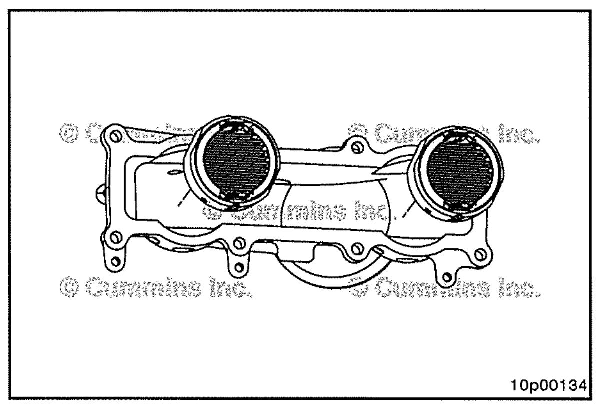
If the corrosion can **not** be removed, or resulted in damage to the connection the electrical connection **must** be replaced.



Install

Fit the two cold starting aids into the air intake connection.

Rotate the cold starting aids to align the cold starting aid holes with the machined holes in the bottom of the air intake connection.



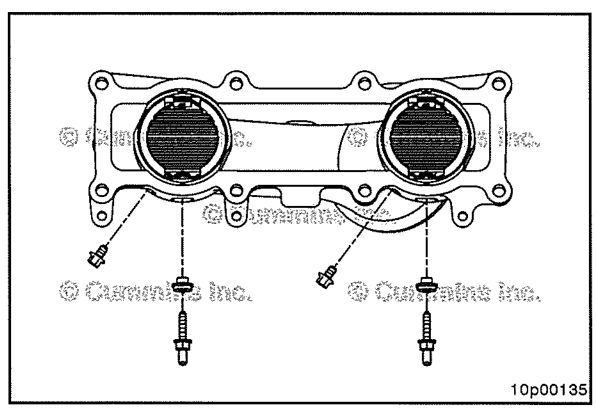
Install the two ground capscrews hand tight.

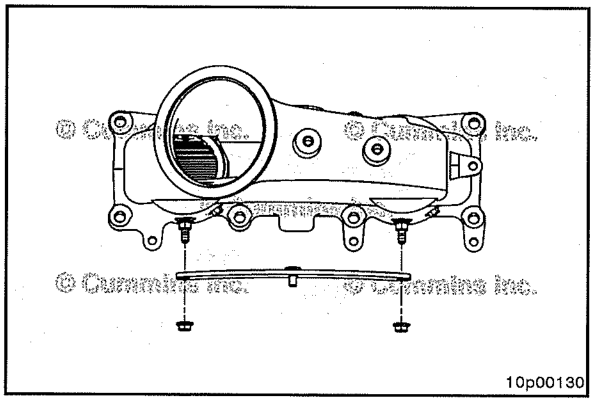
Install the two electrical studs and spacers hand tight.

NOTE: Be sure to install the larger end of the spacer against the air intake connection.

Tighten the ground capscrews and electrical studs to the following specification.

Torque Value: 5.6 N•m [50 in-lb]

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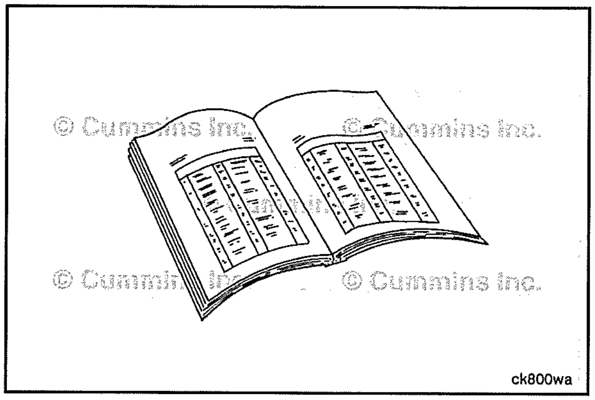
Install the electrical connection.

Install the two electrical connection nuts.

Torque Value: 5.6 N•m [50 in-lb]

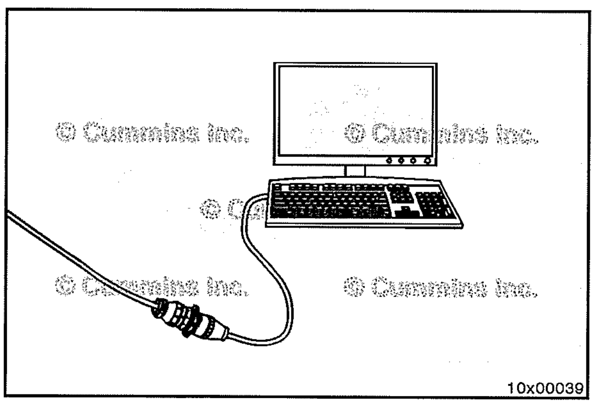

ck800wa

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 Air Intake Connection. Refer to Procedure 010-080 in Section 10.

Connect the cold starting aid wiring. See equipment manufacturer service information.

Connect the batteries. Refer to Procedure 013-009 in Section 13.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Test

WARNING
To reduce the possibility of personal injury, wear protective gloves when handling parts that have been heated.

Connect INSITE™ electronic service tool.

From the list of ECM diagnostic tests, select "Intake Air Heater Override".

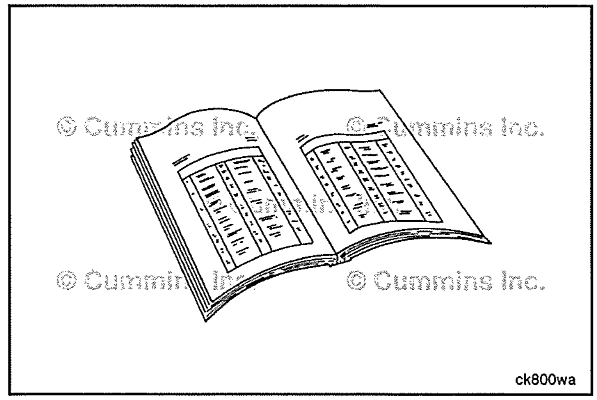
Follow the on-screen instructions to determine if the cold starting aid is functioning properly.

Measure the current draw at the OEM wiring of the cold starting aid by using a clamp on current probe Part Number 3164490, or equivalent.

Cold Starting Aid Current Draw		
MIN		MAX
112.5	Amps	137.5

Finishing Steps

- Install the charge air piping. See equipment manufacturer service information.
- Operate engine and check for leaks.

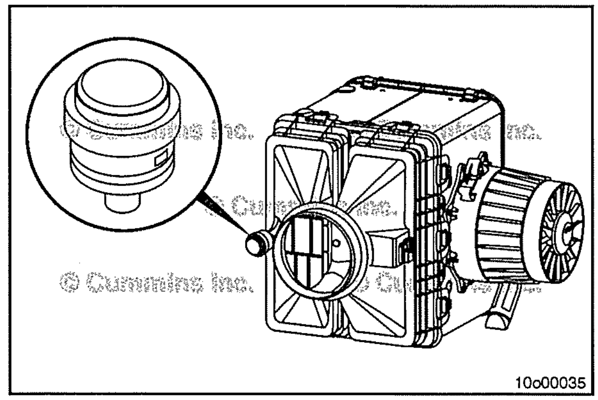


Air Intake Restriction (010-031)

General Information

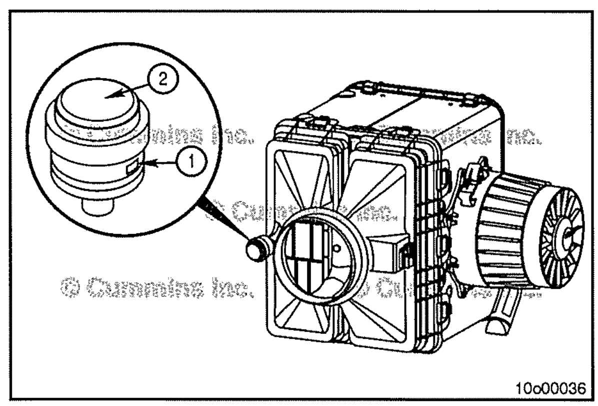
A filter restriction indicator **must** be located on the direct flow air cleaner to provide an indication of the proper time to replace the air filter(s).

A filter restriction indicator can be purchased separately, if one is **not** present on the housing. The restriction indicator is located at the pressure tap on the outlet side of the housing.



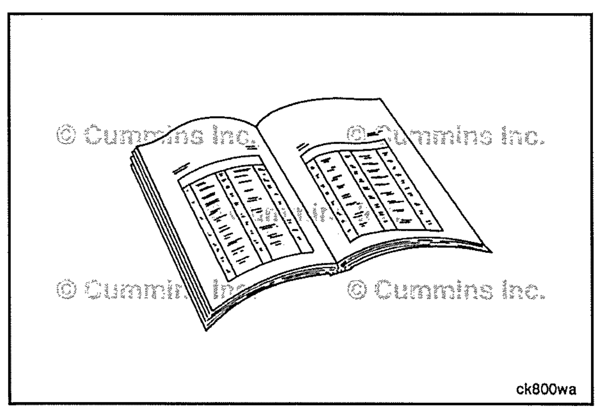
A mechanical filter restriction indicator is available to indicate excessive air restriction through the air filter(s). This instrument is mounted in the air cleaner outlet. The red flag (1) in the window gradually rises as the air filter loads with dirt. When the maximum air filter restriction is indicated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

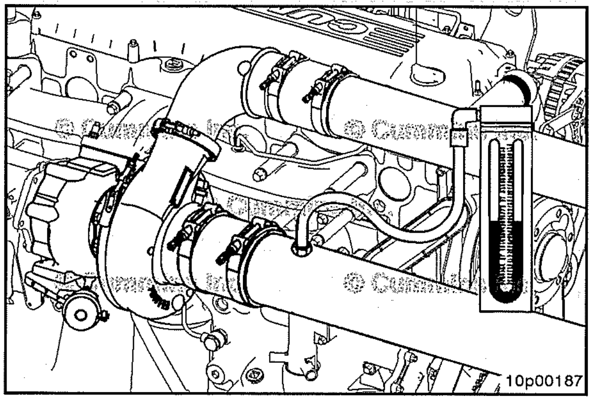
Use the following procedure for the correct air filter restriction specification. Refer to Procedure 018-019 in Section V.



Some restriction indicators are installed with an electronic switch that illuminates a lamp in the cab at full restriction, indicating that the air filters **must** be replaced.

See equipment manufacturer service information for information on resetting this type of indicator once the air filters have been changed.

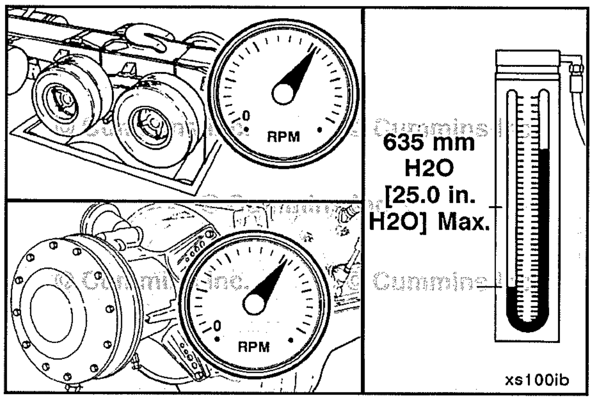




Measure

Install a vacuum measuring tool (mechanical gauge, water manometer, multimeter with pressure transducer, etc.) in the intake air piping.

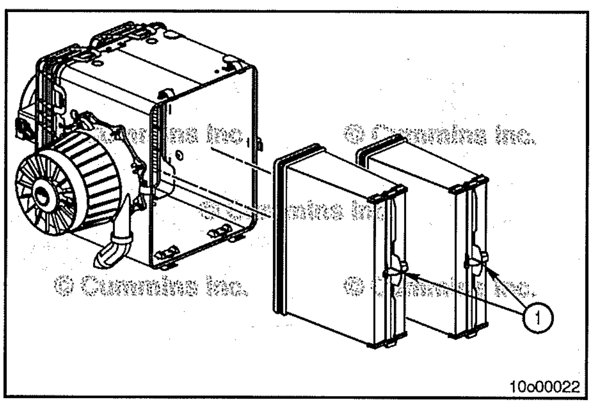
NOTE: The gauge adapter **must** be installed at a 90-degree angle to the airflow in a straight section of pipe, 127 mm [5 in], before the turbocharger compressor inlet.



Operate the engine at full throttle and maximum horsepower rpm with maximum load.

Record the reading on the gauge or manometer.

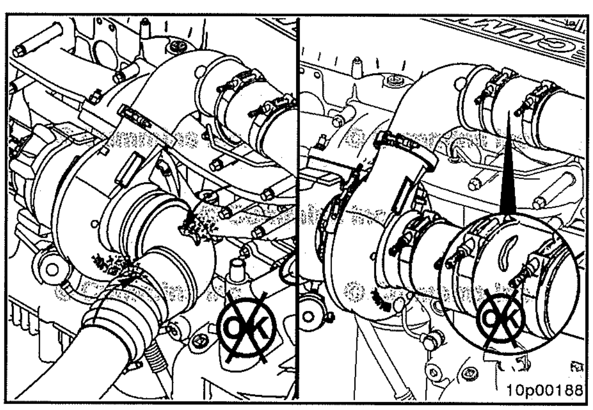
Use the following procedure for the correct air filter restriction specification. Refer to Procedure 018-019 in Section V.



If the air filter restriction exceeds the specification, do the following:

- Change the air filter element. Refer to Procedure 010-014 in Section 10.

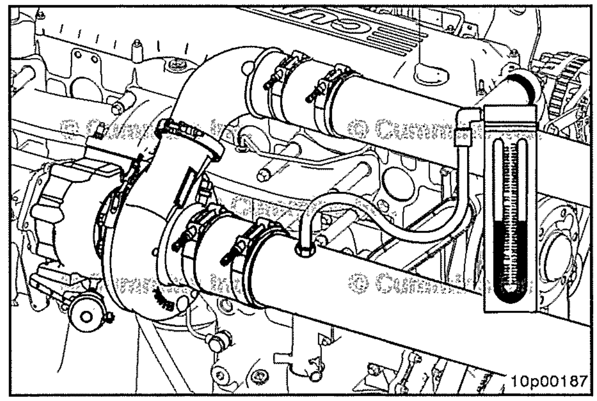
NOTE: The air filter element change interval is based on air filter restriction, but the elements **must** be changed at least every 1500 hours or 1 year. The secondary air filter elements **must** be changed every-other time the primary air filter elements are changed. Proper inspection of the secondary air filter elements **must** be performed and the secondary elements changed, if necessary.



- Inspect the intake air piping for damage. Check for collapsed and dented piping or elbows and loose connections. Refer to Procedure 010-024 in Section 10.

Remove the test equipment.

If the malfunction resulted in coolant, oil, excessive fuel, or excessive black smoke entering the exhaust system, the aftertreatment system **must** be inspected. Refer to Procedure 014-015 in Section 14.



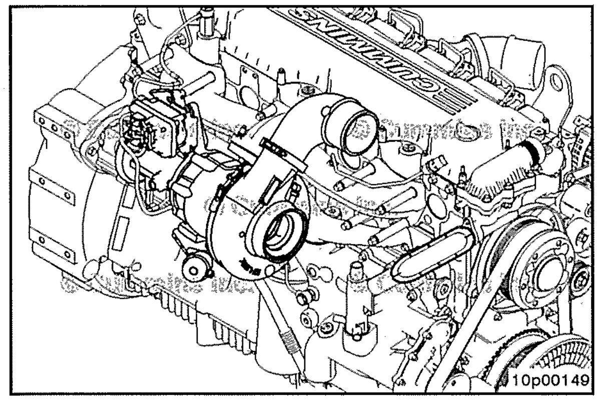
10p00187

Turbocharger (010-033)

General Information

Depending on the vehicle application type, the turbocharger can be mounted in one of two ways.

- The first turbocharger mounting configuration is a standard turbocharger option, where the turbine side of the turbocharger faces the rear of the engine.



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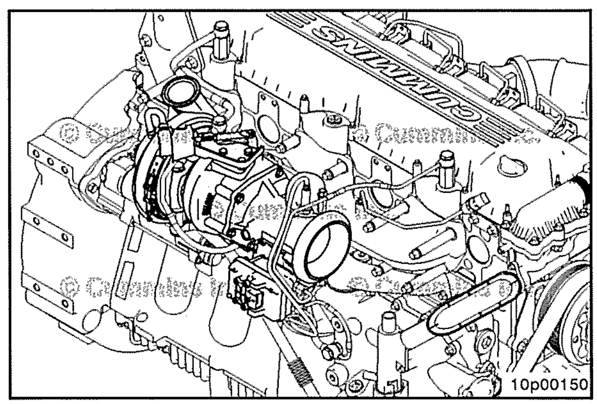
- The other turbocharger mounting configuration is referred to as a front-out turbocharger option, where the turbine side of the turbocharger faces the front of the engine.



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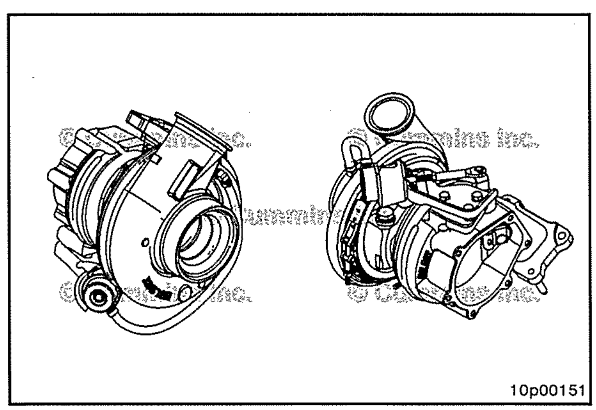
Each turbocharger configuration is also available with coolant cooled or non-coolant cooled turbochargers. Before servicing the turbocharger take note of the configuration and routing of coolant and oil hoses.



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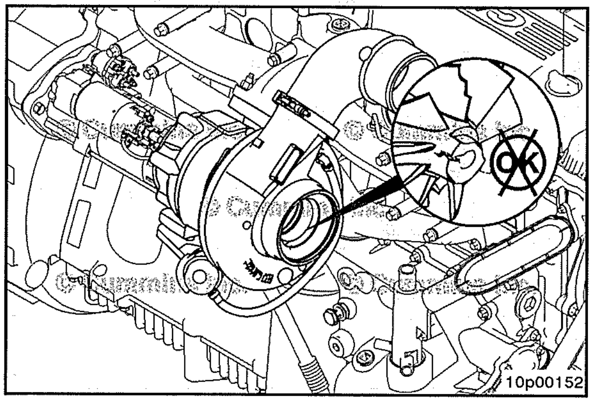
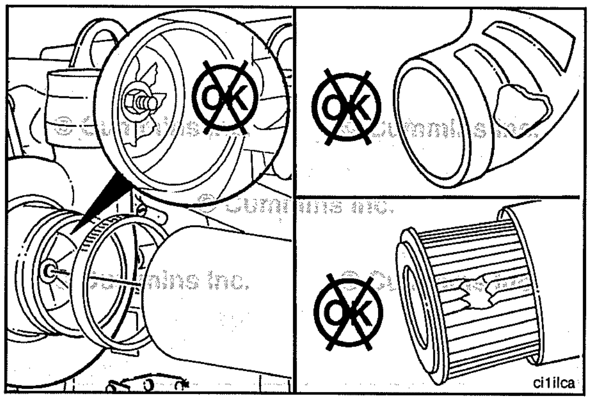


Initial Check

NOTE: Brush away any loose dirt from around the area of air handling connections to avoid contamination of the interior of the engine.

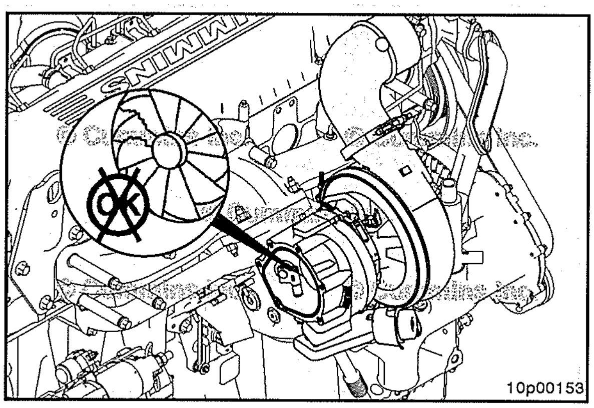
Inspect the turbocharger compressor impeller:

- Remove the intake pipe from the turbocharger.See equipment manufacturer service information.
- Inspect the turbocharger compressor impeller blades for damage.
- Replace the turbocharger if damage is found. Do **not** attempt to repair damaged impeller blades.



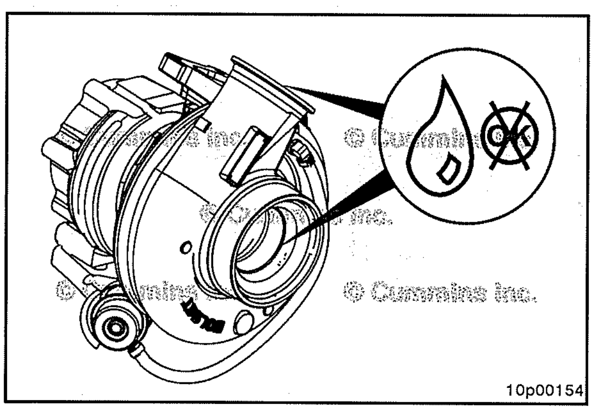
If the compressor impeller is damaged, inspect the intake air piping and the filter element for damage:

- Repair any damage before operating the engine.
- Check for loose clamps.



Inspect the turbocharger turbine wheel.

- Remove the turbocharger exhaust piping. See equipment manufacturer service information.
- Inspect the turbocharger turbine wheel for damage.
- Replace the turbocharger if damage is found. Do **not** attempt to repair damaged turbine blades.



If a turbocharger compressor seal leak is suspected, do the following:

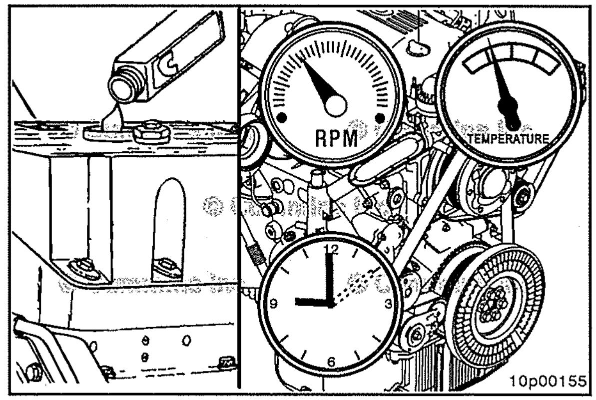
- Inspect the compressor intake and discharge for oil.
- If oil is present in the compressor intake, as well as in the compressor outlet, check upstream from the turbocharger for the source of the oil.
- If oil is present in the compressor intake, as well as in the compressor outlet, check for high oil pressure. Refer to Procedure 007-048 in Section 7.
- A compressor seal leak could also be caused by a boost leak. Check for any intake system leaks. See equipment manufacturer service information.

If oil is present and the Troubleshooting Symptom Trees have been exhausted, replace the turbocharger.

If a turbocharger turbine seal leak is suspected, do the following:

NOTE: Before starting the engine, install all of the turbocharger air plumbing.

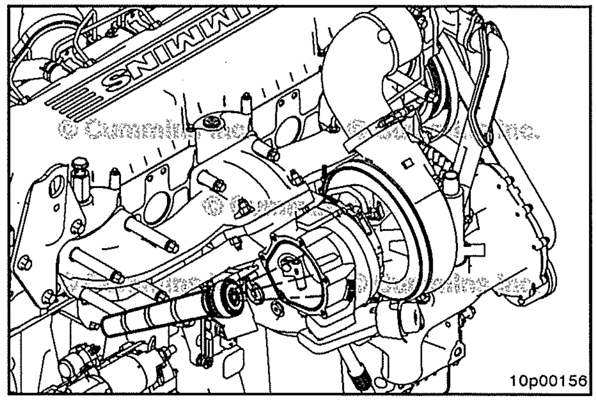
- Add 1 unit of fluorescent tracer, Part Number 3376891, to each 38 liters [10 gal] of engine lubricating oil.
- Operate the engine at low idle for 10 minutes.
- Shut the engine off.
- Allow the turbocharger to cool.
- Remove the intake, exhaust, and compressor outlet piping.



10p00155

Use a high-intensity black light, from Leak test Kit Part Number 2892320 to inspect the turbine outlet for leaks.

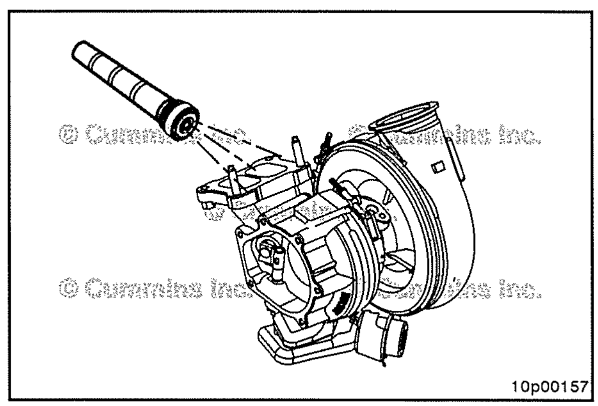
- A yellow glow indicates an oil leak.

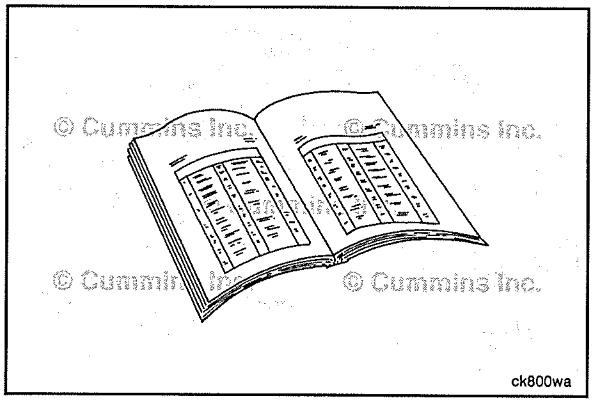

10p00156

If the source of the oil leak can **not** be attributed to any outside sources and the Troubleshooting Symptom Trees have been exhausted, remove the turbocharger.

Use a high-intensity black light in Leak Test Kit, Part Number 2892320, or equivalent, to inspect the turbine inlet for leaks.

- A yellow glow indicates an oil leak.
- If a yellow glow is seen in the turbine inlet, wipe the oil from the turbocharger with a clean shop towel and inspect the engine for the source of the oil.
- If a yellow glow is **not** seen in the turbine inlet, replace the turbocharger.


10p00157



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.

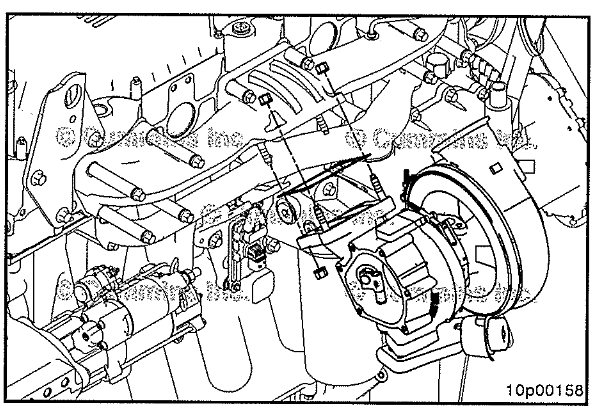
WARNING

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.

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the turbocharger oil supply line. Refer to Procedure 010-046 in Section 10.
- Remove the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.
- If equipped, remove the turbocharger coolant supply and drain lines. Refer to Procedure 010-041 in Section 10.
- Remove the intake and exhaust pipes from the turbocharger. See equipment manufacturer service information.
- Remove the charge-air cooler piping and discharge elbow from the compressor outlet. See equipment manufacturer service information.
- Remove the exhaust pressure regulator. Refer to Procedure 011-105 in Section 11.



Remove

WARNING

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

Spray penetrating oil Part Number 2892116, or equivalent on the four turbocharger mounting nuts and let soak for five minutes before trying to remove the nuts.

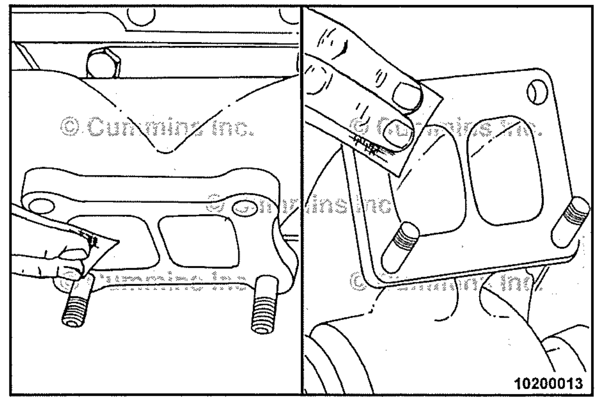
NOTE: If the turbocharger mounting nuts do **not** loosen freely, split the nuts to avoid breaking a mounting stud.

Remove the four turbocharger mounting nuts.

Remove the turbocharger and discard the gasket.

Cover the opening on the exhaust manifold with heavy tape from Air Handling Clean Care Kit, Part Number 4919588.

Clean



⚠CAUTION⚠

While cleaning the exhaust mounting flange ensure, no debris falls into the turbine. Damage to the engine and turbocharger can occur.

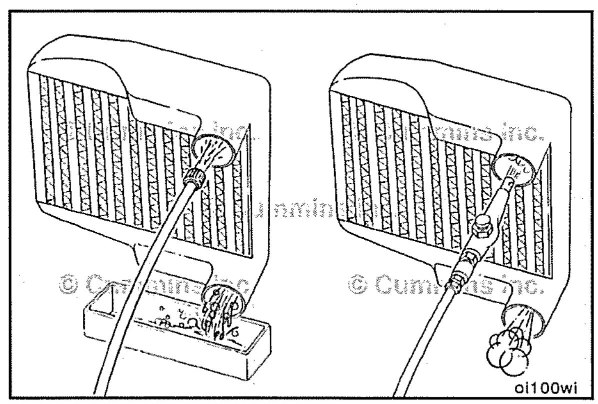
NOTE: All openings on the turbocharger, including the turbine inlet connection, **must** be plugged with caps from the Air Handling Clean Care Kit, Part Number 4919588, during exhaust mounting flange cleaning.

Clean the turbocharger and exhaust manifold where the retaining nut contacts the turbocharger and exhaust manifold.

Clean the mating surfaces with Scotch-Brite™ 7448 abrasive pad.

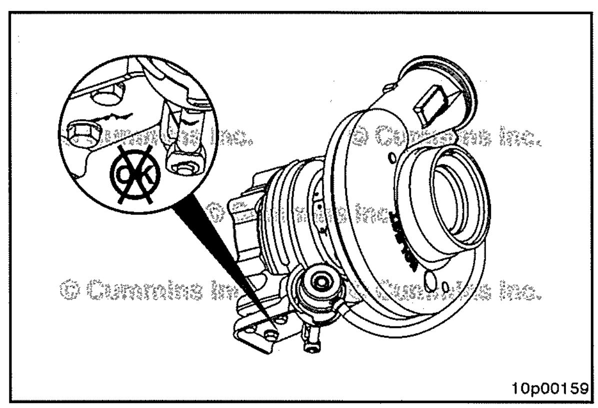
After abrasive cleaning, wipe debris from both surfaces with a clean shop towel.

The surface under the mounting nuts **must** be free of dirt, rust, or any other debris, before applying anti-seize compound.

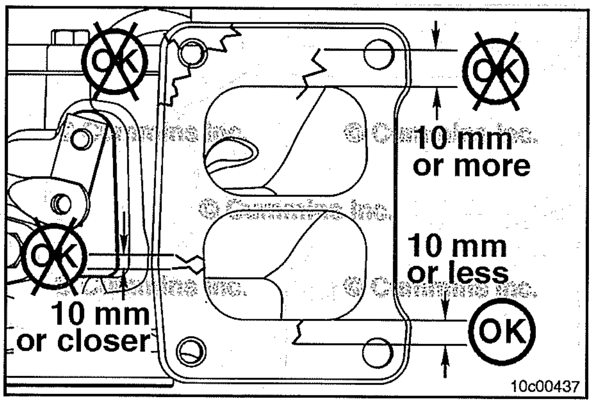


If the engine experiences a turbocharger malfunction or any other occasion where oil or debris is put into the charge-air system, the charge-air system **must** be inspected and cleaned. Refer to Procedure 010-027 in Section 10.

Inspect for Reuse



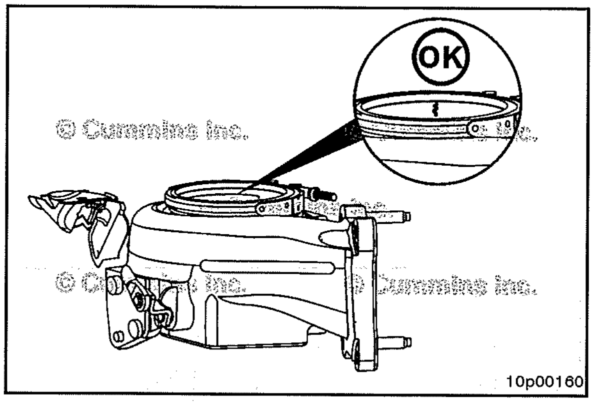
Inspect the wastegate actuator. Refer to Procedure 010-050 in Section 10.



Cracking of the turbine housing inlet flange and the inlet duct generally requires replacement of the turbine housing. Acceptance and rejection guidelines are shown in these illustrations. If an exhaust gasket is available, **always** make certain that cracks do **not** exist within the sealing area.

Check that the turbine housing inlet flange flatness is within 0.1 mm [0.004 in] before accepting the housing for reuse.

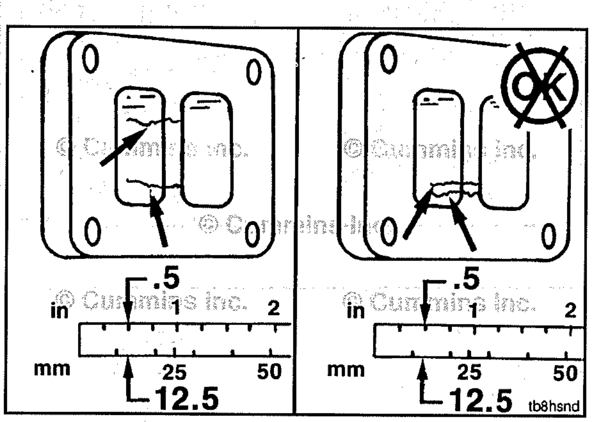
Check the exhaust manifold flange flatness. Refer to Procedure 011-007 in Section 11.



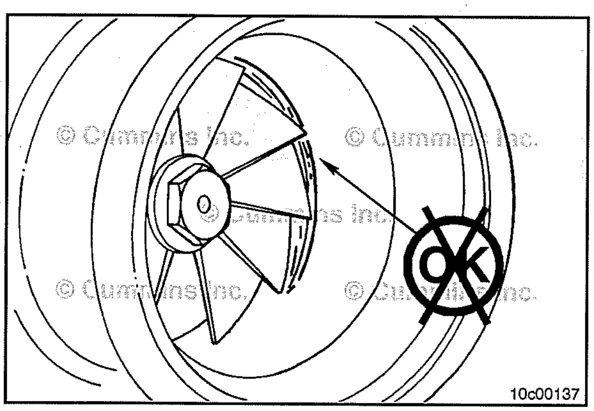
⚠CAUTION⚠

If external cracks are found on the turbine housing, the turbine housing must be replaced.

Cracking of the internal wall at the entry to the turbine wheel (tongue) is acceptable as a service condition, and the turbine housing can be re-used.



Cracks of any length that extend through the divider are acceptable but, **only** if they are separated by at least 12.5 mm [0.50 in].



⚠CAUTION⚠

Do not rotate the turbocharger wheels for long periods of time. The bearings are not lubricated while the engine is not running and excessive rotation could damage the turbocharger.

Check the radial movement of the turbocharger wheels and shaft.

- Use light finger pressure to push the compressor wheel toward the side of the compressor housing and rotate the wheel 360 degrees.
- Replace the turbocharger if the wheel contacts the housing at any point.

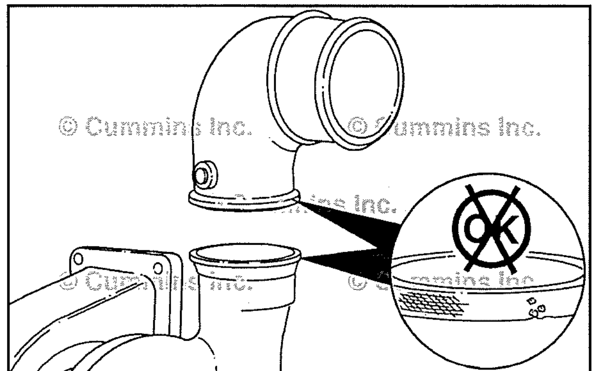
Inspect the turbocharger compressor V-Band outlet and the discharge elbow V-Band connection for dents or fretting.

Replace the turbocharger or discharge elbow, if damaged, to prevent compressed air leaks.

Inspect the compressor wheel for signs of rubbing against the compressor cover. Replace the turbocharger if rubbing evidence is seen.

Use light finger pressure to push the compressor wheel. If the compressor wheel contacts the cover, replace the turbocharger.

If the engine experiences a turbocharger malfunction or any other occasion where oil or debris is put into the charge-air system, the charge-air system **must** be inspected and cleaned. Refer to Procedure 010-027 in Section 10.



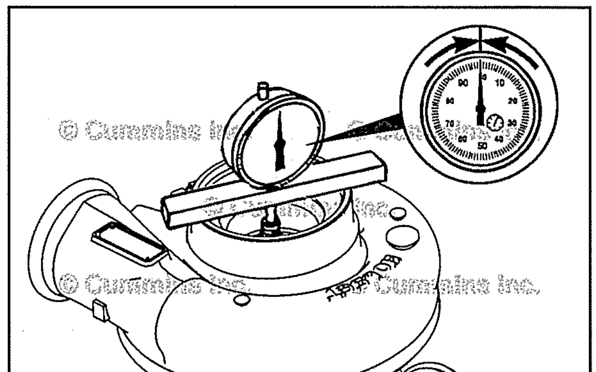
tb1crmb

Measure

Use digital depth gauge, Part Number 3164438.

Push the rotor assembly away from the gauge.

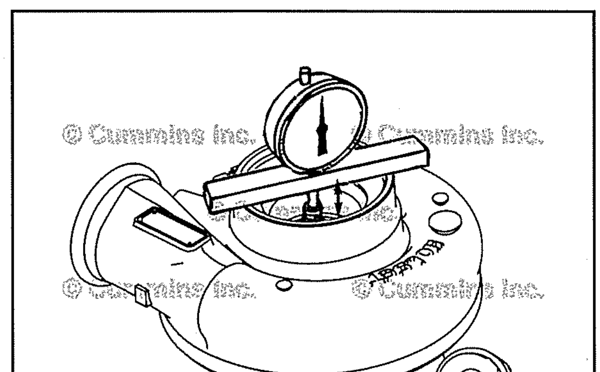
Set a dial depth gauge to zero (0).

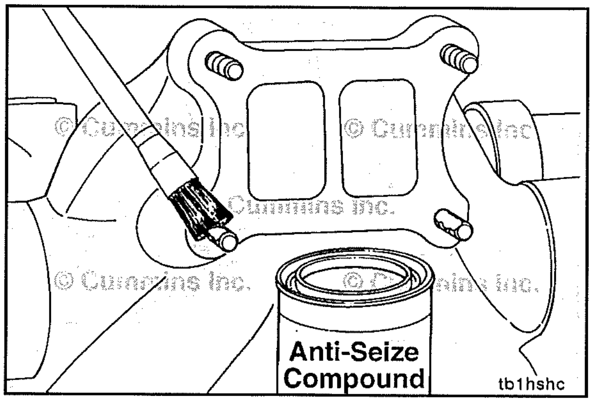

10p00161

Push the rotor assembly toward the gauge and record the reading.

Turbocharger Axial Movement		
mm		in
0.025	MIN	0.001
0.127	MAX	0.005

If the turbocharger axial clearance is **not** within specifications, the turbocharger **must** be replaced.

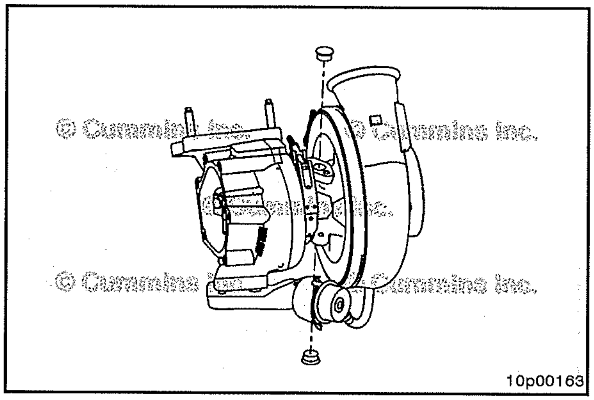

10p00162



Install

Apply a film of high-temperature anti-seize compound, Part Number 3824879, to the turbocharger mounting studs.

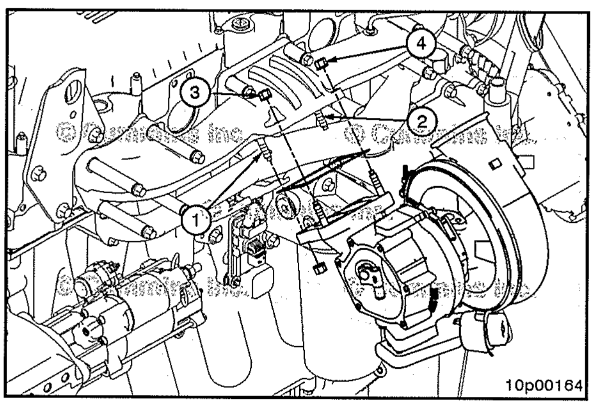
NOTE: Use the following procedure if a turbocharger mounting stud needs to be replaced. Refer to Procedure 011-073 in Section 11.



If installing a new turbocharger:

Remove the plastic shipping plugs from the oil drain and oil supply holes located in the turbocharger bearing housing.

If equipped, remove the plastic shipping plugs from the coolant drain and coolant supply holes located in the turbocharger bearing housing.



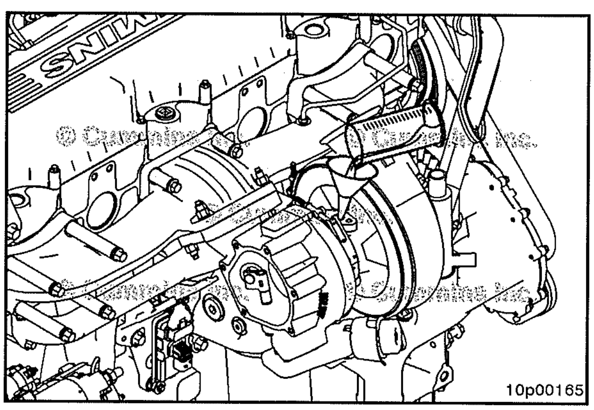
⚠WARNING⚠
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Install a new mounting gasket, the turbocharger and the four mounting nuts.

Tighten the mounting nuts in a criss-cross pattern.

Torque Value: 81 N•m [60 ft-lb]

After all four nuts are tightened, retighten all four nuts in a criss-cross pattern.



Pour approximately 50 to 60 cc [1.7 to 2 oz] of clean engine oil into the turbocharger oil supply opening.

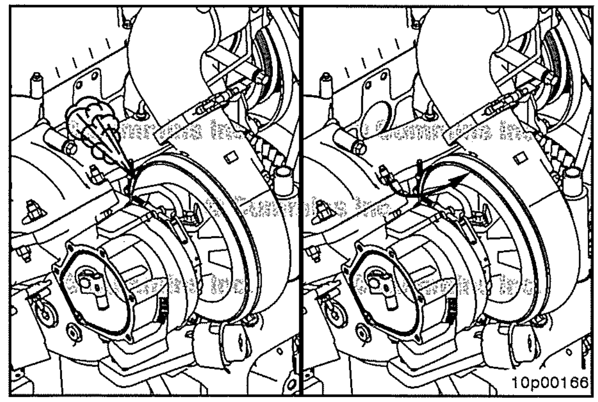
If installing a new turbocharger, it may be necessary to rotate the turbocharger compressor housing to properly align with the charge-air cooler piping.

Rotate the turbocharger compressor housing by loosening the V-band between the turbocharger bearing housing and the turbocharger compressor housing.

Rotate the turbocharger compressor housing to properly align with the charge-air cooler piping.

Tighten the V-band clamp.

Torque Value: 8 N•m [71 ft-lb]

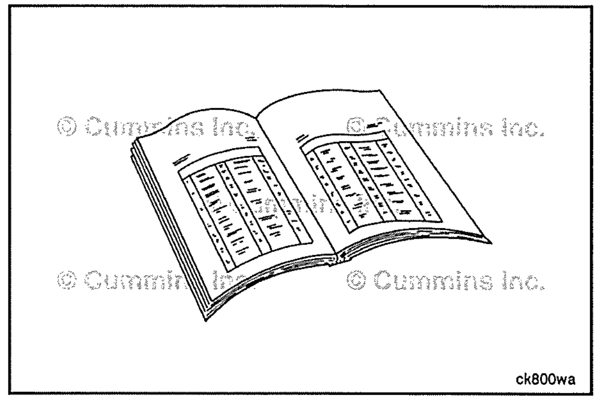


Finishing Steps

⚠WARNING⚠

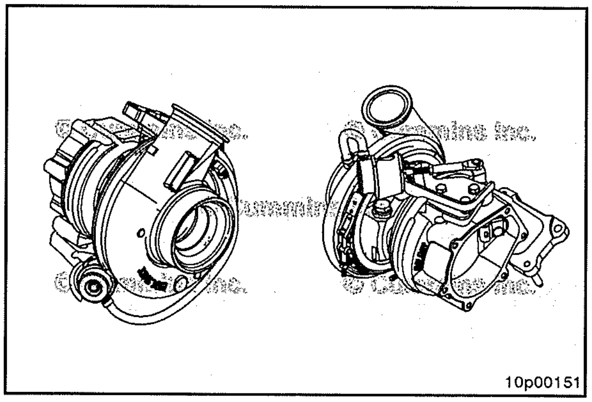
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Install the exhaust pressure regulator. Refer to Procedure 011-105 in Section 11.
- Install the discharge elbow and discharge-air cooler piping on the compressor outlet.
- Install the intake and exhaust pipes on the turbocharger. See equipment manufacturer service information.
- Install the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.
- Install the turbocharger oil supply line. Refer to Procedure 010-046 in Section 10.
- If equipped, install the turbocharger coolant supply and drain lines. Refer to Procedure 010-041 in Section 10.
- Connect the batteries.See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks.



Turbocharger Coolant Hoses (010-041)

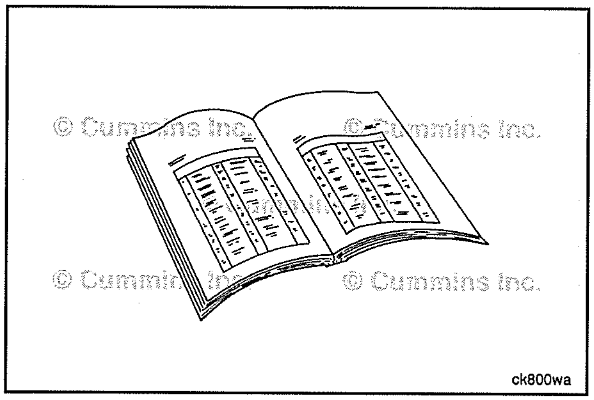
General Information


10p00151

This engine features several turbocharger configuration options. These options include both coolant cooled and non-coolant coolant cooled turbochargers. Each turbocharger configuration requires different coolant lines. Before removing any coolant lines from the engine note the routing of each line. Refer to Procedure 010-033 in Section 10 for more information on turbocharger mounting orientations.

This procedure also includes the removal and installation of the coolant lines for the exhaust pressure regulator. For more information on the exhaust pressure regulator. Refer to Procedure 011-105 in Section 11.

Preparatory Steps


ck800wa

WARNING

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

WARNING

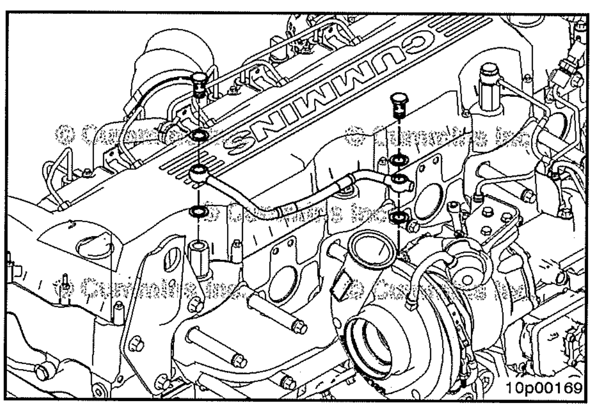
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

WARNING

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.

- Disconnect the batteries. See equipment manufacturer service information.
- Drain the coolant. Refer to Procedure 008-018 in Section 8.

Remove


10p00169

Coolant Cooled Turbocharger

NOTE: Use a second wrench to hold the coolant line fitting while loosening the line.

Remove the turbocharger coolant return line retaining clips and mounting capscrews.

Remove the turbocharger coolant return line from the turbocharger and cylinder head.

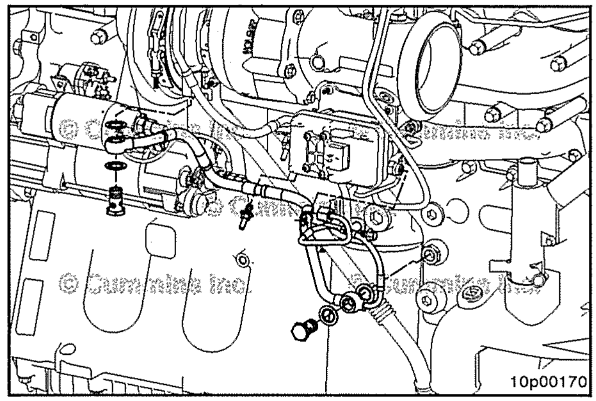
Discard the sealing washers.

NOTE: Use a second wrench to hold the coolant line fitting while loosening the line.

Remove turbocharger coolant supply line retaining clips and mounting capscrews.

Remove the turbocharger coolant supply line from the turbocharger, lubricating oil cooler module and the exhaust pressure regulator.

Discard the sealing washers.

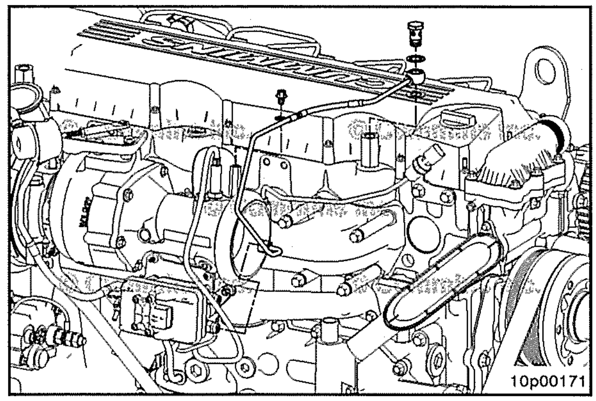


NOTE: Use a second wrench to hold the coolant line fitting while loosening the line.

Remove the exhaust pressure regulator coolant return line retaining clips and mounting capscrews.

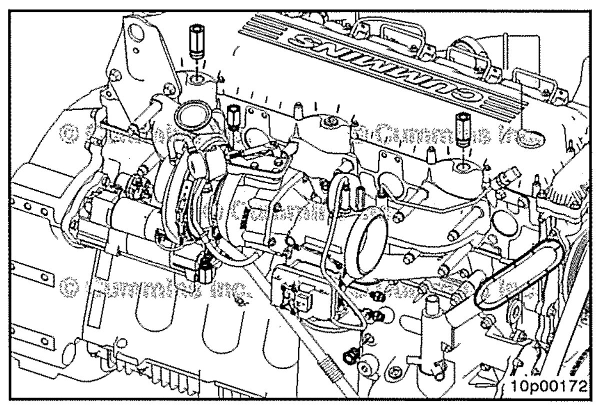
Remove the exhaust pressure regulator coolant return line from the cylinder head and exhaust pressure regulator.

Discard the sealing washers.



NOTE: Remove the coolant line fittings **only** if damaged or required by another part replacement.

If necessary, remove the coolant line fittings from the cylinder head, turbocharger, lubricating oil cooler module and exhaust pressure regulator.



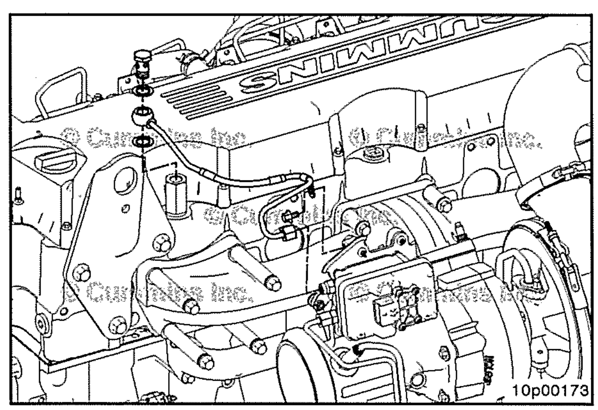
Non-coolant Cooled Turbocharger

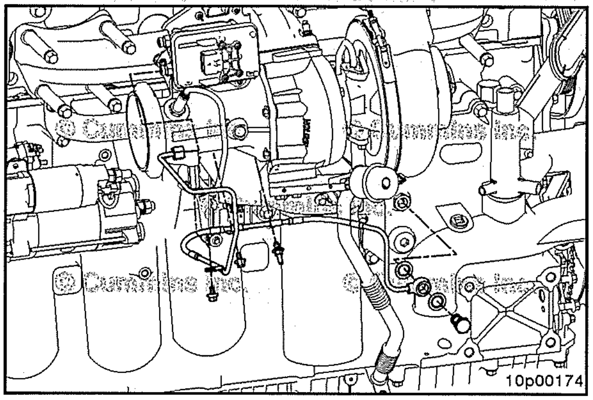
NOTE: Use a second wrench to hold the coolant line fitting while loosening the line.

Remove turbocharger coolant return line retaining clips and mounting capscrews.

Remove the turbocharger coolant return line from the turbocharger and cylinder head.

Discard the sealing washers.



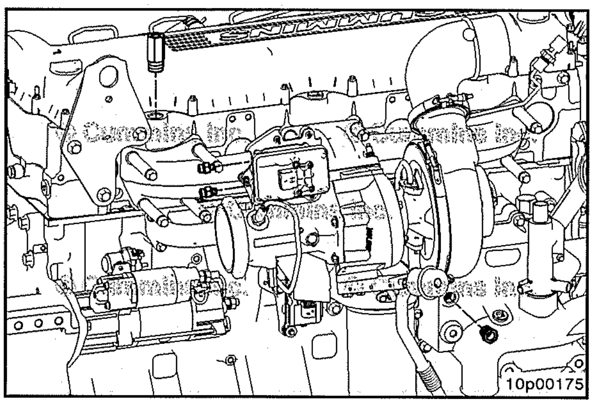


NOTE: Use a second wrench to hold the coolant line fitting while loosening the line.

Remove turbocharger coolant supply line retaining clips and mounting capscrews.

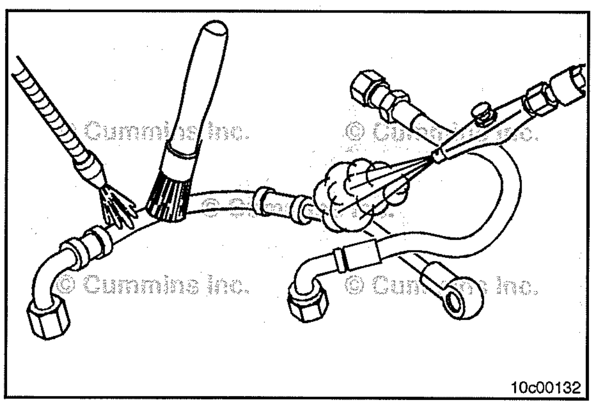
Remove the turbocharger coolant supply line from the turbocharger and the lubricating oil cooler housing.

Discard the sealing washers.



NOTE: Remove the coolant line fittings **only** if damaged or required by another part replacement.

If necessary, remove the coolant line fittings from the cylinder head, lubricating oil cooler module and exhaust pressure regulator.



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

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

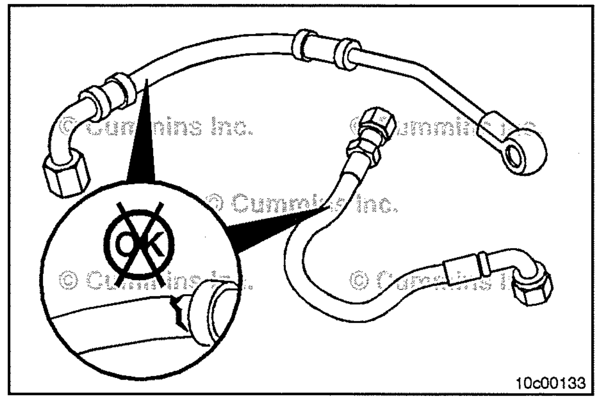
WARNING

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

Clean the turbocharger coolant hoses with solvent.

Dry with compressed air.

Check the turbocharger coolant lines for cracks or other damage. Replace if damage is found.



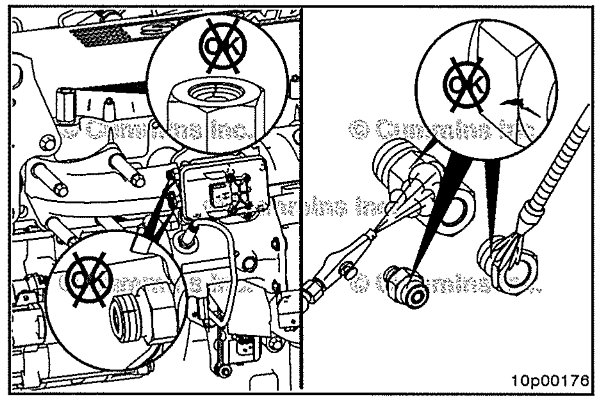
Check the faces of the coolant fittings on the engine and on the turbocharger to make sure they are **not** damaged.

If removed, clean the coolant fittings with solvent.

Dry with compressed air.

Inspect the sealing o-rings for damage and swelling.

Replace the o-rings if damaged or swollen.



Install

Coolant Cooled Turbocharger

If removed, install the coolant line fittings.

Tighten the fittings in the cylinder head (1).

Torque Value: 45 N•m [34 ft-lb]

Tighten the fittings in the turbocharger (2).

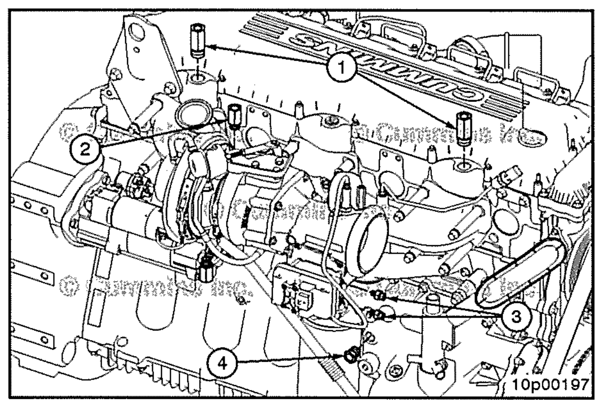
Torque Value: 41 N•m [30 ft-lb]

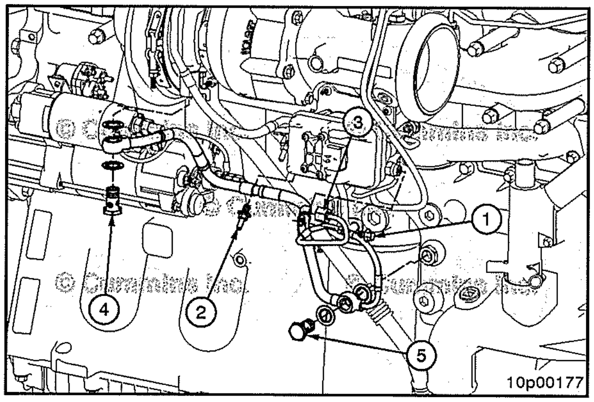
Tighten the fittings in the exhaust pressure regulator (3).

Torque Value: 8 N•m [71 in-lb]

Tighten the fitting in the lubricating oil cooler module (4).

Torque Value: 35 N•m [26 ft-lb]





NOTE: Use a second wrench to hold the coolant line fitting while tightening the line.

Install and hand tighten the turbocharger coolant supply line and new sealing washers at the exhaust pressure regulator, lubricating oil cooler module and turbocharger.

Install and hand tighten the exhaust pressure regulator coolant supply line retaining clips and mounting capscrews.

Tighten the retaining clip on the exhaust pressure regulator housing (1).

Torque Value: 18 N•m [159 in-lb]

Tighten the retaining clip on the NOx sensor mounting bracket (2).

Torque Value: 18 N•m [159 in-lb]

Tighten the coolant line at the exhaust pressure regulator fitting (3).

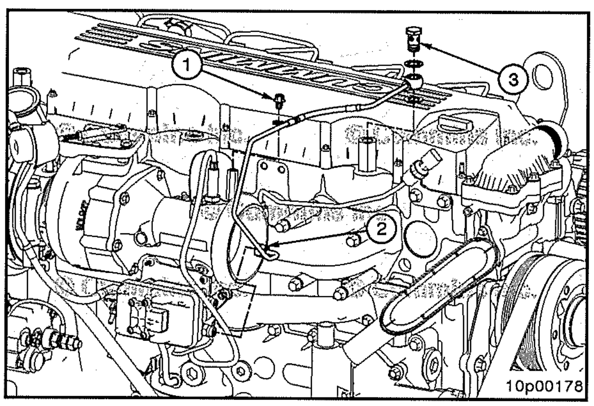
Torque Value: 16 N•m [142 in-lb]

Tighten the coolant line banjo at the turbocharger fitting (4).

Torque Value: 35 N•m [26 ft-lb]

Tighten the coolant line banjo at the lubricating oil cooler module (5).

Torque Value: 35 N•m [26 ft-lb]



NOTE: Use a second wrench to hold the coolant line fitting while tightening the line.

Install and hand tighten the exhaust pressure regulator coolant return line and new sealing washers at the cylinder head and exhaust pressure regulator.

Install and hand tighten the exhaust pressure regulator coolant return line retaining clips and mounting capscrews.

Tighten the retaining clip on the exhaust pressure regulator housing (1).

Torque Value: 18 N•m [159 in-lb]

Tighten the coolant line at the exhaust pressure regulator fitting (2).

Torque Value: 16 N•m [142 in-lb]

Tighten the coolant line banjo at the cylinder head fitting (3).

Torque Value: 35 N•m [26 ft-lb]

NOTE: Use a second wrench to hold the coolant line fitting while tightening the line.

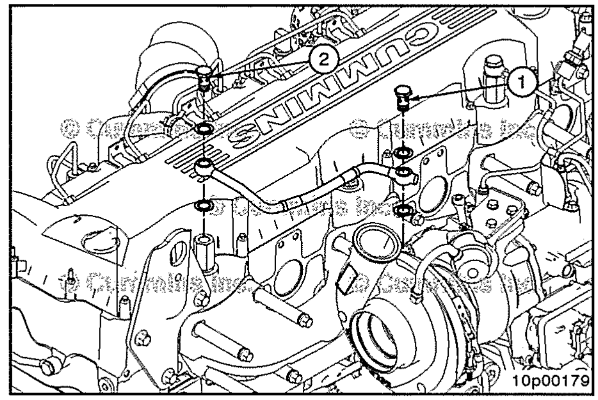
Install and hand tighten the turbocharger coolant return line and new sealing washers from the turbocharger and cylinder head.

Install and hand tighten the turbocharger coolant return line retaining clips and mounting capscrews.

Tighten the coolant lint at the turbocharger fitting (1).

Tighten the coolant line banjo at the cylinder head fitting (2).

Torque Value: 35 N•m [26 ft-lb]



Non-coolant Cooled Turbocharger

If removed, install the coolant line fittings.

Tighten the fittings in the cylinder head (1).

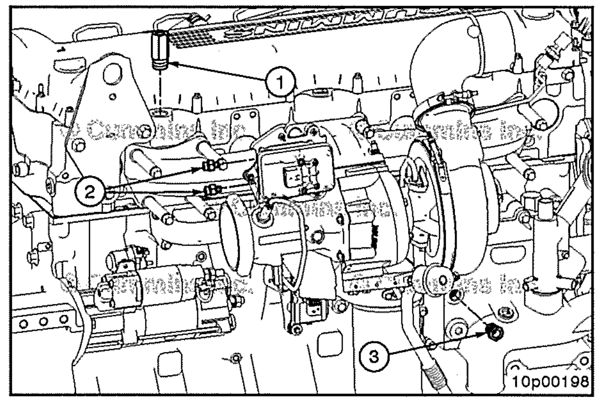
Torque Value: 45 N•m [34 ft-lb]

Tighten the fittings in the exhaust pressure regulator (2).

Torque Value: 8 N•m [71 in-lb]

Tighten the fitting in the lubricating oil cooler module (3).

Torque Value: 35 N•m [26 ft-lb]



NOTE: Use a second wrench to hold the coolant line fitting while tightening the line.

Install and hand tighten the turbocharger coolant supply line and new sealing washers at the exhaust pressure regulator, lubricating oil cooler module and turbocharger.

Install and hand tighten the exhaust pressure regulator coolant supply line retaining clips and mounting capscrews.

Tighten the retaining clip on the exhaust pressure regulator housing (1).

Torque Value: 18 N•m [159 in-lb]

Tighten the retaining clip on the NOx sensor mounting bracket (2).

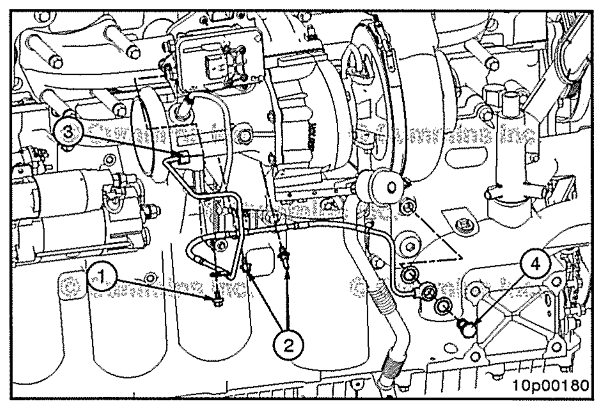
Torque Value: 18 N•m [159 in-lb]

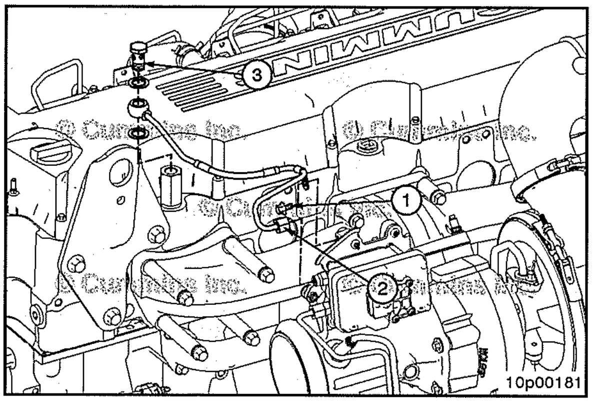
Tighten the coolant line at the exhaust pressure regulator fitting (3).

Torque Value: 16 N•m [142 in-lb]

Tighten the coolant line banjo at the lubricating oil cooler module (4).

Torque Value: 35 N•m [26 ft-lb]





NOTE: Use a second wrench to hold the coolant line fitting while tightening the line.

Install and hand tighten the exhaust pressure regulator coolant return line and new sealing washers at the cylinder head and exhaust pressure regulator.

Install and hand tighten the exhaust pressure regulator coolant return line retaining clips and mounting capscrews.

Tighten the retaining clip on the exhaust pressure regulator housing (1).

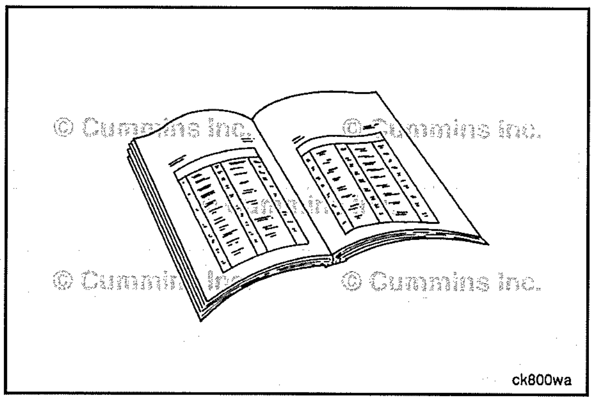
Torque Value: 18 N•m [159 in-lb]

Tighten the coolant line at the exhaust pressure regulator fitting (2).

Torque Value: 16 N•m [142 in-lb]

Tighten the coolant line banjo at the cylinder head fitting (3).

Torque Value: 35 N•m [26 ft-lb]



Finishing Steps

WARNING

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

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.

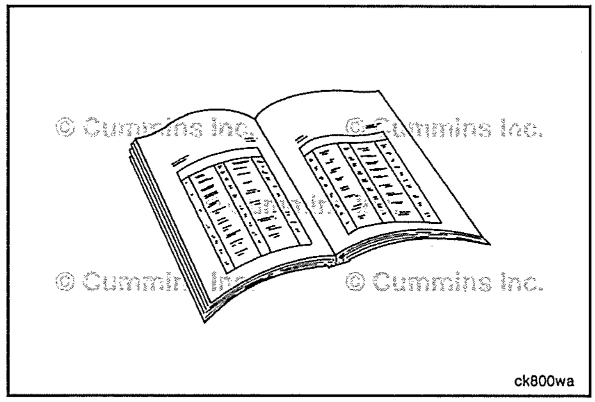
WARNING

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 engine with coolant. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

Turbocharger Oil Drain Line (010-045)

Preparatory Steps

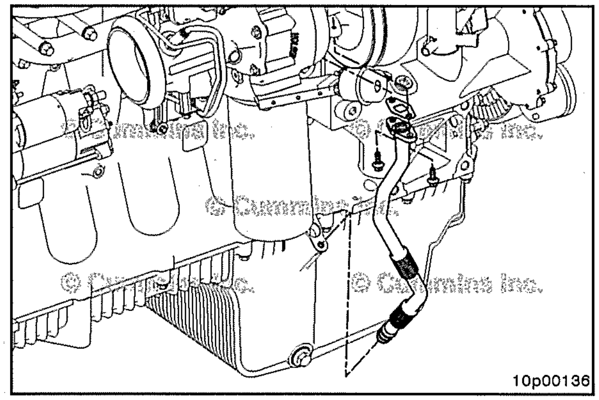


⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.

Remove



⚠CAUTION⚠

Be careful not to bend or kink the turbocharger oil drain line when removing the line. Doing so can damage the line. If the line is damaged upon removal it must be replaced.

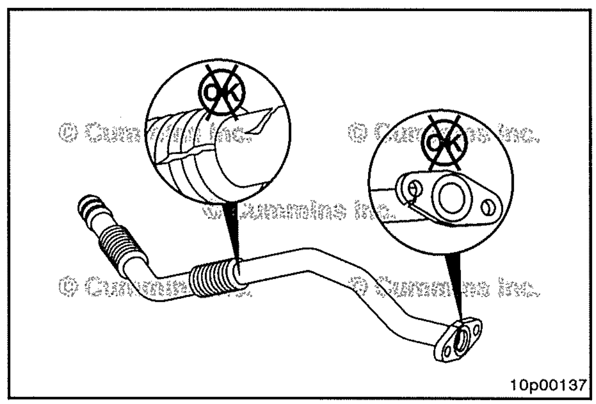
Remove the turbocharger oil drain line from the turbocharger.

Remove and discard the gasket.

Grasp the turbocharger oil drain line at its base and pull oil drain line from the oil pan by hand.

NOTE: The turbocharger oil drain line can be rotated and pulled to assist in removal of the drain line.

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⚠

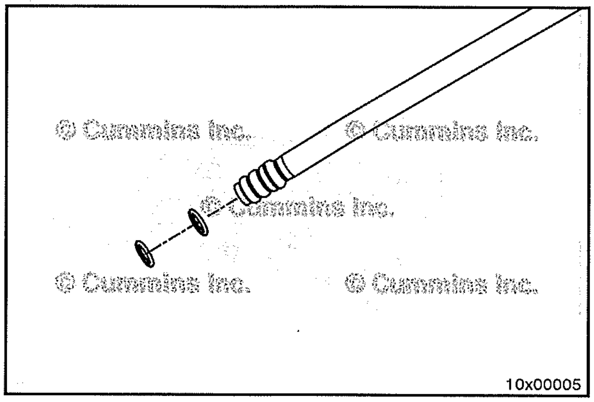
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the drain line with solvent.

Dry the line with compressed air.

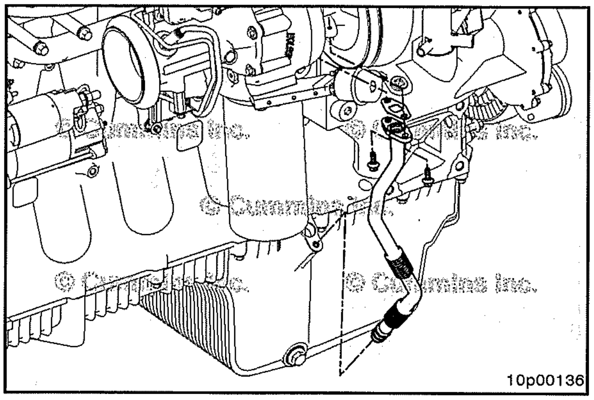
Check the line for cracks or other damage.

Replace the drain line if it is damaged.



Check the drain line o-rings for damage.

Replace the o-rings if they are damaged.



Install

CAUTION

Do not bend or kink the drain line while installing the line. Doing so can possibly damage line. If the line is damaged upon removal it must be replaced.

NOTE: Be sure the o-rings are installed into the turbocharger oil drain line.

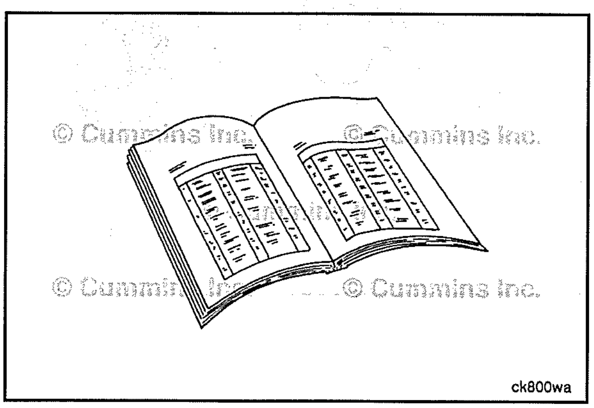
NOTE: Clean engine oil can be applied to the turbocharger oil drain line o-rings to ease the installation of the line.

Insert the bottom of the drain line into oil pan.

NOTE: The turbocharger oil drain line can be rotated into place to ease in the installation of the line.

Install the drain line with a new gasket to the bottom of the turbocharger.

Torque Value: 23 N•m [204 in-lb]



Finishing Steps

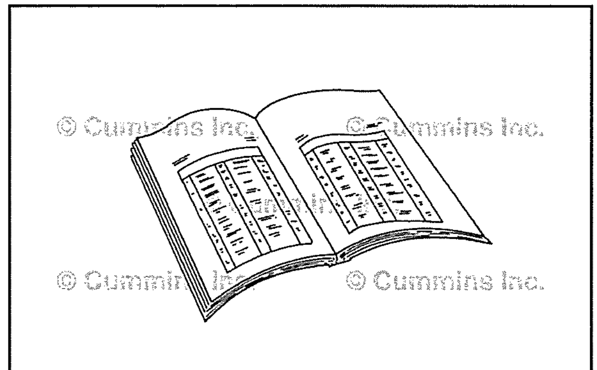
WARNING

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 batteries. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks.

Turbocharger Oil Supply Line (010-046)

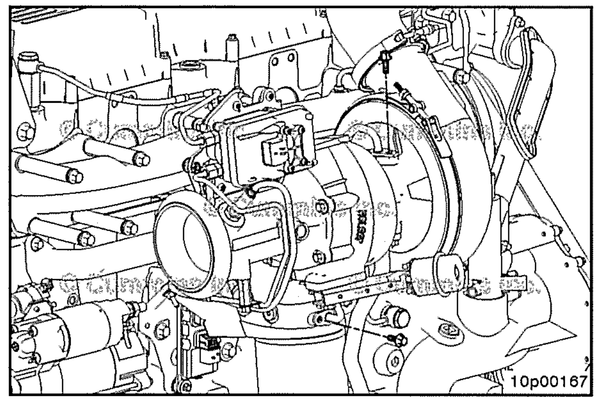
Preparatory Steps


ck800wa

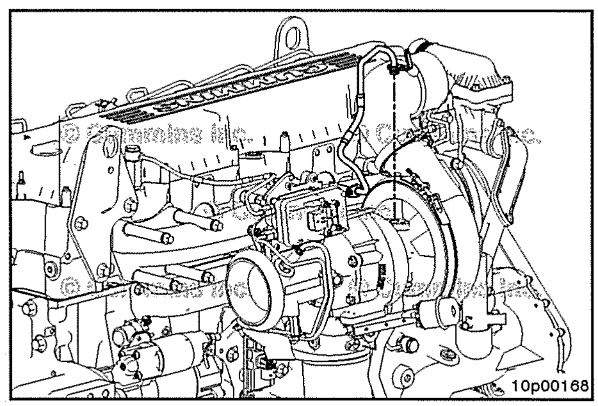
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries. See equipment manufacturer service information.

Remove

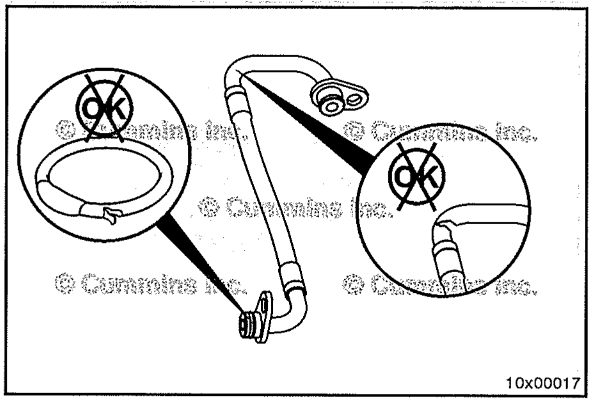

10p00167

Remove the capcrews from the lubricating oil filter head and the turbocharger bearing housing.


10p00168

Remove the turbocharger oil supply line from the lubricating oil filter head then the turbocharger bearing housing.

To prevent debris from entering the engine, install plugs into the open ports in the turbocharger and lubricating oil filter head from the clean care kit, Part Number 4919073.



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⚠

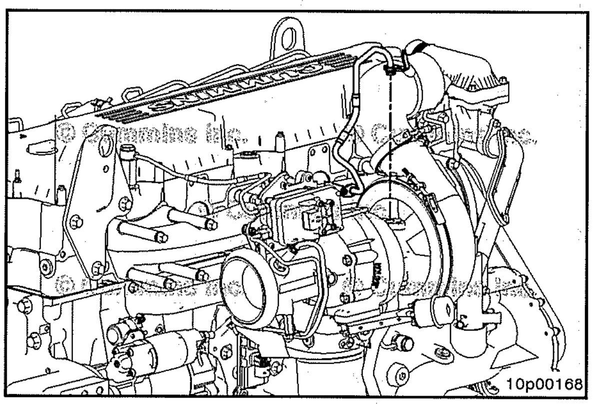
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the supply line with solvent.

Dry with compressed air.

Check the o-rings for cuts or deformation. Replace the o-rings if damage is found.

Check the supply line for cracks or other damage. Replace the supply line if damage is found.



Install

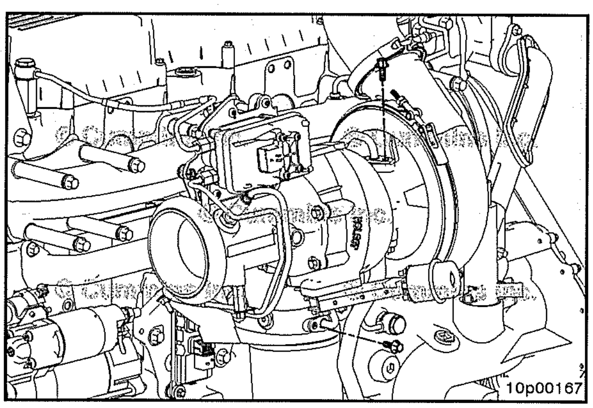
⚠CAUTION⚠

Proper routing of the turbocharger oil supply line is critical to prevent a malfunction. Avoid any line-to-metal contact.

Pour 60 to 90 cc [2 to 3 oz] of clean engine oil into the turbocharger oil supply opening.

Install the supply line at the turbocharger bearing housing then at the lubricating oil filter head.

NOTE: Clean engine oil can be applied to the turbocharger oil supply line o-rings to ease the installation of the line.



NOTE: Ensure the capscrews are free of any oil before installing them on the engine.

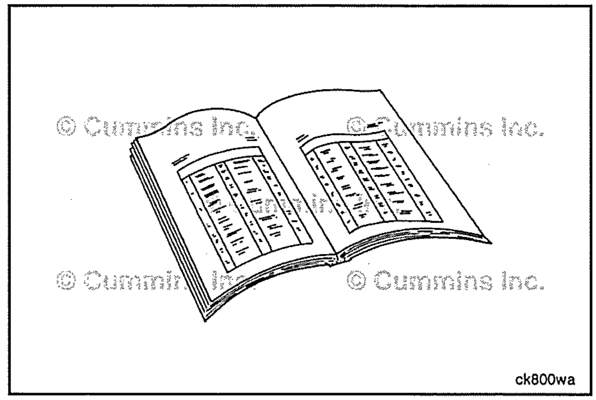
Install the capcrews onto the lubricating oil filter head and the turbocharger bearing housing.

Torque Value: 18 N•m [159 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 batteries. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks.

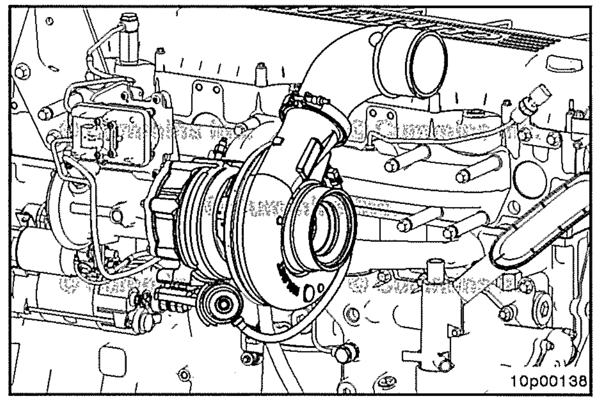


Turbocharger Wastegate Actuator (010-050)

Initial Check

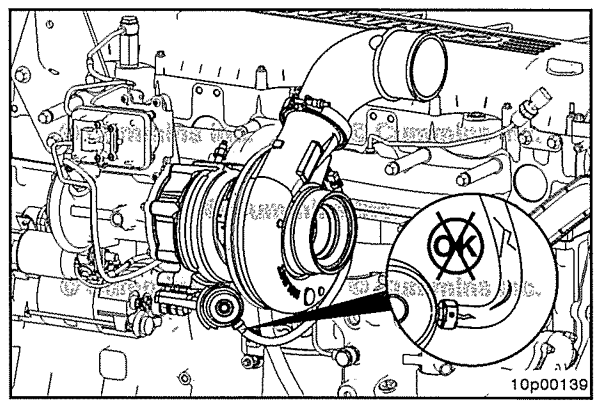
This engine is equipped with a wastegated turbocharger to limit the peak boost level and rotor speed.

The turbocharger actuator air line transfers boost pressure from the turbocharger compressor housing to the wastegate actuator.



Inspect the turbocharger actuator air line for cracks, holes, tampering, or restrictions.

If damage or tampering is found the turbocharger actuator air line **must** be replaced. Refer to Procedure 010-118 in Section 10.



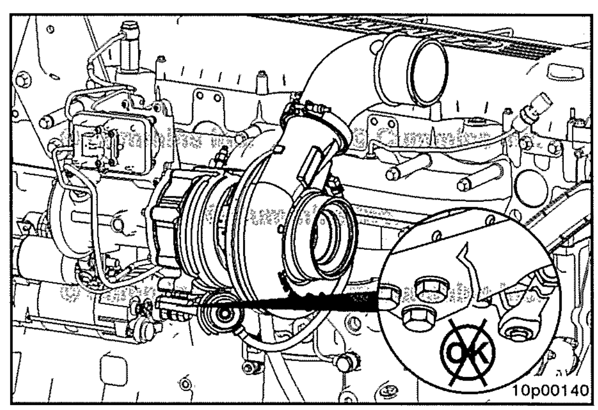
⚠CAUTION⚠
A bent wastegate mounting bracket, actuator rod, or lever can cause improper operation.

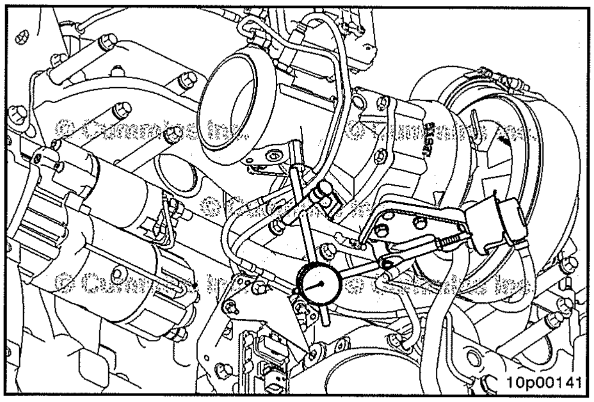
Inspect the actuator rod, and lever for damage.

If the actuator rod or lever is damaged or bent, the wastegate actuator **must** be replaced.

Inspect the wastegate mounting bracket for cracks and other damage.

If the wastegate mounting bracket is damaged, replace the turbocharger. Refer to Procedure 010-033 in Section 10.



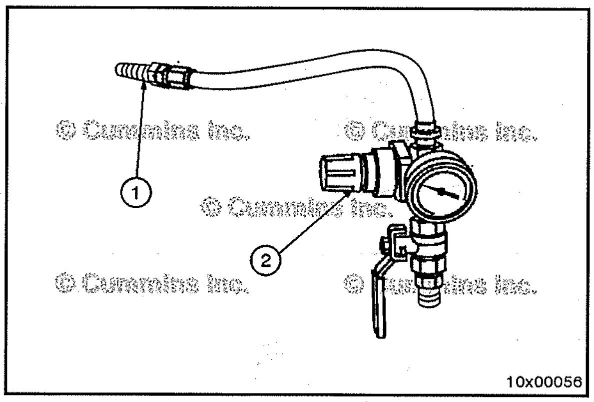


⚠ WARNING ⚠

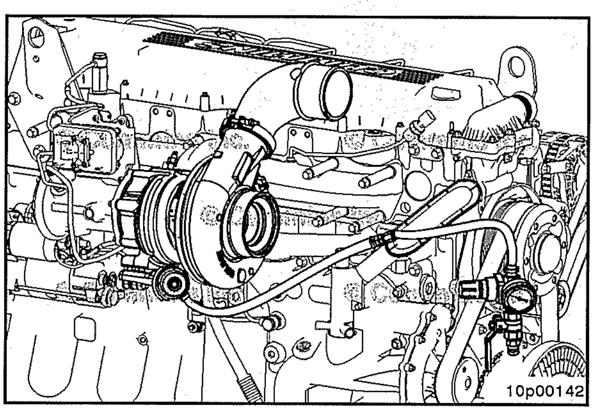
The turbocharger and turbocharger components can remain hot after the engine has been shut down or secured. To reduce the possibility of fire, property damage, burns, or other serious personal injury, allow the turbocharger system to cool down before beginning this procedure or repair and make sure that no combustible materials are located where it might come in contact with a hot turbocharger or turbocharger components.

To verify the wastegate actuator travel, install service tool, Part Number 3377399, on the wastegate cover with the magnetic base and the dial indicator from service kit Part Number 3164438, resting on the end of the actuator end link. The dial indicator should be aligned with the actuator shaft.

NOTE: Access to the wastegate actuator may be difficult with the turbocharger installed on the engine. If necessary, remove the turbocharger from the engine. Refer to Procedure 010-033 in Section 10.



Install the fitting, Part Number 5298595 (1), into the pressure regulator, Part Number 3164231 (2).



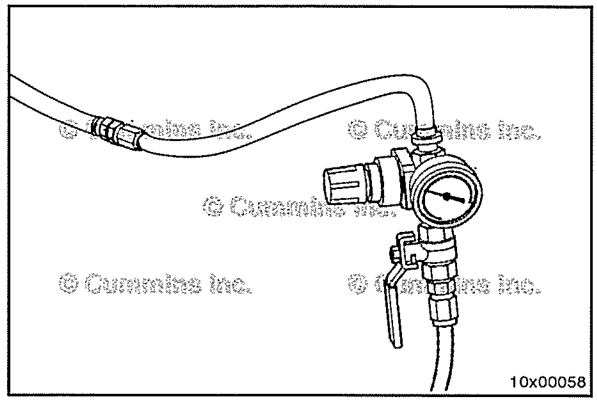
Disconnect the turbocharger actuator air line from the turbocharger compressor housing and discard the hose clamp.

Install the air line onto the pressure regulator assembly using a new hose clamp.

Air leaks should **not** be detected through a functional wastegate canister. If an air leak is detected replace the wastegate actuator.

Connect an air supply to the turbocharger wastegate actuator. Apply regulated air pressure of 205 kPa [30 psi] to the wastegate actuator to measure the travel.

Cycle the air pressure to the actuator assembly several times to work the system. Do **not** exceed 240 kPa [35 psi].



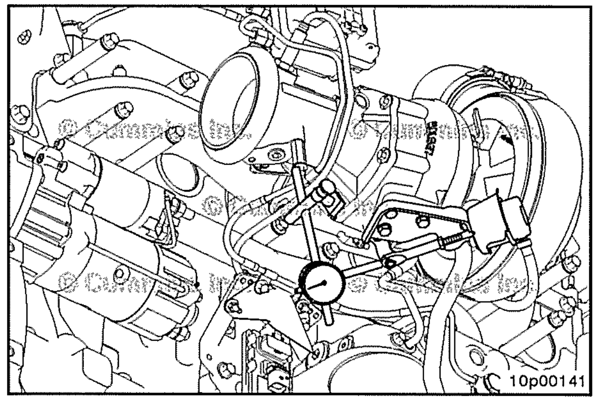
If the turbocharger has been removed from the engine, the turbocharger **must** sit so the actuator shaft is horizontal. If the actuator shaft is **not** horizontal, the measurement will **not** be accurate.

Measure the actuator rod for correct travel. If the actuator travel is **not** within the specifications, the wastegate actuator **must** be replaced.

To make sure an accurate measurement is obtained, it is essential to use the specified tools and procedures.

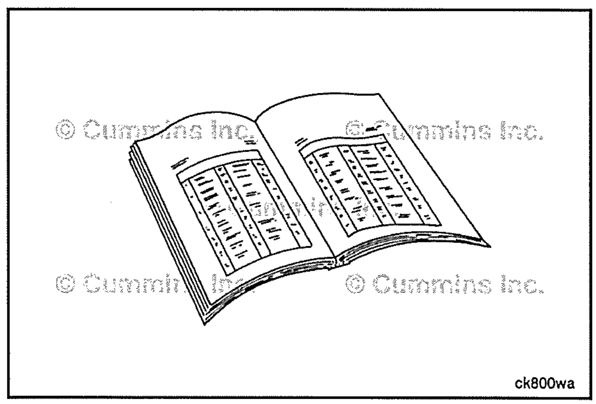
Turbocharger Wastegate Rod Travel at 205 kPa [30 psi]

mm		in
0.33	MIN	0.013
1.27	MAX	0.050



Preparatory Steps

- Remove the turbocharger. Refer to Procedure 010-033 in Section 10.

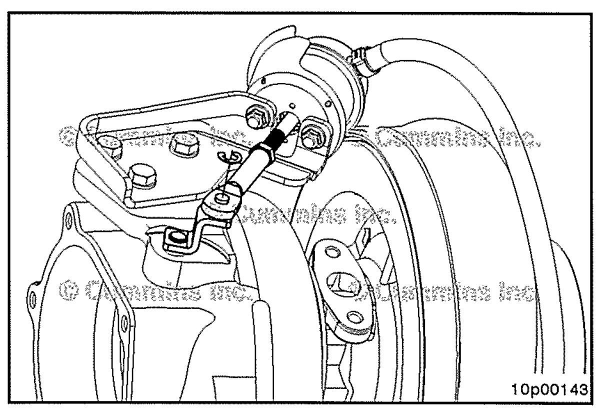


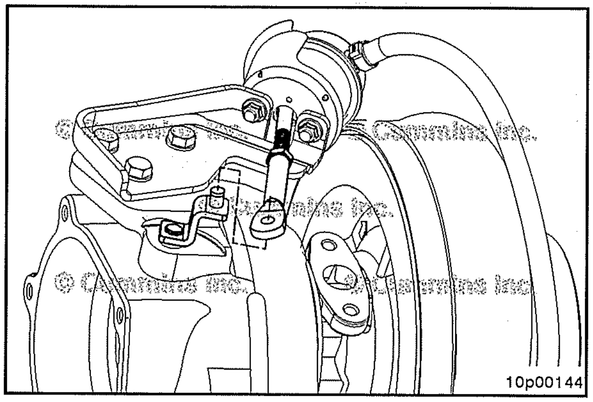
Remove

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

If **not** previously removed, remove the retaining clip from the control lever.

NOTE: This can be done with a pair of needle nose pliers.

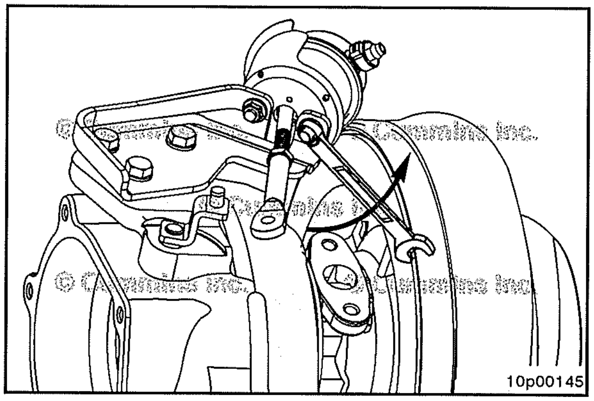




If **not** previously removed, disconnect the wastegate actuator end link from the control lever pin.

NOTE: A screwdriver can be used to gently remove the wastegate actuator end link from the control lever pin.

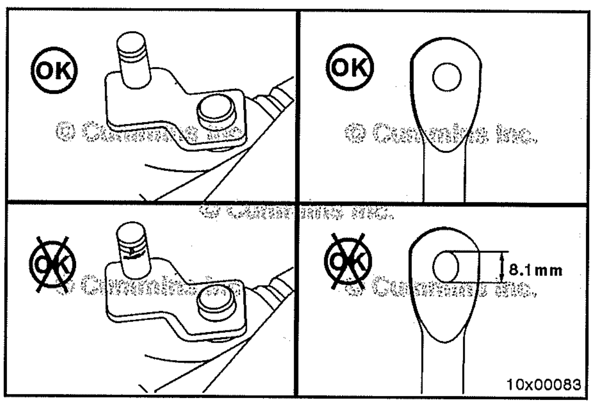
NOTE: The wastgate actuator end link will compress quickly once the end link is removed from the control lever pin.



Remove the turbocharger actuator air line. Refer to Procedure 010-118 in Section 10.

Remove the two wastegate actuator mounting nuts.

Remove the wastegate actuator.



Inspect for Reuse

NOTE: The wastegate actuator end-link **must** be removed to inspect the turbocharger wastegate actuator.

Remove the retaining clip from the control lever.

Lift the wastegate actuator end-link from the pin.

NOTE: A screwdriver can be used to gently remove the wastegate actuator end link from the control lever pin.

NOTE: The wastgate actuator end link will compress quickly once the end link is removed from the control lever pin.

Inspect the control lever pin.

If the control lever pin is worn excessively (see graphic), replace the turbocharger. Refer to Procedure 010-033 in Section 10.

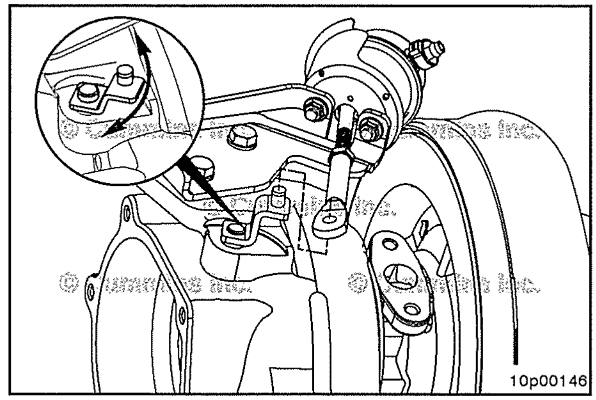
Inspect the actuator end link. The largest end link hole diameter should **not** exceed 8.1 mm (0.32 in).

If the actuator end link is worn excessively, replace the actuator.

Rotate the lever by hand to verify that the wastegate shaft turns freely and is **not** seized.

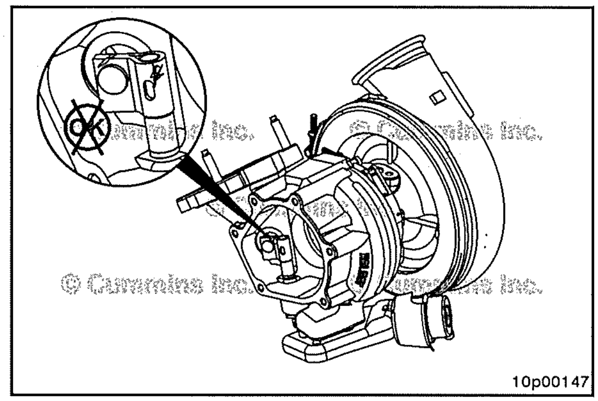
Check for excessive movement between the shaft and bushing.

Replace the turbocharger if the shaft and bushing are damaged or seized. Refer to Procedure 010-033 in Section 10.



10p00146

Check the wastegate valve and valve seat for cracks and other damage. If damage is found replace the turbocharger. Refer to Procedure 010-033 in Section 10.



10p00147

Install

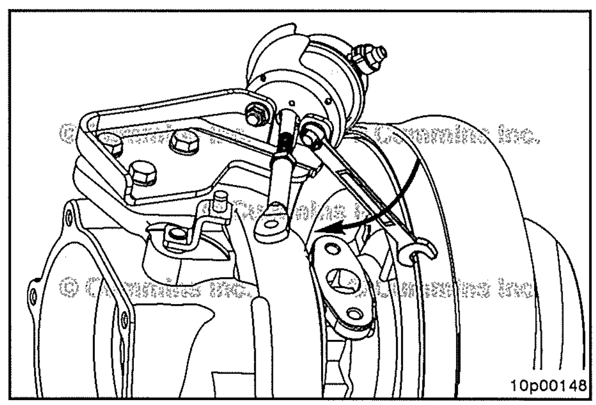
Install the two wastegate actuator mounting nuts.

Torque Value: 8.5 N•m [75 in-lb]

Install the turbocharger actuator air line and the pressure regulator assembly.

Gently apply air pressure to the wastegate actuator. Until the actuator end link can be installed on the control link pin.

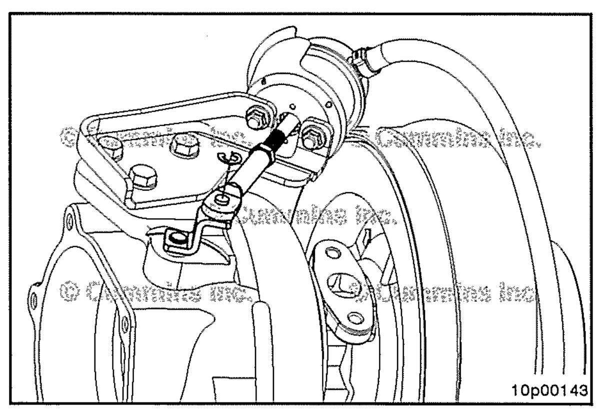
Install the actuator end link onto the control link pin.



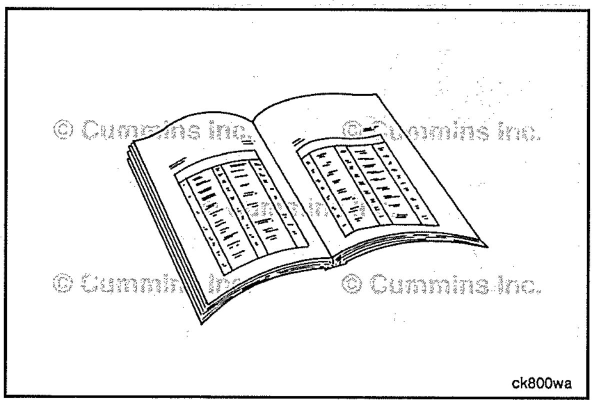
10p00148

Install the retaining clip onto the control lever.

Install the turbocharger actuator air line. Refer to Procedure 010-118 in Section 10.

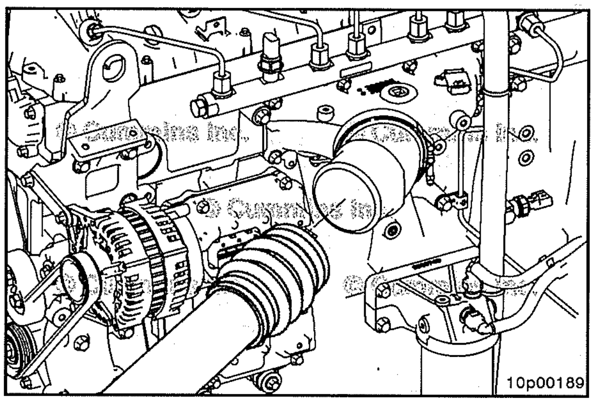


10p00143



Finishing Steps

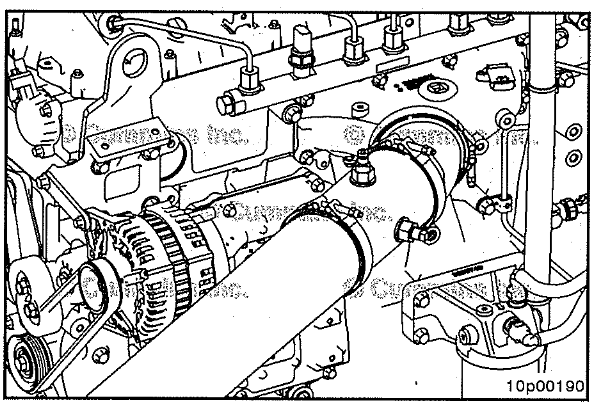
- Install the turbocharger. Refer to Procedure 010-033 in Section 10.
- Operate the engine and check for proper operation.



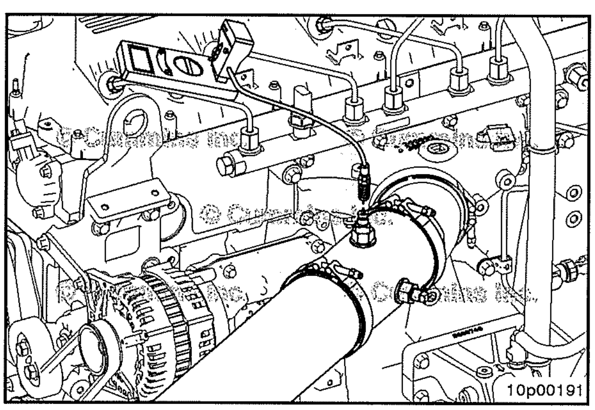
Intake Manifold Pressure (010-057)

Measure

Remove the air intake connection adapter from the air intake connection. See equipment manufacturer service information.



Install testing boot Part Number 5298904 from kit 5298903 onto the air intake connection.



Install the pressure adaptor, Part Number 3164491 onto multimeter, Part Number 3164489. Both are from service tool kit Part Number 3400162.

Install the female quick connect coupling, Part Number 3376920 onto the pressure adaptor.

Install the female quick connect coupling onto the quick connect fitting installed on the testing boot.

Rout the pressure adaptor wiring so it can be viewed in the cab of the vehicle.

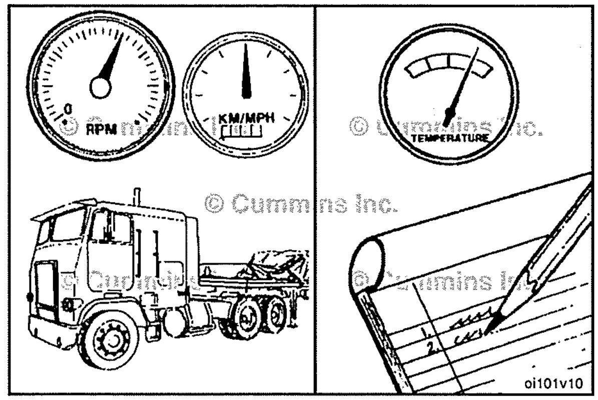
NOTE: The pressure adaptor wiring **must** be routed away from any heat sources or moving parts to ensure it does **not** get damaged during testing.

Operate the engine at rated rpm and full load.

NOTE: If a road test is performed two people should perform the test. One to drive the unit, the other to monitor the temperatures.

Compare the value to the specifications given in the engine performance data sheets.

NOTE: Stall speed is **not** full power.

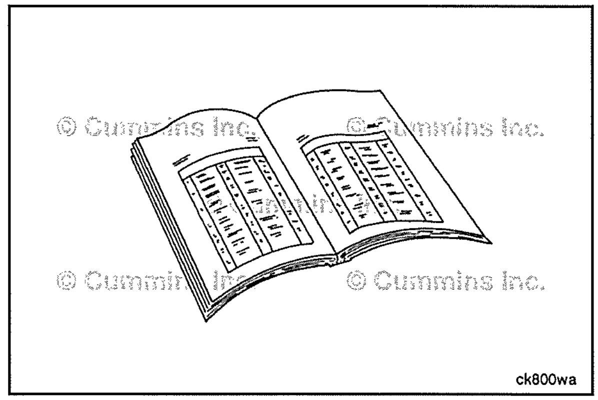


oi101v10

Finishing Steps

⚠CAUTION⚠
The testing boot must be removed after testing. Failure to remove the testing boot could result in air leaks.

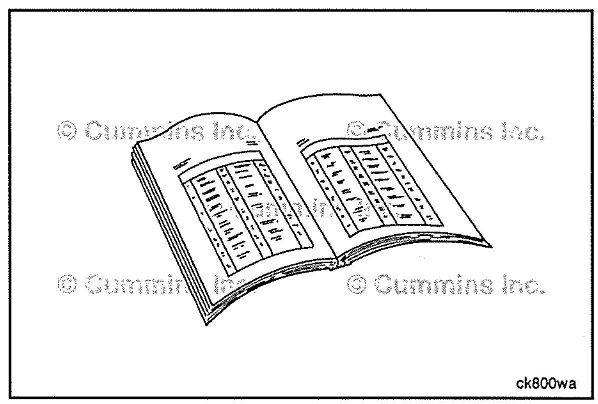
- Remove all testing equipment.
- Install the original charge air cooler boot onto the intake air connection. See equipment manufacturer service information.
- Operate engine and check for leaks.


ck800wa

Air Intake Connection (010-080)

Preparatory Steps

- Disconnect the air intake connection adapter.
- Disconnect the intake manifold air pressure/ temperature sensor from the engine harness. Refer to Procedure 019-159 in Section 19.
- Disconnect the wire harness attachments from the air intake connection.
- If applicable, disconnect the cold start aid wiring. Refer to Procedure 010-029 in Section 10.
- Disconnect the air compressor supply line from the air intake manifold. Refer to Procedure 012-024 in Section 12.


ck800wa

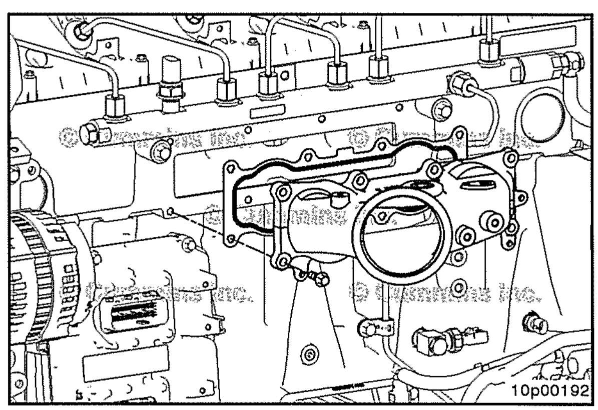
Remove

Remove the fir tree that holds the crankcase breather to the air intake connection.

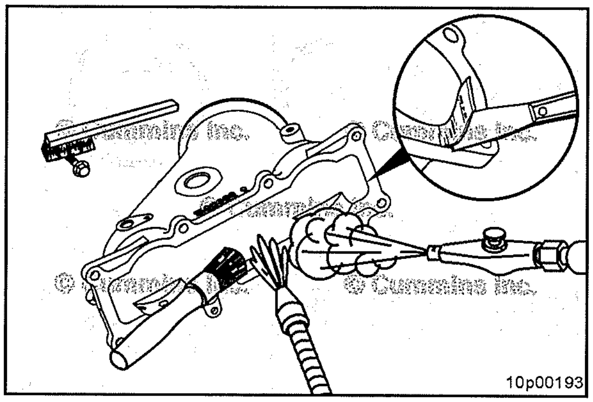
Remove the eight capscrews holding the air intake connection to the cylinder head.

Remove and discard the air intake connection gasket.

Use protective caps and heavy tape from the Air Handling Clean Care Kit, Part Number 4919588, to cover open points on the plumbing and engine.


10p00192

Clean and Inspect for Reuse


10p00193

⚠WARNING⚠

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

⚠WARNING⚠

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

NOTE: Before cleaning the inside of the air intake connection, make sure to remove the air pressure/ temperature sensor.

If necessary, remove the cold starting aids from the air intake connection. Refer to Procedure 010-029 in Section 10.

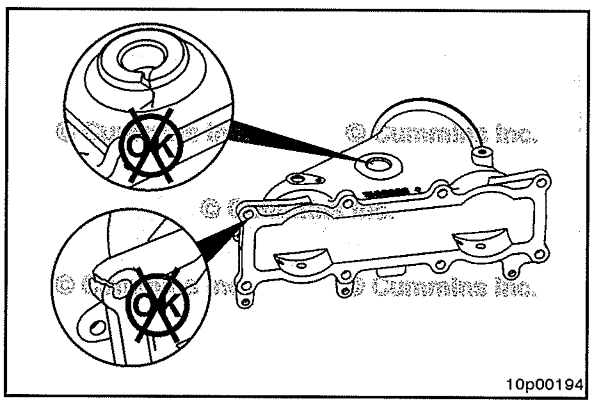
Clean the air intake connection mounting capscrews.

Clean the air intake connection gasket surface.

Clean the air intake connection. Saturate the inside of the air intake with solvent.

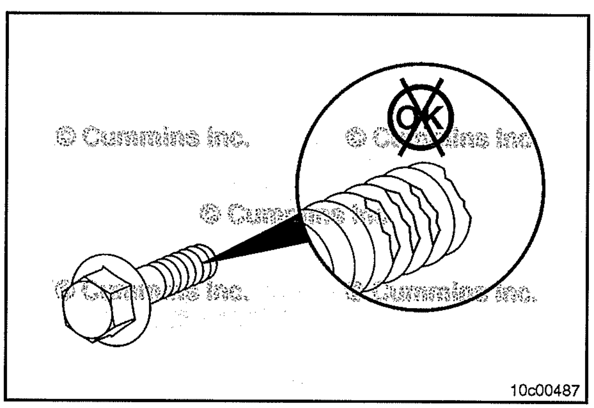
Clean the debris with a non-abrasive brush.

Dry the air intake connection with compressed air.



10p00194

Inspect the air intake connection for cracks or other damage. Replace the connection if it is damaged.



10c00487

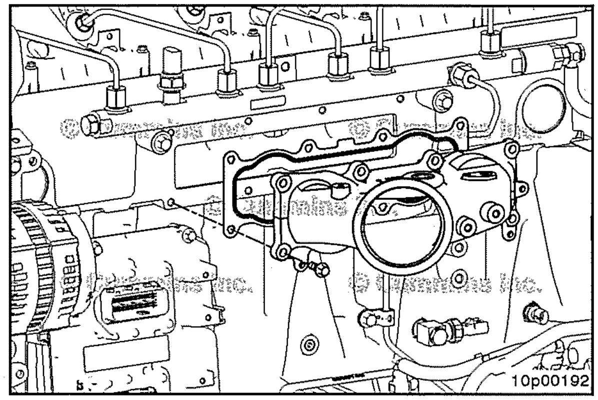
Inspect the air intake connection capscrews for stripped threads or other damage. Replace the capscrews if they are damaged.

Install

If applicable, install the cold starting aids. Refer to Procedure 010-029 in Section 10.

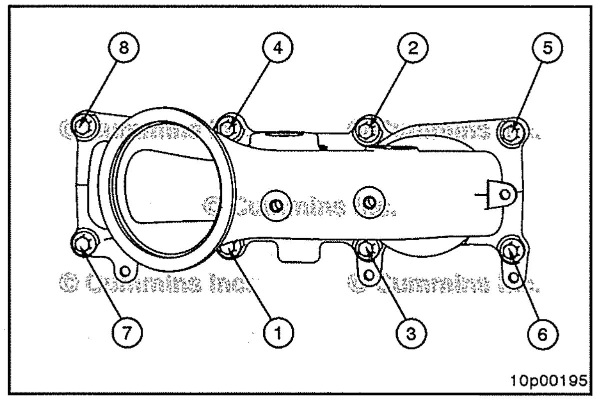
Install a new gasket between the cylinder head and the air intake connection.

Install the eight capscrews hand-tight.



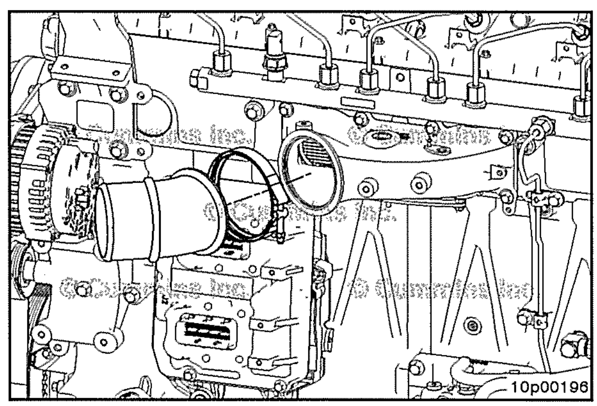
Tighten the capscrews according in the sequence shown.

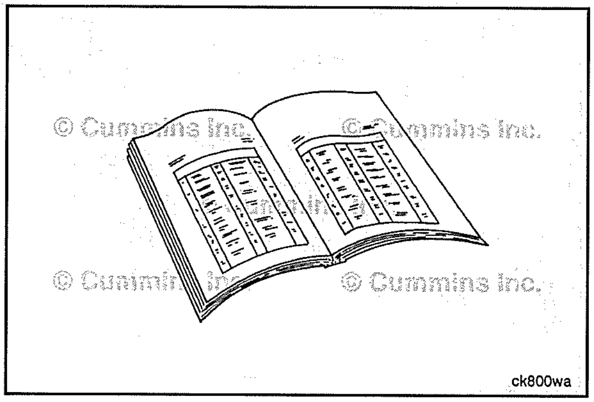
Torque Value: 23 N•m [204 in-lb]



Install the air intake connection adapter.

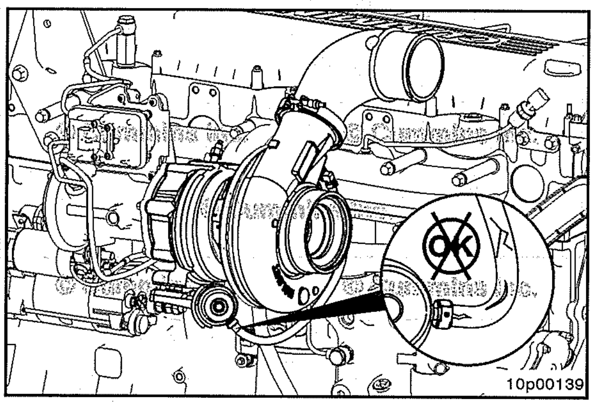
Torque Value: 8 N•m [71 in-lb]





Finishing Steps

- Install the fir tree that holds the crankcase breather to the air intake connection.
- Connect the air compressor supply line from the air intake manifold. Refer to Procedure 012-024 in Section 12.
- If applicable, connect the cold start aid wiring. Refer to Procedure 010-029 in Section 10.
- Connect the wire harness attachments from the air intake connection.
- Connect the intake manifold air pressure/ temperature sensor from the engine harness. Refer to Procedure 019-159 in Section 19.
- Operate the engine to normal operating temperature and check for air leaks.

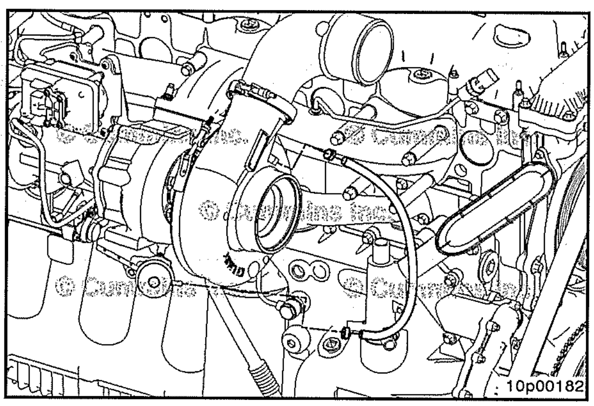


Turbocharger Actuator Air Line (010-118)

Initial Check

The turbocharger actuator air line transfers boost from the turbocharger compressor housing to the turbocharger wastegate actuator.

Inspect the turbocharger actuator air line for cracks or holes. Inspect the air line for tampering. The air line should be free of any restrictions. Replace the air line if damage or tampering is found.



Remove

Remove the hose clamps at the wastegate actuator and the turbocharger compressor housing.

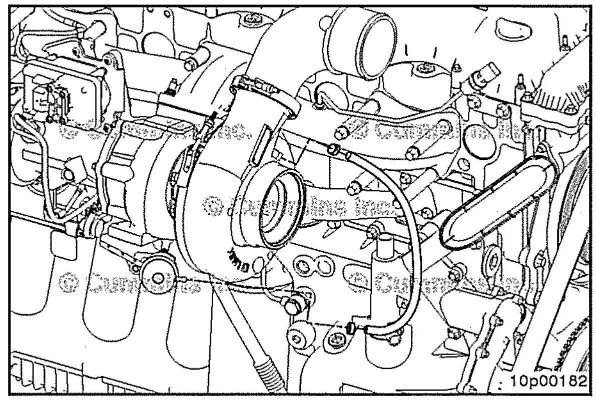
Remove the turbocharger actuator air line.

Discard the hose clamps.

Install

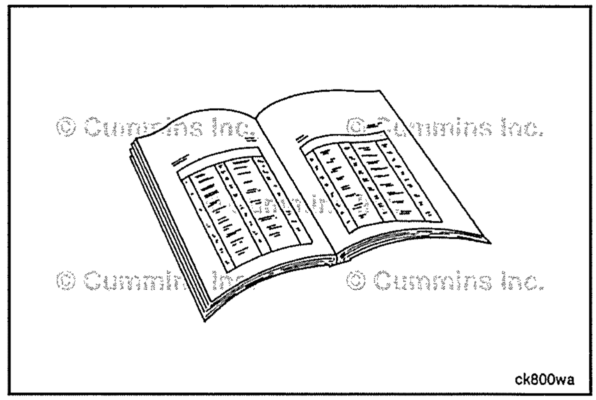
Install the new turbocharger actuator air line.

Install new hose clamps at the wastegate actuator and the turbocharger compressor housing.



Finishing Steps

- Operate the engine to normal operating temperature and check for leaks.

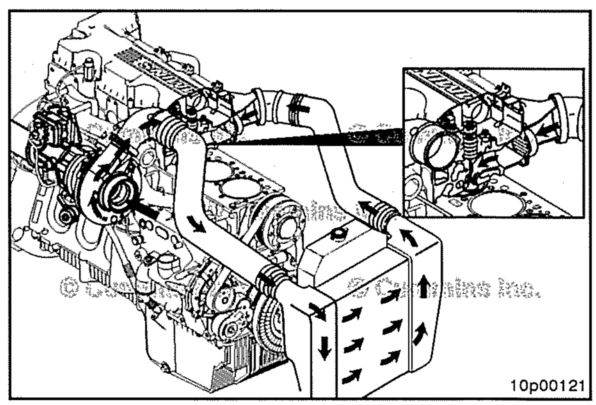


Air Intake System Diagnostics (010-139)

General Information

If there are any fault codes present, troubleshoot the corresponding fault code troubleshooting trees.

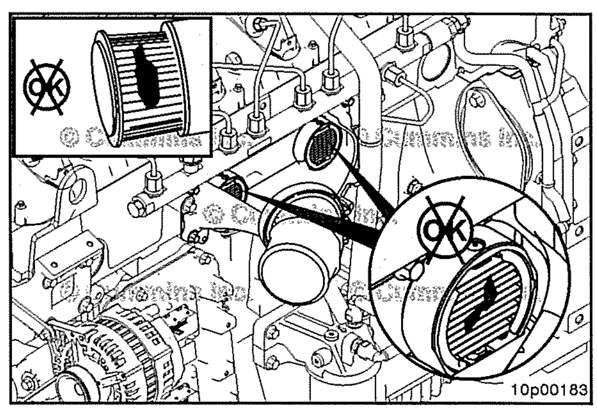
NOTE: Use the following procedure for exhaust system component diagnostics. Refer to Procedure 011-056 in Section 11.

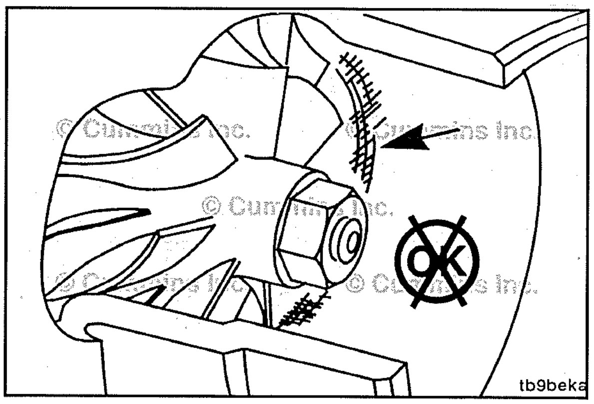


Intake Air Restriction

Air intake restriction can result in reduced engine performance. Air intake restriction is often a result of dirty air filter elements or cold start aids.

Use the following procedure to test the engine for air intake restriction. Refer to Procedure 010-031 in Section 10.





Malfunctioning Turbocharger

⚠WARNING⚠

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

⚠WARNING⚠

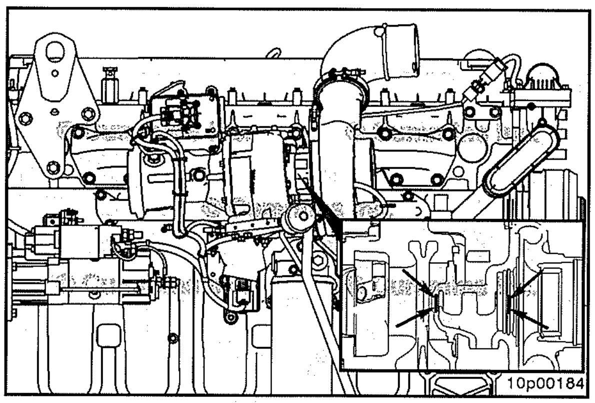
Some solvents are flammable and toxic. Read the manufacturer's instructions before using.

⚠WARNING⚠

Use skin and eye protection when handling caustic solutions to reduce the possibility of personal injury.

Damaged turbocharger internal components can reduce its effectiveness. Bearing damage can produce friction, which will slow the speed of the rotor assembly. Worn bearings can also allow the blades of the rotor assembly to rub the housing, reducing the rotor assembly speed.

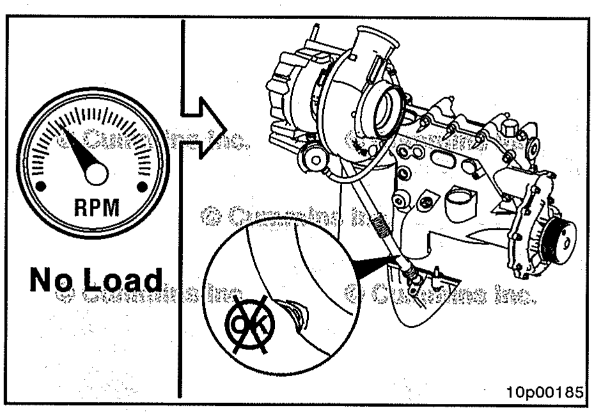
To inspect for blades rubbing against the housing, clean the area between the housing and the blades with a cotton-tip swab treated with cleaning solvent. This will remove any dirt that has accumulated on the housing due to the close proximity of the blade path and provide a clean surface for inspection.



Seal rings are used on each end of the rotor assembly. The primary function of the seals is to prevent exhaust gases and compressed air from entering the turbocharger housing. Lubricating oil leakage from the seals is rare, but it can occur.

NOTE: Excessive crankcase pressure will **not** allow the oil to drain from the turbocharger. This will load the bearing housing and allow lubricating oil to leak past the seal rings and into the intake and exhaust of the engine.

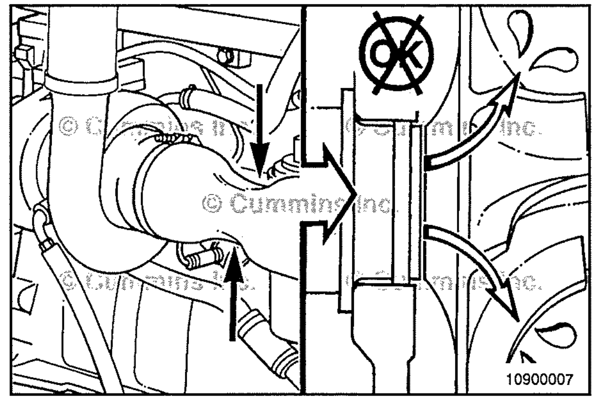
If turbine seal leakage into the exhaust occurs on engines with an aftertreatment system, the aftertreatment system **must** be inspected before it can be used again.



A restricted or damaged lubricating oil return line will cause the turbocharger housing to be pressurized, causing lubricating oil to migrate past the seal rings on both intake and exhaust sides of the turbocharger.

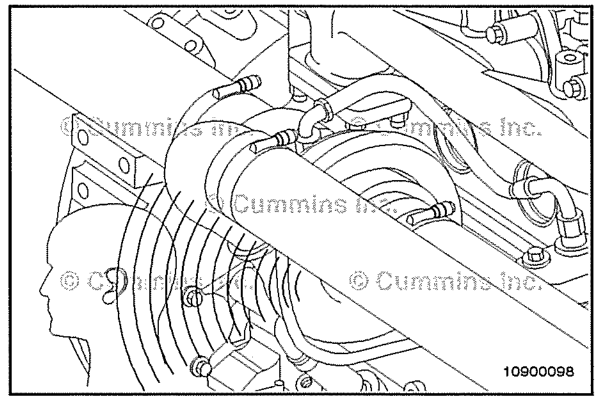
High intake or exhaust restrictions can cause a vacuum between the compressor and the turbocharger housing, resulting in lubricating oil leaking past the seal rings at the compressor (intake) side.

NOTE: If this occurs, it is necessary to flush the charge-air cooler to clean oil from the intake system. Refer to Procedure 010-027 in Section 10. Clean the air intake connection. Refer to Procedure 010-080 in Section 10. Clean the cold starting aid. Refer to Procedure 010-029 in Section 10.



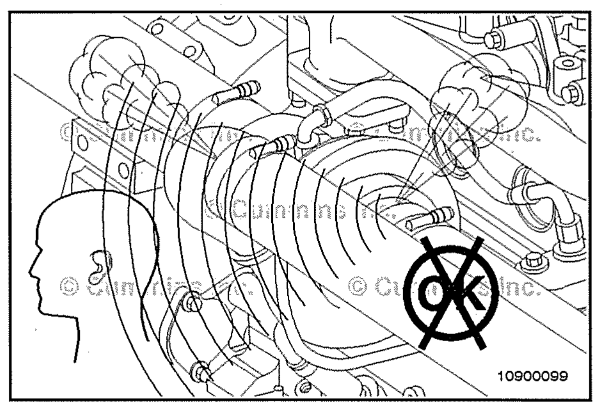
Turbocharger Noise

It is normal for the turbocharger to emit a "whining" sound that varies in intensity, depending on turbine wheel speed. The sound is caused by the very high rotational speed of the rotor assembly and the method used to balance the rotor assembly during manufacturing.



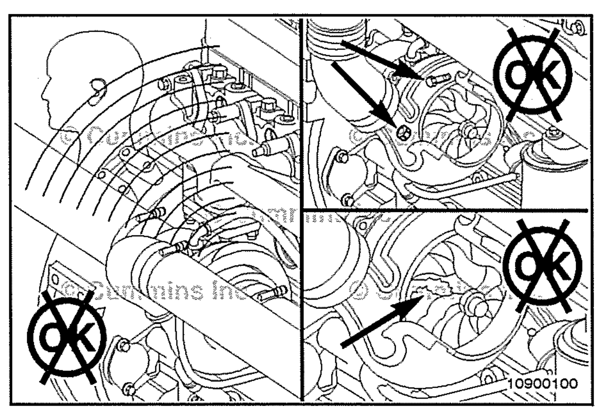
Leaks in the air system intake and/or exhaust components can produce excessive engine noise. A leaking noise usually sounds like a high-pitched whining or sucking.

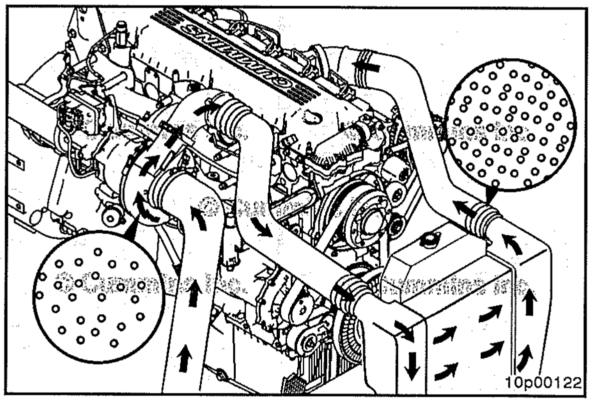
Check for leaks in the intake and exhaust system. Check to make sure all hose clamps are tight.Refer to Procedure 010-024 in Section 10.



Lower pitched sounds or rattles, at slower engine speeds, can indicate that debris is in the system or that the rotor assembly is contacting the housings.

Remove the turbocharger inlet and check for foreign objects. If suspected, check for turbocharger blade damage and bearing clearance. Refer to Procedure 010-033 in Section 10.





Charge Air Cooled Engines

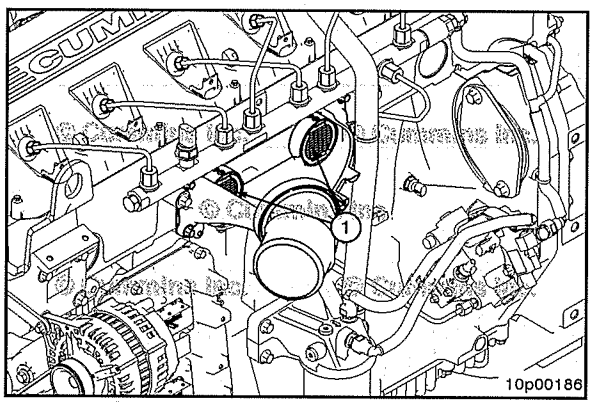
The engine uses a chassis-mounted charge-air cooler to improve engine performance and reduce emissions. This system also uses large-diameter piping to transfer the air from the engine turbocharger to the charge-air cooler, then returns the air from the charge-air cooler to the engine intake air connection.

As the intake air is compressed by the turbocharger, the air temperature increases. This heated air is then passed through the charge-air cooler, which cools the air. Cool air is more dense, which allows more air to be compressed into the cylinder, yielding a much higher combustion efficiency.

Use the following procedure to inspect the charge-air cooler for proper operation. Refer to Procedure 010-027 in Section 10.

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

NOTE: The long-term integrity of the charge-air cooling system is the responsibility of the vehicle and component manufacturers.



Cold Starting Aid

The integral cold starting aid (1) is a dual element intake air heater used to pre-heat the intake air under cold ambient conditions. A symptom of a damaged cold starting aid is a hard start in cold ambient temperatures and/or white smoke on engine startup.

To verify that the cold starting aid is functioning properly. Refer to Procedure 010-029 in Section 10.

Dust Ejection Valve (010-146)

General Information

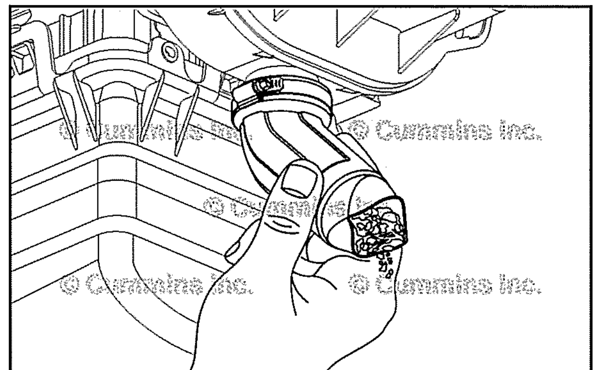
The dust ejection valve is a thin flexible rubber boot located at the bottom of the pre-cleaner on the air cleaner assembly. It is used to accumulate and remove dust ejected from the pre-cleaner.

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

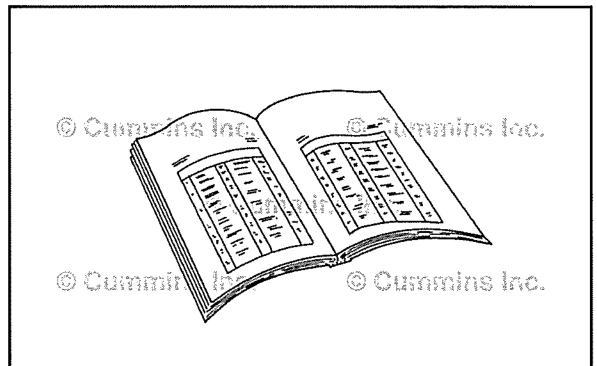
Purge the dust ejection valve of dust by squeezing the valve until it opens. This may have to be performed multiple times depending on the severity of dust or debris found in the valve. If debris is **not** able to be purged from the valve, remove the valve and clean out by hand. See the Remove section.


10100097

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.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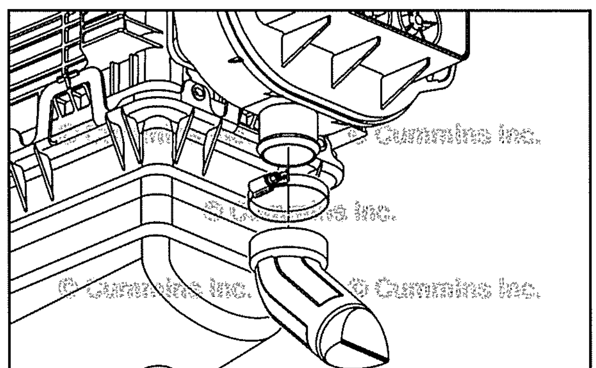
Remove

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.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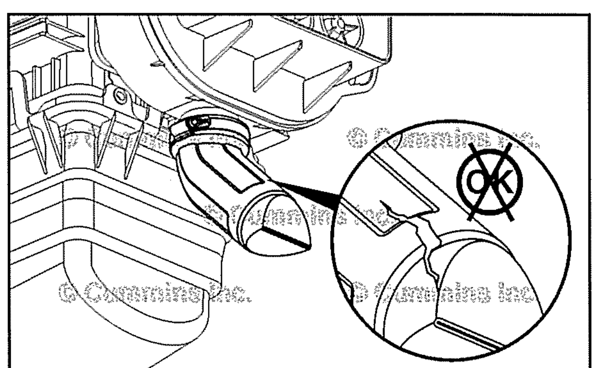
Inspect for Reuse

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



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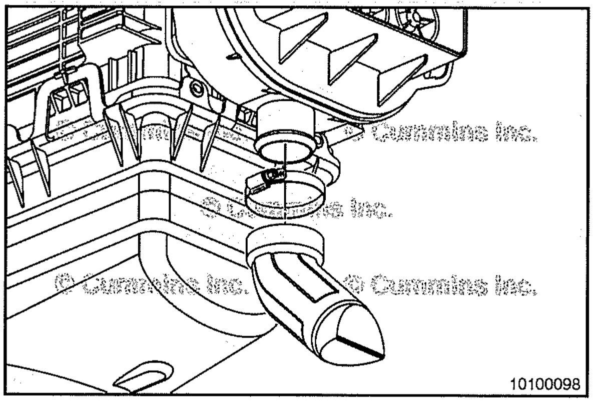
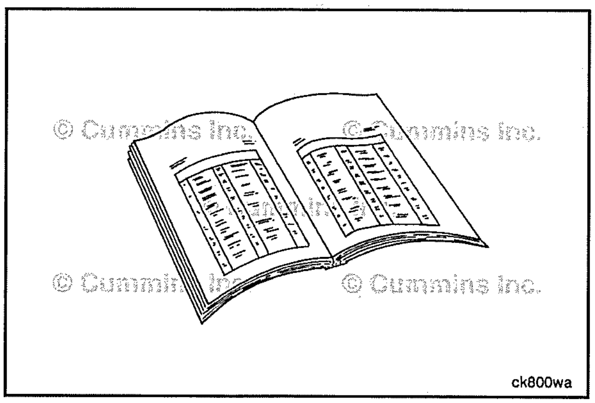


10100098

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]



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Finishing Steps

- Start the engine.
- Check for leaks.

Section 11 - Exhaust System - Group 11

Section Contents

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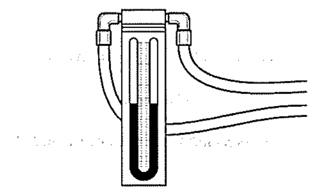
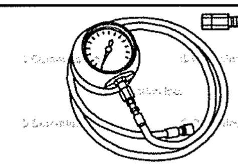
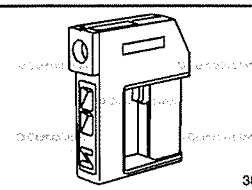
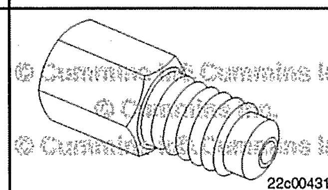
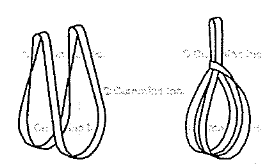
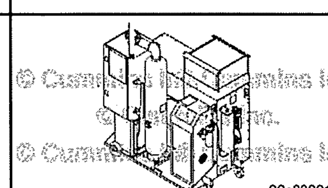
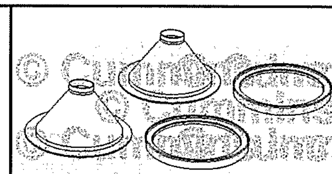
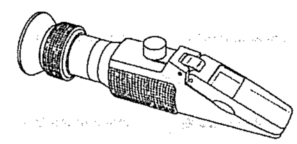
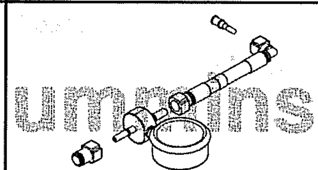
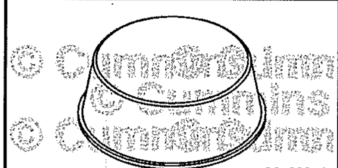
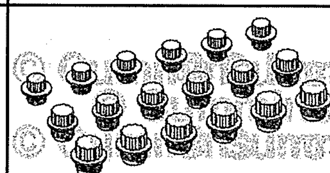
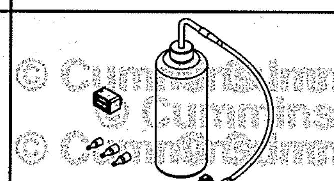
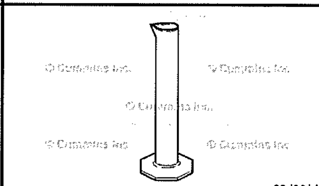
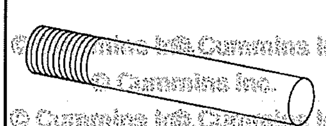
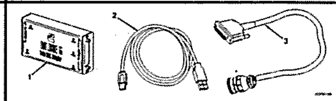
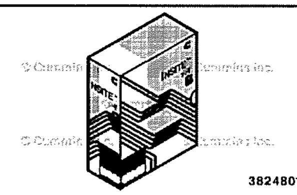
Service Tools

Exhaust System

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

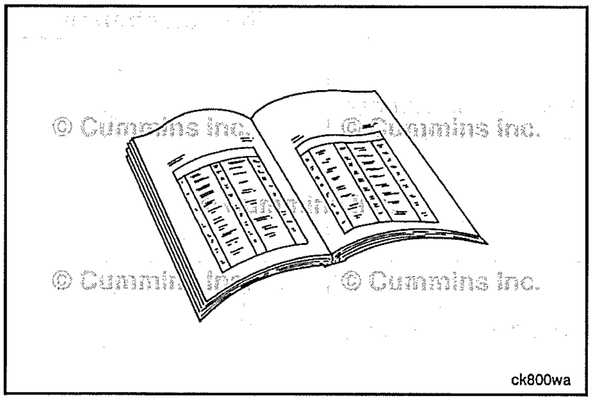
Tool No.	Tool Description	Tool Illustration
ST-1111-3	**Manometer** Used to measure exhaust restriction.	 eg100ja
ST-1273	**Pressure Gauge** Used to measure inches of mercury (in Hg) pressure.	 og8togi
3164487	**Infrared Thermometer** Used to measure the surface temperature of the exhaust components.	 3824941
4918576	**Pressure Adapter Fitting** This fitting is inserted into the thermistor ports of the aftertreatment system in order to measure the pressure and pressure differences at various points in the aftertreatment system.	 22c00431
3375957	**Nylon Lifting Sling (1 inch x 6 ft)** Aids in the removal and installation of heavy components.	 ks8togo
4919052	**Diesel Particulate Filter Cleaner** This machine is used with diesel particulate filter cleaner adapter kit, Part Number 4919172 or 4919182, to clean the diesel particulate filter once it is removed from the vehicle. (For use in the U.S.A. and Canada.)	 22c00331

Tool No.	Tool Description	Tool Illustration
4919172	**Diesel Particulate Filter Cleaner Mounting Adapter Kit** Used with diesel particulate filter cleaner, Part Number 4919052, to adapt the diesel particulate filter to the cleaner. Software unlock card, Part Number 4919055, is included in this adapter kit to upload the required cleaning parameters.	 22c00329
4919554	**Refractometer** Used to measure diesel exhaust fluid concentration level.	 ra8toda
5299005	**Pressure Gauge Tool Kit** Used when measuring aftertreatment diesel exhaust fluid dosing unit flow.	 22700012
4919425	**Air Handling Clean Care Kit for Vehicle Plumbing** Contains a variety of caps to used to prevent contamination of the vehicle air handling plumbing during service procedures.	 22c00356
4919569	**Threaded Plugs** Used for plugging the diesel particulate filter (DPF) and diesel oxidation catalyst (DOC) temperature and pressure ports. Contains plug, Part Number 4919495, for differential temperature on DPF and DOC, Part Number M12X1.25-6H. Contains plug, Part Number 4919496, for delta pressure on DPF, Part Number M14X1.5-6H. Contains plug, Part Number 4919497, for delta pressure on DPF, Part Number M16X1.5-6H	 22c00372
5298533	**Diesel Exhaust Fluid (DEF) Doser Cleaning Kit** Used for cleaning the DEF doser during the repair of Fault Code 1682.	 22o00010
4919139	**Graduated Beaker** Used to measure diesel exhaust fluid flow.	 22d00140
3376488	**Assembly Guide Pins** Used to guide components on engine for assembly (M10 x 1.5).	 3822784

Tool No.	Tool Description	Tool Illustration
3824879	**Heavy Duty Anti-Seize** This is a multi-purpose anti-seize lubricant. This is an all purpose anti-seize lubricant that speeds assembly and disassembly of studs, bolts, capscrews, flanges, and fittings.	
2892092	**Data Link Adapter Kit** INLINE™ 6 adapter and associated cables are used to connect a computer to an engine data link.	
3886388	**INSITE™ Electronic Service Tool Kit** This kit contains INSITE™ electronic service tool software for use with Cummins® engines. The kit is used to troubleshoot, program, and adjust electronic features.	

Exhaust Manifold, Dry (011-007)

Preparatory Steps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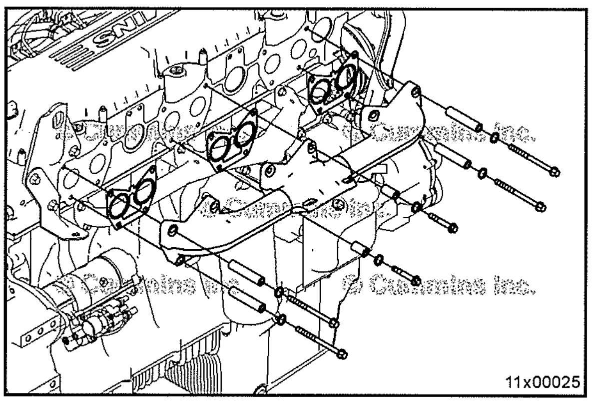
⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the air intake and exhaust piping from the turbocharger. See equipment manufacturer service information. Use protective caps from the Air Handling Clean Care Kit, Part Number 4919588, to cover the connection points.
- Remove the turbocharger. Refer to Procedure 010-033 in Section 10.
- Remove the exhaust gas pressure sensor tube. Refer to Procedure 011-027 in Section 11.

Remove


11x00025

NOTE: The four center capscrews and spacers are a different length than the eight outer capscrews. Take note of this difference.

Remove the two upper capscrews, lock washers, and spacers from the end sections of the exhaust manifold and install two guide pins, Part Number 3376488.

NOTE: To make guide pins remove the hexagon head from exhaust manifold mounting capscrews.

Remove the remaining capscrews, lock washers, spacers, exhaust manifold, and gaskets.

Discard the gaskets.

NOTE: Apply a thin coating of nickel-based high-temperature compound grease, Part Number 3824879 or equivalent, to the coarse threads of the manifold capscrews, after removal.

Clean and Inspect for Reuse

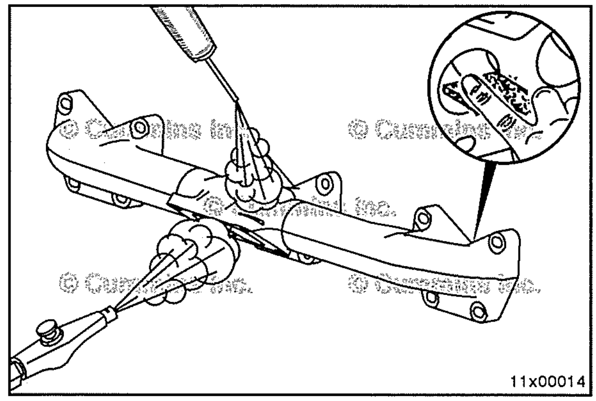
⚠WARNING⚠
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

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

Use a 240-grit abrasive pad to remove carbon deposits from the sealing surfaces.

Use steam to clean the exhaust manifold.

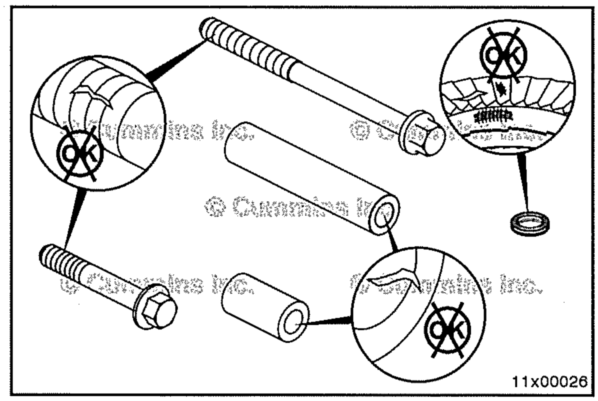
Dry with compressed air.



11x00014

Inspect the capscrews and spacers for cracks and damage. If they are damaged, they **must** be replaced.

Inspect the lock washers for cracks, damage, and corrosion. If any damage or if heavily corroded, they **must** be replaced.

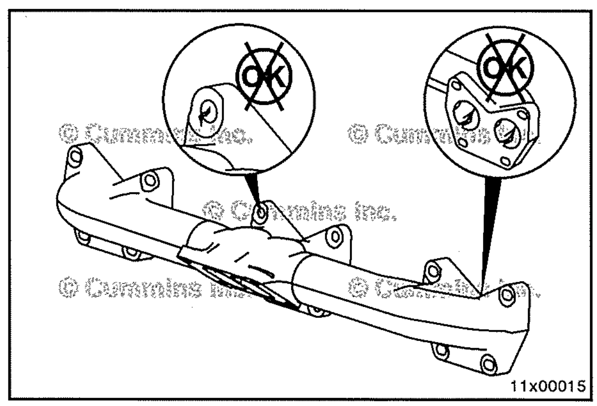


11x00026

Inspect the exhaust manifold for cracks or damage.

A charge-air cooler malfunction can cause progressive damage to the exhaust manifold. If the exhaust manifold is damaged, check the charge-air cooler. Refer to Procedure 010-027 in Section 10.

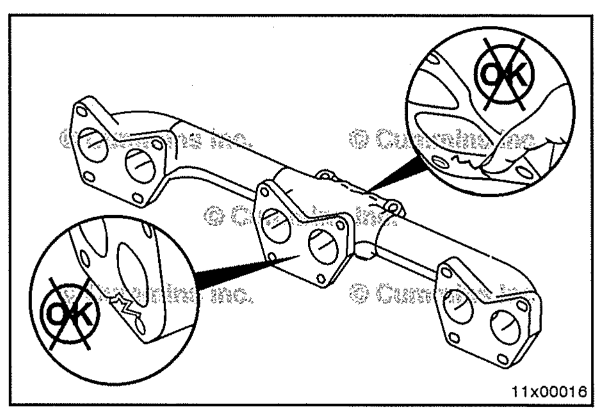
NOTE: Use the following procedure if a turbocharger mounting stud needs to be replaced. Refer to Procedure 011-073 in Section 11.



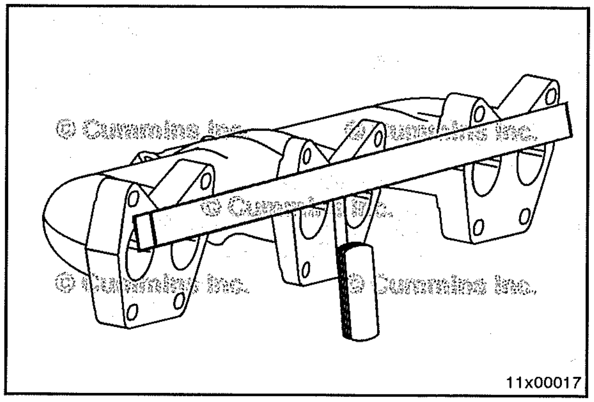
11x00015

Inspect the mounting surfaces for cleanliness, signs of fretting, and other damage.

After cleaning, if visible gouges can be felt with your fingernail across the sealing bead area, it is **not** acceptable and the exhaust manifold **must** be replaced.



11x00016

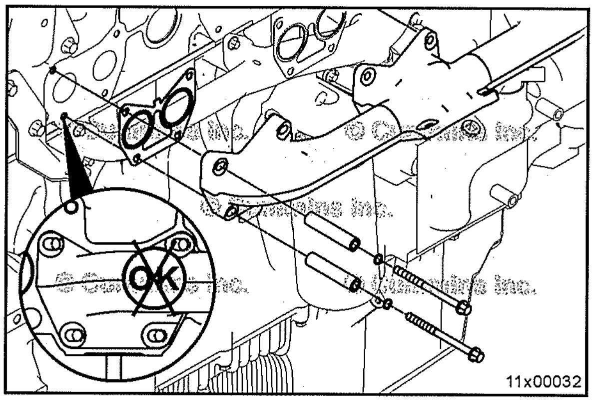

11x00017

Measure the manifold surface for flatness. Place a straight edge gauge, Part Number 4918219 or equivalent, over all of the exhaust ports in the manifold. Measure, with a feeler gauge, the gap between the port surface and the straight edge gauge.

Exhaust Manifold Flatness

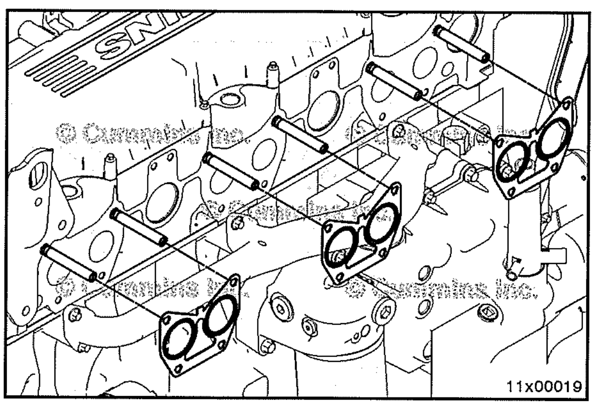
mm		in
0.10	MAX	0.004

If any port measures out of specification, replace the manifold.



11x00032

Check the manifold to cylinder head fit. If the manifold mounting capscrew holes do **not** line up with the tapped holes in the cylinder head, replace the exhaust manifold.

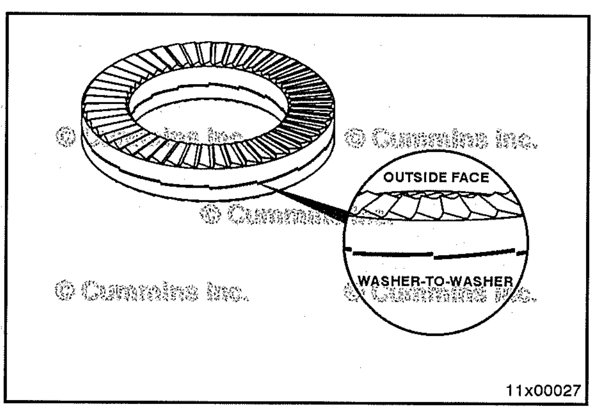

11x00019

Install

Install a guide pin, Part Number 3376488, in the top holes of each cylinder head exhaust port.

Install a new gasket over each guide pin.

Do **not** use any kind of adhesive to hold the gaskets.



11x00027

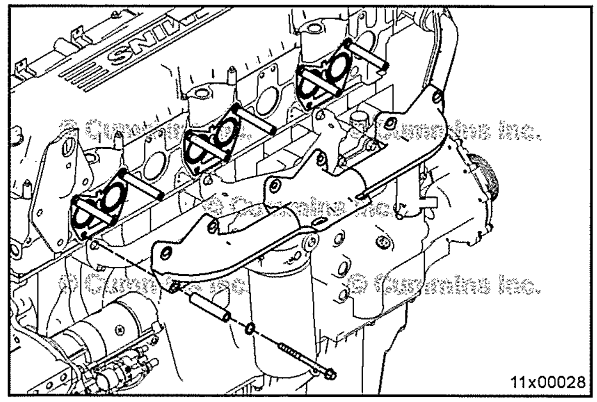
NOTE: New lock washers are glued together in the proper orientation. If old lock washers are used, they **must** be installed with the correct faces mated. The washer-to-washer mating surface has gentle slopes but the outside surface has sharper, steeper slopes.

NOTE: If using new capscrews, do **not** apply any compounds to the capscrew threads. New capscrews have an anti-seize film already applied.

If a capscrew is reused, to aid in future removal, apply a coating of high temperature anti-seize compound, Part Number 3824879 or equivalent, to the capscrew threads.

NOTE: The four center capscrews and spacers are a different length than the eight outer capscrews. Reinstall per the note in the 'Remove' step.

Install the exhaust manifold, tubular spacers, lock washers, and capscrews. Install the bottom capscrews, tubular spacers, and lock washers first. Then remove the guide pins and install the top capscrews, tubular spacers, and lock washers.

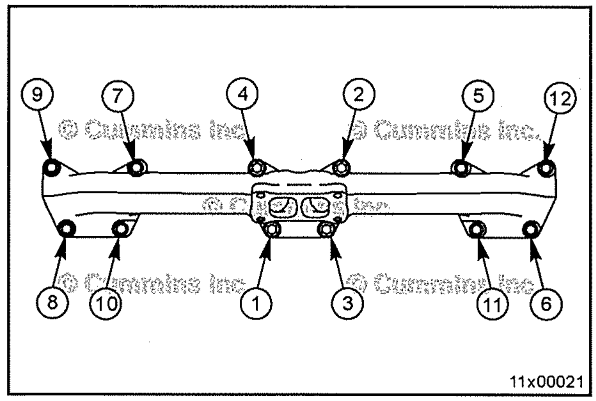


Tighten the capscrews in the sequence shown.

The torque values given have been established using anti-seize compound as a lubricant.

Torque Value: 50 N•m [37 ft-lb]

NOTE: Do **not** overtighten the capscrews.

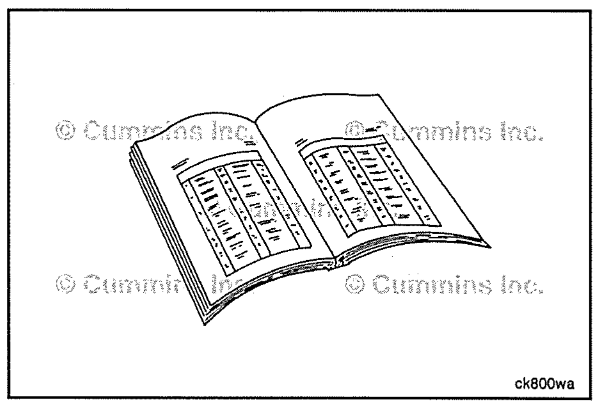


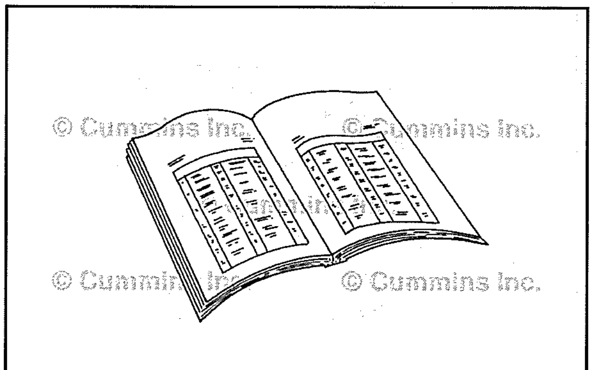
Finishing Steps

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 turbocharger. Refer to Procedure 010-033 in Section 10.
- Install the exhaust gas pressure sensor tube. Refer to Procedure 011-027 in Section 11.
- Install the air intake and exhaust piping to the turbocharger. See equipment manufacturer service information.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for air or exhaust leaks.



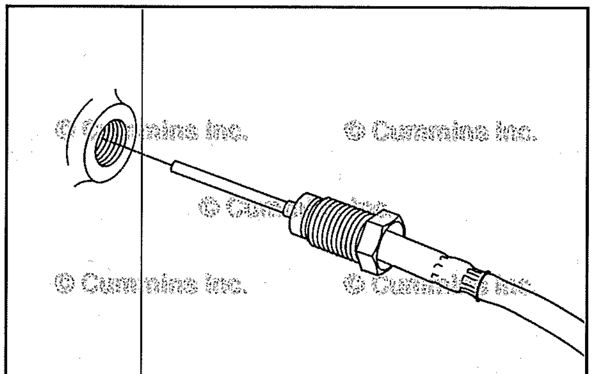

ck800wa

Exhaust Restriction (011-009)

Preparatory Steps

- Perform a stationary regeneration, if possible, to make sure the aftertreatment is clean prior to performing the exhaust restriction test. Refer to Procedure 014-016 in Section 14.

NOTE: Some fault codes may prevent a stationary regeneration from being started/completed. If that is the case, move on to the next step.


11d00112

Measure

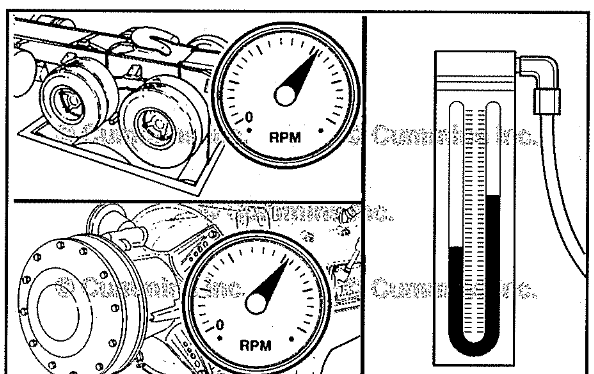
Remove the aftertreatment diesel oxidation catalyst (DOC) inlet temperature sensor from the aftertreatment inlet and disconnect it from the wiring harness.

Install the pressure gauge adapter, Part Number 4918576.

Connect a Cummins® manometer or pressure gauge, Part Number ST-1273, to the pressure gauge adapter.

Protect the hose from heat. Use a 305 mm [12 in] minimum length of metal tubing leading from the exhaust pipe connection.

NOTE: Disconnecting the aftertreatment DOC inlet temperature sensor will trigger Fault Code 3314. Do **not** troubleshoot this fault code during this exhaust restriction test.



pe200kb

NOTE: To achieve an accurate exhaust restriction test, be sure a stationary regeneration was performed prior to conducting the exhaust restriction test.

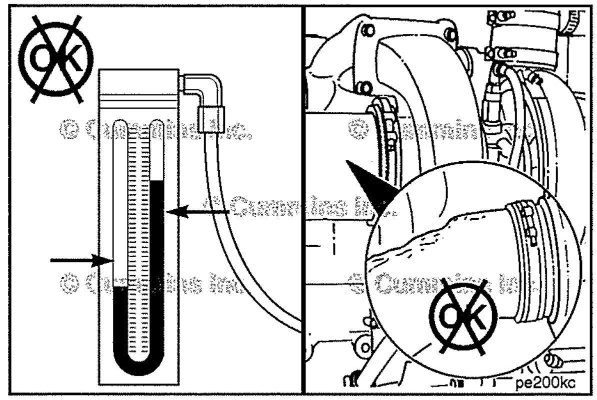
Operate the engine at rated speed and record the exhaust restriction. Refer to Procedure 018-020 in Section V.

If exhaust pressure exceeds the specifications, inspect the exhaust piping for damage. See equipment manufacturer service information.

If the exhaust pressure exceeds the specifications:

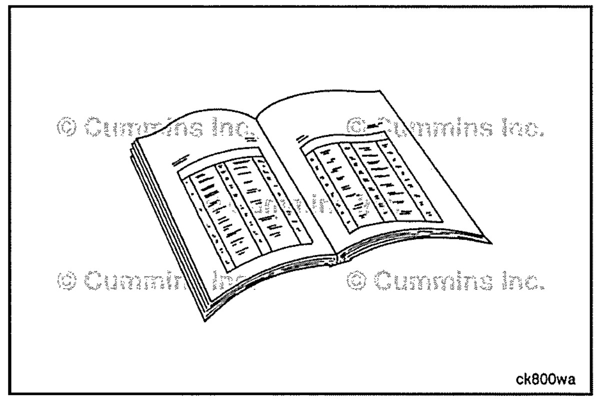
1 Check for a plugged aftertreatment DPF.
2 Check for a plugged aftertreatment DOC.
3 Check for a damaged or restricted selective catalytic reduction (SCR) decomposition tube and SCR catalyst.

Extended engine operation with high exhaust restriction can lead to damaged turbocharger oil seals. Use the following procedure to inspect the turbocharger for progressive damage. Refer to Procedure 010-033 in Section 10.



Finishing Steps

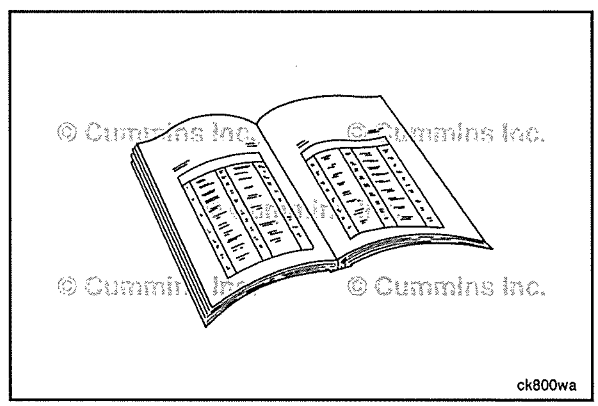
- Remove the test equipment and install the aftertreatment diesel oxidation catalyst inlet temperature sensor. See equipment manufacturer service information.
- Operate the engine and verify that all fault codes are inactive.



Exhaust Gas Pressure Sensor Tube (011-027)

Preparatory Steps

- Remove exhaust gas pressure sensor. Refer to Procedure 019-376 in Section 19.

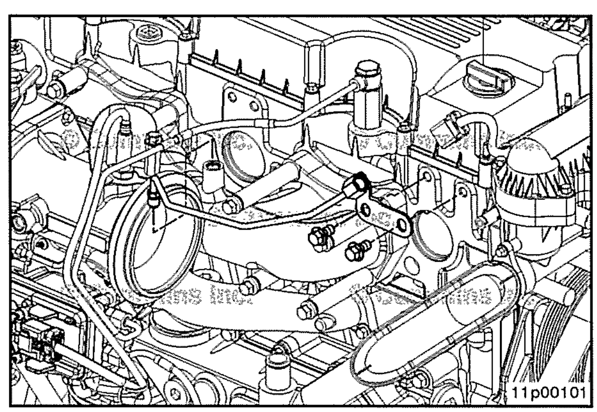


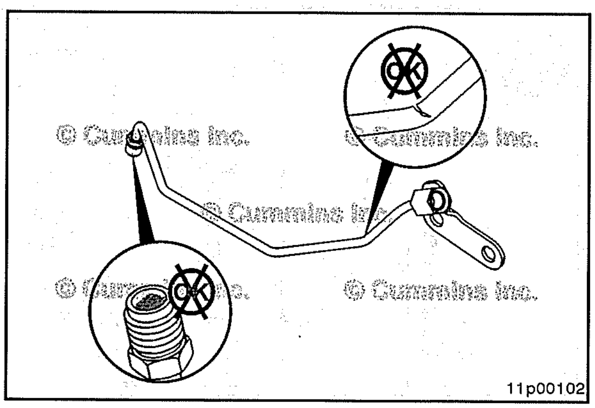
Remove

Loosen the tube nuts at the exhaust manifold.

Remove capscrews at cylinder head.

Remove the tube.





11p00102

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

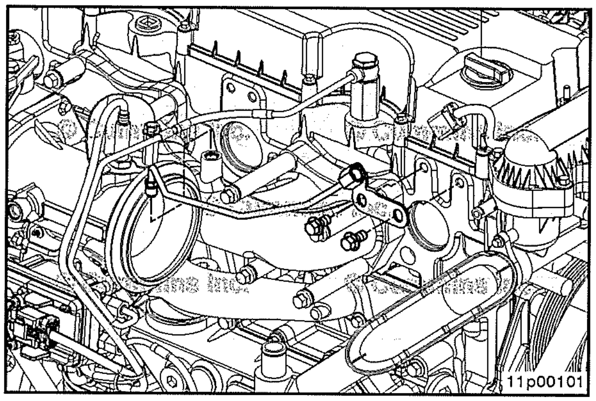
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Inspect the inside of the tube. If the tube is clogged, use compressed air to remove debris or soot buildup.

Clean the outside of the tube with solvent.

Dry with compressed air.

Check the tube for cracks and thread damage. Replace the tube, if cracks or other damage is found.


11p00101

Install

Apply a film of high temperature anti-seize compound to the threads of the tube nuts.

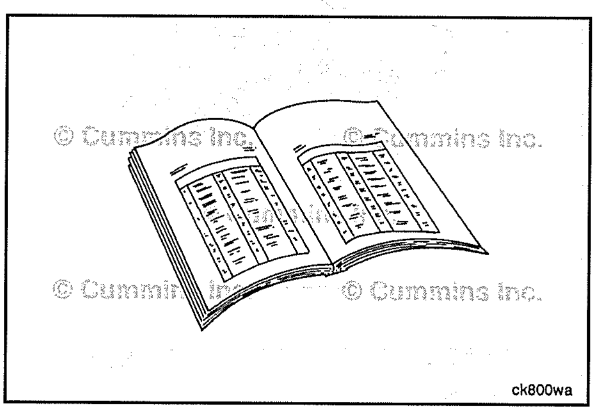
Install the tube.

Install capscrews at cylinder head.

Torque Value: 46 N•m [34 ft-lb]

Tighten the tube nuts.

Torque Value: 16 N•m [142 in-lb]



ck800wa

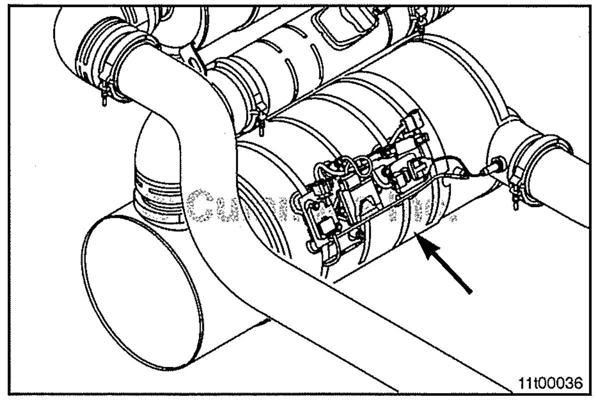
Finishing Steps

- Install exhaust gas pressure sensor. Refer to Procedure 019-376 in Section 19.
- Start the engine and verify proper operation.
- Use INSITE™ electronic service tool to check for fault codes.

If a malfunction resulted in coolant, oil, excessive fuel, or excessive black smoke entering the exhaust system, the aftertreatment system **must** be inspected. Refer to the Aftertreatment Diesel Oxidation Catalyst and Aftertreatment Diesel Particulate Filter Reuse Guidelines, Bulletin 4021600.

Aftertreatment Selective Catalytic Reduction (SCR) Catalyst (011-036)

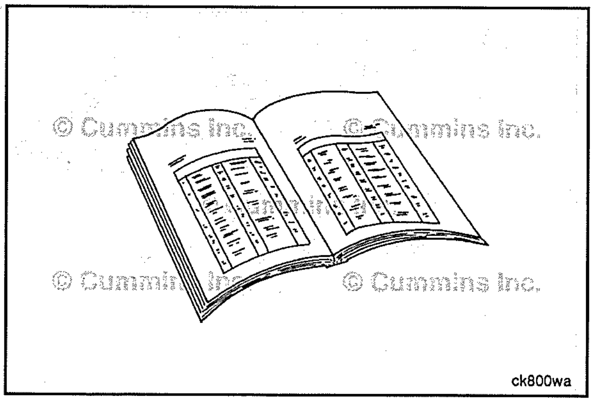
General Information



⚠WARNING⚠
The exhaust and exhaust components can remain hot after the engine has been shut down or secured. 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 might come in contact with hot exhaust or exhaust components.

⚠CAUTION⚠
The catalyst elements contained in the aftertreatment system are made of brittle material. Do not drop or strike the side of the aftertreatment system, as damage to the catalyst element can result.

Due to the number of varying exhaust aftertreatment applications, this procedure has been written to be generic. **Not** all illustrations within this procedure will represent the application being serviced.



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⚠

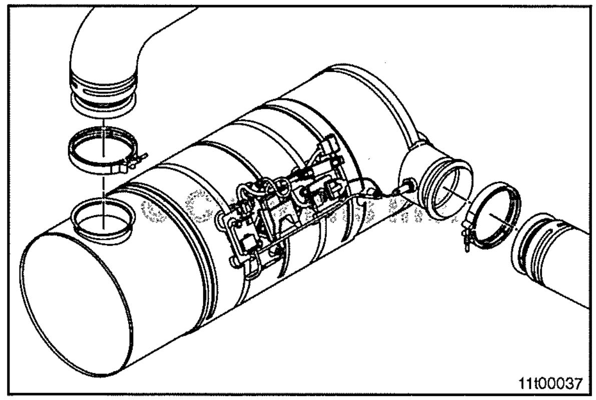
During regeneration, exhaust gas temperature can reach 800 °C [1500°F], and exhaust system surface temperature can exceed 700 °C [1300°F], which is hot enough to ignite or melt common materials, and to burn people. The exhaust and exhaust components can remain hot after the vehicle has stopped moving. 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.

⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.
- Clean the area with compressed air to remove any loose debris.
- Draw an orientation reference line across each of the V-band and Torca™ clamps on either end of the aftertreatment SCR canister. This will aid in lining up the clamps and canister to their original orientation during installation.
- Remove the NOx sensor probe. Refer to Procedure 019-451 in Section 19.
- Disconnect OEM wiring harness from exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Disconnect OEM wiring harness from aftertreatment outlet NOx sensor. Refer to Procedure 019-451 in Section 19.

Remove



WARNING

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

Support the aftertreatment decomposition tube to prevent it from being freely suspended after the aftertreatment SCR catalyst is removed. If supporting the tube it is **not** an option, remove the aftertreatment decomposition tube. Refer to Procedure 011-062 in Section 11.

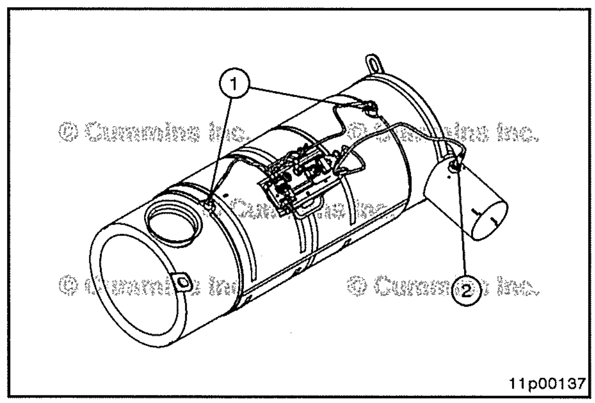
Support the aftertreatment SCR catalyst with a lowering jack.

Remove the clamps on either end of the aftertreatment SCR catalyst.

Remove the exhaust hangers that support the aftertreatment SCR catalyst and slowly remove the canister from the vehicle.

Discard the gasket from the V-band joint.

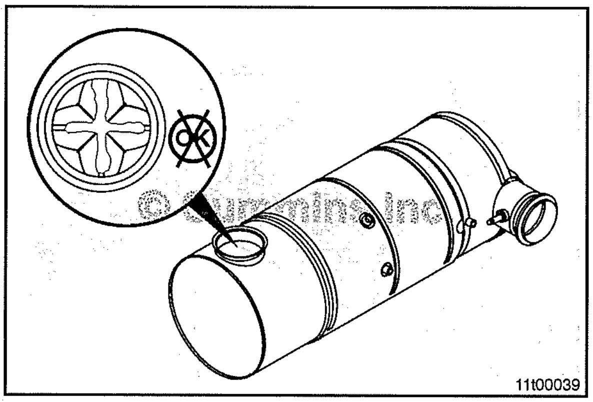
Disassemble



If the aftertreatment SCR catalyst is being replaced or removed, complete the following procedures to remove the key parts of the aftertreatment SCR catalyst.

Disconnect and remove the aftertreatment exhaust gas temperature sensor probes (1). Refer to Procedure 019-449 in Section 19.

Remove the aftertreatment outlet NOx sensor probe (2). Refer to Procedure 019-451 in Section 19.



Clean and Inspect for Reuse

⚠CAUTION⚠

Do not use a metallic object to clean the aftertreatment SCR catalyst. This will scratch the surface of the aftertreatment SCR catalyst which may cause future excessive diesel exhaust fluid (DEF) crystallization buildup.

Inspect the aftertreatment SCR catalyst for cracks or puncture holes, especially around the weld areas.

Replace the aftertreatment SCR catalyst if it is damaged.

Replace the aftertreatment SCR catalyst if it is soaked with oil, fuel, or coolant.

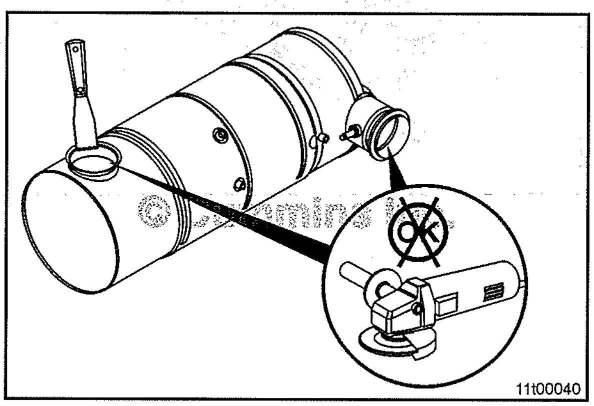
Inspect the aftertreatment SCR catalyst inlet for DEF deposits.

If buildups are present, carefully scrape the buildup with a non-metallic object to clean the majority of the buildup from the catalyst.

NOTE: Do **not** use a mechanical device to remove DEF deposits from the aftertreatment SCR catalyst.

NOTE: Do **not** use a pressure washer to remove DEF deposits from the aftertreatment SCR catalyst.

NOTE: If crystallization buildup was present after installation, complete a stationary regeneration to make sure that any of the remaining DEF crystallization has been removed from the aftertreatment SCR catalyst.

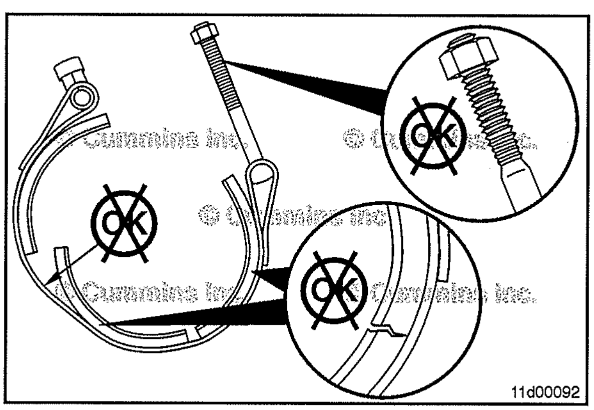


Inspect the exhaust flanges for corrosion or other damage.

Use a putty knife to remove any residual gasket material from the flanges on the aftertreatment SCR catalyst.

Avoid dropping fragments of gasket material into the aftertreatment SCR catalyst.

Do **not** grind on the flange surface, as this can damage the flange and cause the connection to leak.



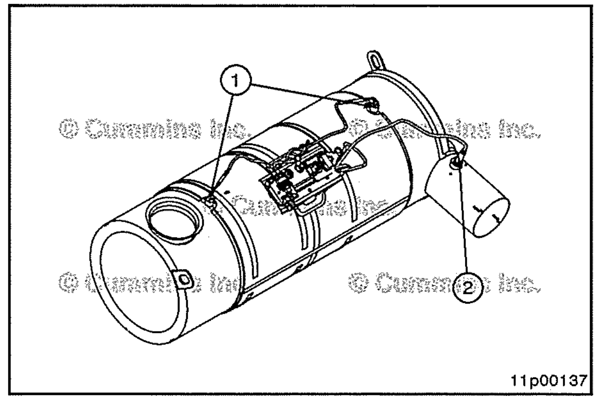
Inspect the V-band clamps and mounting straps for signs of overextension.

The V-band **must not** be bent or damaged.

Inspect the V-band clamp and mounting strap threads for damage.

Replace the V-band clamp or mounting strap if damage is found.

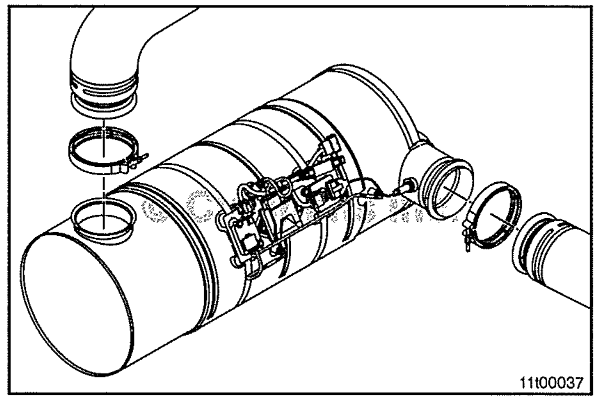
Assemble



Install the aftertreatment outlet NOx sensor module (2) on the aftertreatment SCR catalyst temperature sensor interface module mounting bracket. Refer to Procedure 019-451 in Section 19.

Install the aftertreatment exhaust gas temperature sensor assembly (1). Refer to Procedure 019-449 in Section 19.

Install



WARNING

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

CAUTION

Do not use an air tool to tighten the V-band clamp. An air tool will damage the threads.

Place the aftertreatment SCR catalyst on the vehicle. Use the exhaust hangers to support the canister.

Align the catalyst in the same orientation as marked previously.

NOTE: Horizontal aftertreatment SCR catalysts incorporate a water drain hole in the outlet section of the canister. If a new horizontal aftertreatment SCR catalyst is being installed, make sure the drain hole is located toward the bottom of the installation, within ±10 degrees of the vertical axis.

NOTE: Where applicable, install and tighten the full Marmon™ clamps before the spherical Marmon™ clamps, to account for misalignment in the aftertreatment system.

Apply a coat of Cummins® anti-seize compound, Part Number 3824879, or equivalent, onto the threads of the V-band clamp. Install a new gasket on the V-band connection of the aftertreatment SCR catalyst and install the opposite of removal. Tighten the V-band and Torca™ clamps.

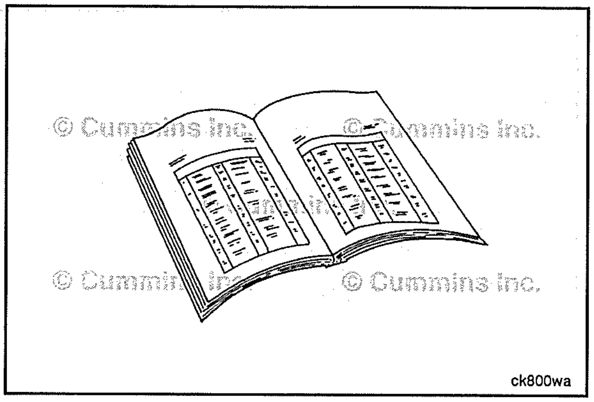
Torque Value:
V-band Clamp 14 N•m [124 in-lb]

Torque Value:
Torca™ Clamp 55 N•m [41 ft-lb]

Connect the OEM wiring to the aftertreatment interface harness.

Install the aftertreatment outlet NOx sensor probe. Refer to Procedure 019-451 in Section 19.

Tighten the exhaust hangers. See equipment manufacturer service information for specifications.



ck800wa

Finishing Steps

⚠ WARNING ⚠

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

- Connect the batteries. See equipment manufacturer service information.
- Start the engine and check the system for leaks.
- Use INSITE™ electronic service tool to check for active fault codes.
- If buildups were present, complete a stationary regeneration to make sure that any of the remaining DEF crystallization has been removed from the aftertreatment SCR catalyst.
- Continue to monitor for leaks at the exhaust joints.

Aftertreatment Diesel Particulate Filter (011-041)

General Information

WARNING

During regeneration, exhaust gas temperature could reach 800°C [1500°F], and exhaust system surface temperature could exceed 700°C [1300°F], which is hot enough to ignite or melt common materials, and to burn the skin. The exhaust and exhaust components can remain hot after the vehicle has stopped moving. To avoid the risk of fire, property damage, burns, or 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.

CAUTION

The aftertreatment diesel oxidation catalyst (DOC) elements contained in the aftertreatment system are made of brittle material. Do not drop or strike the side of the aftertreatment system as damage to the aftertreatment DOC element can result.

Due to the number of varying exhaust aftertreatment applications, this procedure contains generic information. **Not** all illustrations within this procedure will represent the applications being serviced.

NOTE: If a malfunction resulted in oil, excessive fuel, or excessive black smoke entering the exhaust system, the aftertreatment system must be inspected. Refer to the Aftertreatment Diesel Oxidation Catalyst and Aftertreatment Diesel Particulate Filter Reuse Guidelines, Bulletin 4021600.

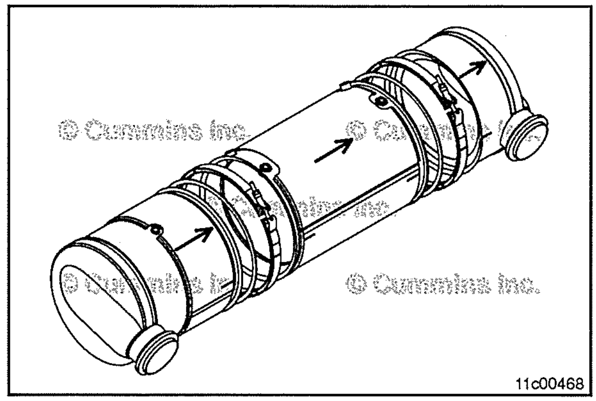
The aftertreatment system is composed of three sections. These sections are:

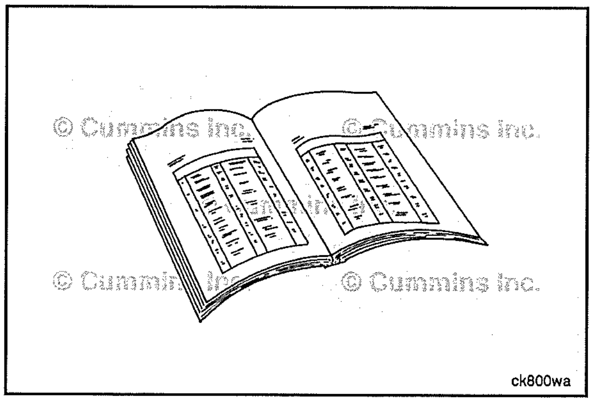
1 Aftertreatment DOC

2 Aftertreatment Diesel Particulate Filter (DPF)

3 Outlet.

NOTE: Damage to the aftertreatment system due to mishandling, vehicle collision, and road debris is **not** covered by Cummins Inc. warranty.





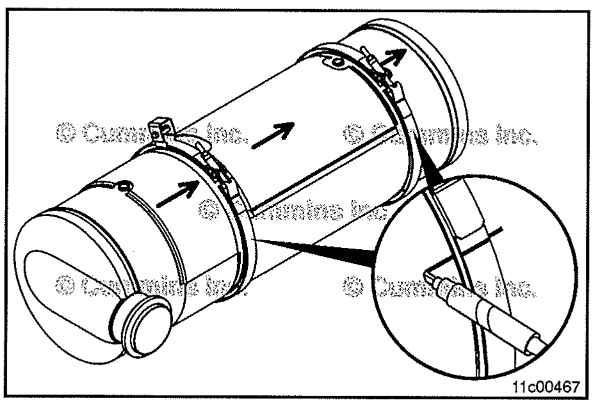
ck800wa

Preparatory Steps

WARNING

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

- Disconnect the batteries. See the equipment manufacture service information.
- Disconnect OEM wiring harness from exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Disconnect OEM wiring harness from aftertreatment diesel particulate filter differential pressure sensor. Refer to Procedure 019-443 in Section 19.
- Disconnect the aftertreatment DPF differential pressure sensor tubes, if necessary. Refer to Procedure 011-047 in Section 11.
- Remove the aftertreatment exhaust gas temperature sensor from the bosses in the diesel oxidation catalyst. Refer to Procedure 019-449 in Section 19.
- Remove the aftertreatment DPF differential pressure sensor mounting bracket. Refer to Procedure 011-046 in Section 11.

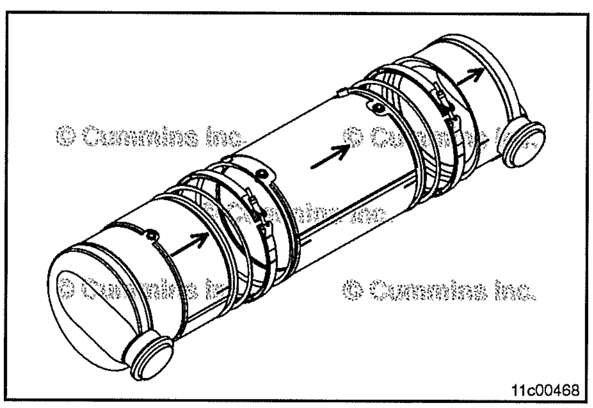


11c00467

Remove

Mark the direction of the exhaust flow on the outside of the aftertreatment DPF to aid in installation.

Mark an orientation reference line across each of the V-band clamps, aftertreatment canister sections, and connection points to the tailpipe to align each piece of hardware to its original orientation during installation.



11c00468

WARNING

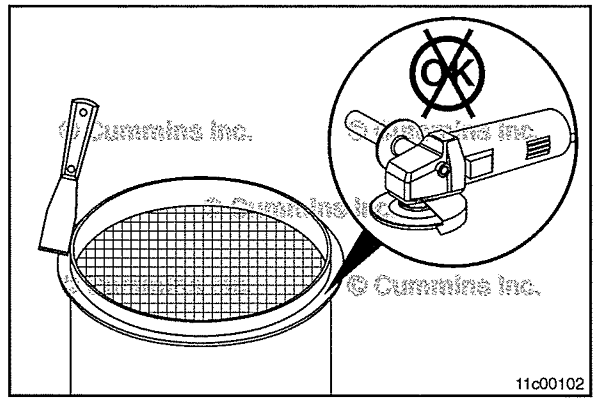
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

NOTE: If necessary, remove any additional mounting hardware to remove the aftertreatment DPF from the vehicle.

Remove the V-band clamps from the inlet and outlet flanges of the aftertreatment DPF.

Remove and discard the gaskets.

Inspect for Reuse



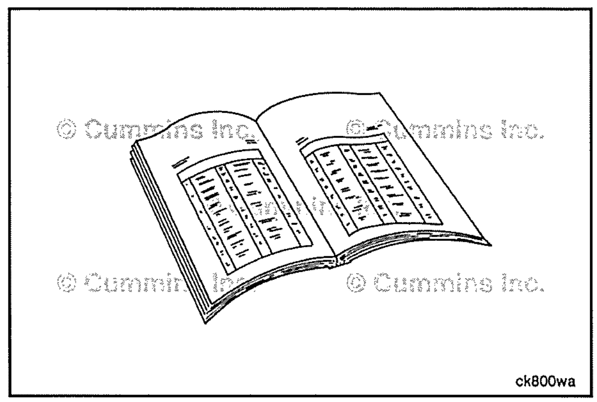
⚠CAUTION⚠

Do not use a grinder or abrasive air tool to remove residual gasket material, as this can damage the flange and cause the connection to leak. Do not use an open flame to burn off soot accumulation from the face of the aftertreatment DPF. Do not scrape off soot accumulation from the face of the aftertreatment DPF.

NOTE: The aftertreatment DPF relies on gas flow through the walls to collect soot. To accomplish gas flow through the walls of the filter, every other cell on the face of the filter is plugged with a ceramic material. Therefore it is **not** possible to see light straight through the holes in the aftertreatment DPF.

Remove any residual gasket material from the flanges on the aftertreatment DPF with a scraping tool.

Avoid dropping fragments of gasket material into the aftertreatment DPF.

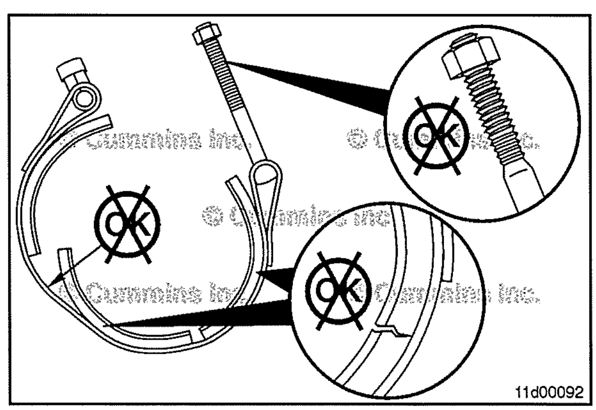


Refer to the Catalyst and Aftertreatment Particulate Filter Reuse Guidelines, Bulletin4021600, to inspect the inlet and outlet faces of the aftertreatment DPF for signs of damage. Replace the aftertreatment DPF if damage is found.

If the aftertreatment DPF has been removed for cleaning and is considered reusable according to the Catalyst and Aftertreatment Particulate Filter Reuse Guidelines, Bulletin 4021600, the filter can be cleaned using DPF cleaner, Part Number 4918840 or 4919052, with adapter kit, Part Number 4919172, or other Cummins Inc. approved cleaning machines. See equipment manufacturer service information for appropriate cleaning procedures.

While air cleaning is allowed, the Cummins Inc. preferred method would be to exchange the DPF at the recommended maintenance interval.

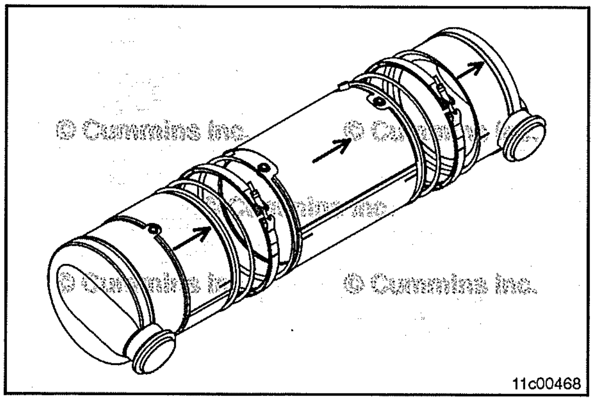
NOTE: If the aftertreatment DPF was removed due to an active Fault Code 1981 or Fault Code 1922 and is contaminated with coolant, it **must** be replaced with a new or ReCon® aftertreatment DPF.



Inspect the V-band clamps and mounting straps for signs of over extension. The band **must not** be bent or damaged.

Inspect the V-band clamps and mounting strap threads for damage.

Replace the V-band clamp or strap if damage is found.



Install

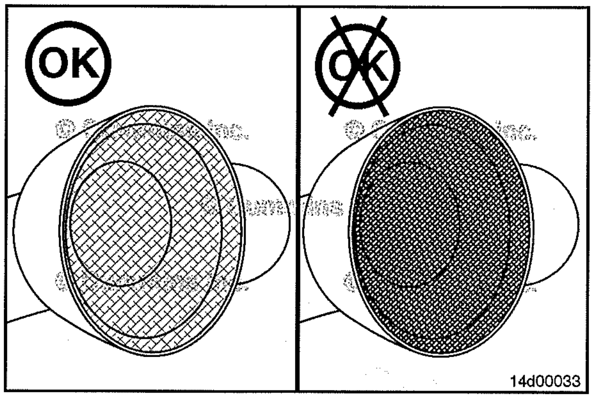
Install new gaskets on the inlet and outlet of the aftertreatment DPF canister.

Loosely tighten the V-band clamps to allow rotation for final alignment of the differential pressure sensor tubes.

Use the orientation reference line drawn across each of the V-band clamps, aftertreatment canister sections, and connection points to the tailpipe, to align each piece of hardware to its original orientation.

Tighten the V-band clamps.

Torque Value: 20 N•m [177 in-lb]



NOTE: The aftertreatment DPF is **not** 100 percent efficient. Some accumulation of exhaust residue/soot is normal and does **not** indicate a malfunctioning aftertreatment DPF.

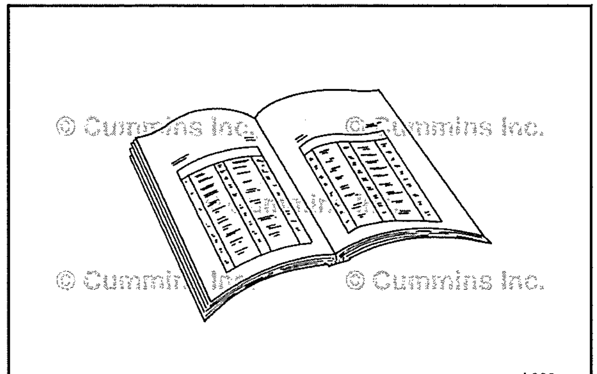
A heavy buildup of exhaust residue/soot can indicate a malfunction of the aftertreatment DPF.

If the aftertreatment DPF is being replaced due to black smoke, and the exhaust stack is found to have heavy black soot accumulation, clean the last 152 to 254 mm [6 to 10 in] of the exhaust system outlet.

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.



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- Install the aftertreatment DPF differential pressure mounting bracket. Refer to Procedure 011-046 in Section 11.
- Install the aftertreatment gas temperature sensor to the bosses in the diesel oxidation catalyst. Refer to Procedure 019-449 in Section 19.
- Connect the aftertreatment DPF differential pressure sensor tubes, if necessary. Refer to Procedure 011-047 in Section 11.
- Connect OEM wiring harness to exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Connect OEM wiring harness to aftertreatment diesel particulate filter differential pressure sensor. Refer to Procedure 019-443 in Section 19.
- Connect the batteries. See equipment manufacturer service information.
- Use INSITE™ electronic service tool to perform the Aftertreatment Maintenance Reset – All procedure.
- Use INSITE™ electronic service tool to perform the Aftertreatment Filter Installation procedure.

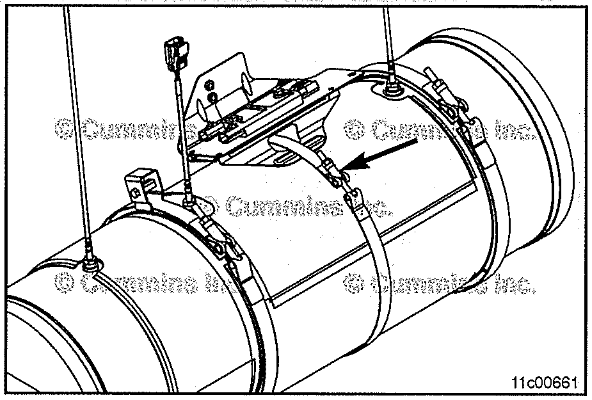
  NOTE: The Aftertreatment Maintenance Reset - All and Aftertreatment Maintenance Filter Installation can be found under the Advanced ECM Data section of INSITE™ electronic service tool.

  NOTE: In situations where Fault Code 1981 is active and Fault Codes 2639, 1921, and 1922 are **not** active, it is **not** necessary to perform a stationary regeneration after cleaning the aftertreatment DPF. If the aftertreatment DPF was replaced, it is **not** necessary to perform a stationary regeneration.

  NOTE: In situations where Fault Code 1981 and/or 1922 are active and the aftertreatment DPF was cleaned, and **not** replaced, a stationary regeneration **must** be performed after installing the filter on the vehicle.

- Operate the vehicle on an engine dynamometer or perform a road test with the engine at rated load for a minimum of 5 minutes to make sure the aftertreatment system is performing properly. Refer to Procedure 014-005 in Section 14.
- Check for exhaust leaks.
- Check for fault codes.

  NOTE: If a malfunction resulted in coolant entering the exhaust system, perform the Aftertreatment Regeneration Test to determine if the DPF needs to be replaced. Refer to Procedure 014-016 in Section 14.



Aftertreatment Diesel Particulate Filter Differential Pressure Sensor Mounting Bracket (011-046)

General Information

CAUTION

The catalyst elements contained in the aftertreatment system are made of brittle material. Do not drop or strike the side of the aftertreatment system, as damage to the catalyst element can result.

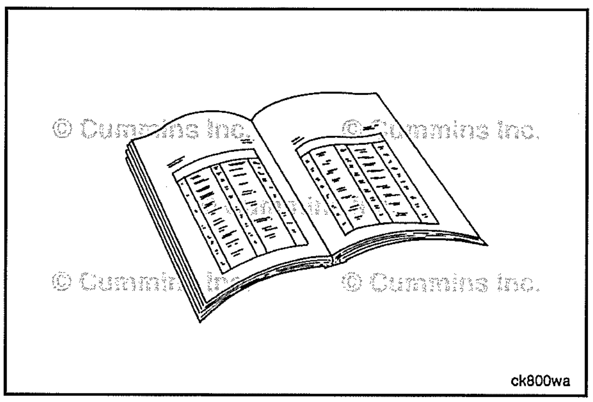
Due to the number of exhaust aftertreatment applications, this procedure is generic. **Not** all illustrations within the procedure will represent all applications.

The exhaust aftertreatment system is composed for four sections. These sections are:

1 Aftertreatment diesel oxidation catalyst.

2 Aftertreatment diesel particulate filter.

3 Outlet.



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.

CAUTION

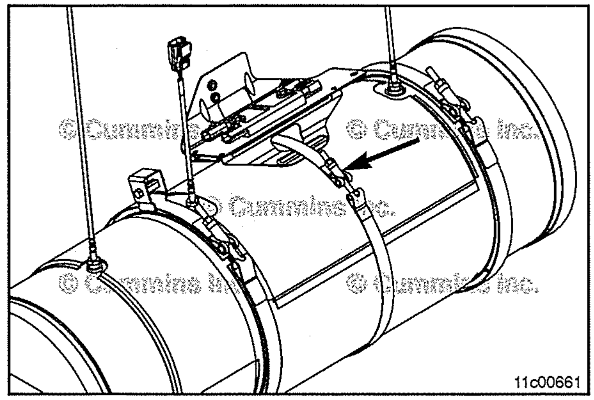
The aftertreatment diesel particulate filter and catalyst can remain hot for long periods of time after the engine has stopped.

- Disconnect the batteries. See equipment manufacture service information.
- Disconnect OEM wiring harness from aftertreatment exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Disconnect OEM wiring harness from diesel particulate differential pressure sensor. Refer to Procedure 019-443 in Section 19.
- Remove the aftertreatment diesel particulate filter differential pressure sensor tubes. Refer to Procedure 011-047 in Section 11.
- Remove the aftertreatment diesel particulate filter differential pressure sensor. Refer to Procedure 019-443 in Section 19.
- Remove aftertreatment exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Mark the orientation and location of the bracket before it is removed, to aid installation if there is **not** a locating tab present.

Remove

Remove the nut on the aftertreatment diesel particulate filter differential pressure sensor mounting bracket strap.

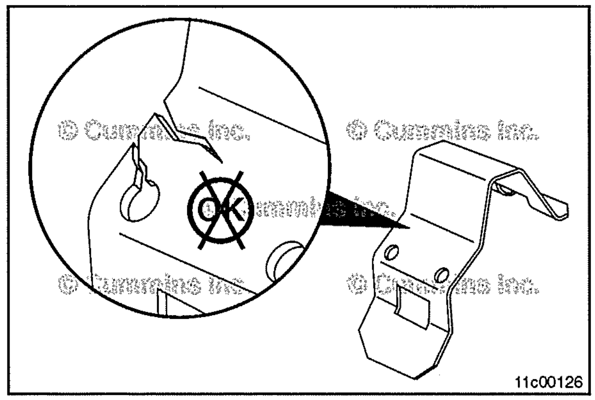
Remove the differential pressure sensor mounting bracket and strap.



Clean and Inspect for Reuse

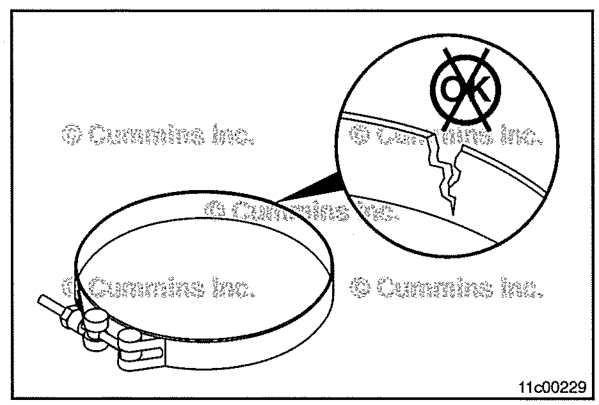
Inspect the differential pressure sensor mounting bracket for cracks, damaged threads, or broken studs.

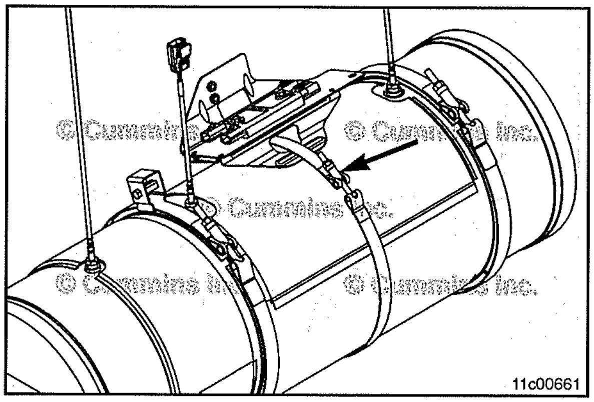
Replace the differential pressure sensor mounting bracket if it is damaged.



Inspect the differential pressure sensor mounting bracket strap for cracks, damaged threads, or bends.

Replace the differential pressure sensor mounting bracket strap if it is damaged.





Install

⚠CAUTION⚠

The aftertreatment system must be installed so the aftertreatment diesel particulate filter differential pressure sensor tubes slope downward to drain condensation away from the differential pressure sensor.

NOTE: Make sure the aftertreatment system is oriented so the aftertreatment diesel particulate filter differential pressure sensor is installed in the same orientation noted during disassembly.

Install the differential pressure sensor mounting bracket and strap. Be sure to align the cylindrical locating tab, if present, with the mounting bracket, as noted during removal.

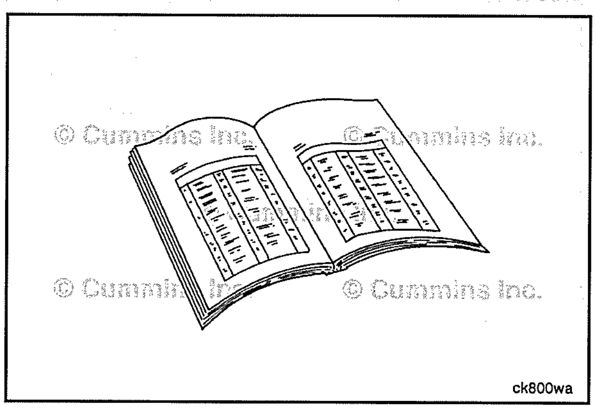
If there is **not** a locating tab, use the reference mark that was made during removal.

Apply a coating of anti-seize compound to the threads of the aftertreatment diesel particulate filter differential pressure sensor mounting bracket strap.

Install the nut on the aftertreatment diesel particulate filter differential pressure sensor mounting bracket strap.

Tighten the differential pressure sensor mounting bracket strap.

Torque Value: 7 N•m [62 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 aftertreatment diesel particulate filter differential pressure sensor. Refer to Procedure 019-376 in Section 19.
- Install the aftertreatment diesel particulate filter differential pressure sensor tubes. Refer to Procedure 011-047 in Section 11.
- Install aftertreatment exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Connect OEM wiring harness to aftertreatment exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Connect OEM wiring harness to diesel particulate differential pressure sensor. Refer to Procedure 019-443 in Section 19.
- Connect the batteries. See equipment manufacture service information.
- Operate the engine and check for proper operation.

Aftertreatment Diesel Particulate Filter Differential Pressure Sensor Tubes (011-047)

General Information

WARNING

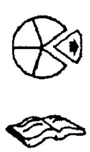
The material captured in a partial flow diesel particulate filter and/or a diesel particulate filter may contain elevated concentrations of metals. Primarily zinc, molybdenum, and possibly polynuclear aromatic hydrocarbons, that may be regulated. These materials must be characterized, handled, and disposed of according to applicable local regulations. In addition, due to the presence of the above-listed chemicals and other potentially toxic components such as oxides of calcium, zinc, phosphorous, silicon, sulfur, and iron, exhaust filter maintenance must be completed only by appropriately trained personnel.

The aftertreatment diesel particulate filter differential pressure sensor tubes connect the aftertreatment diesel particulate filter differential pressure sensor to the ports on the aftertreatment system. There are two aftertreatment diesel particulate filter differential pressure sensor tubes. One tube connects to the aftertreatment system upstream of the aftertreatment diesel particulate filter and the other connects downstream of the aftertreatment diesel particulate filter.

Due to the number of aftertreatment applications, this procedure is generic. **Not** all illustrations within the procedure will represent all applications.

Excessive carbon deposits inside the aftertreatment diesel particulate filter differential pressure sensor tubes can cause a CHECK ENGINE light to illuminate.

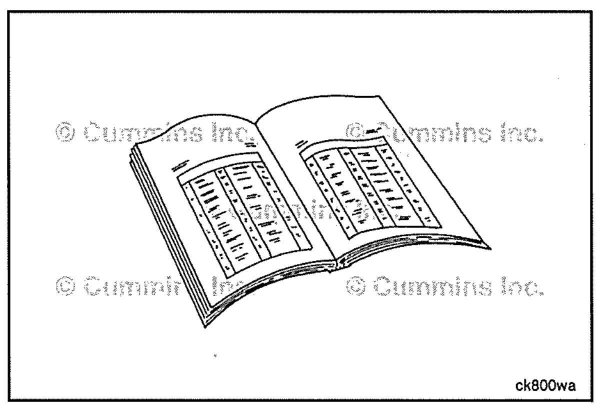
Preparatory Steps

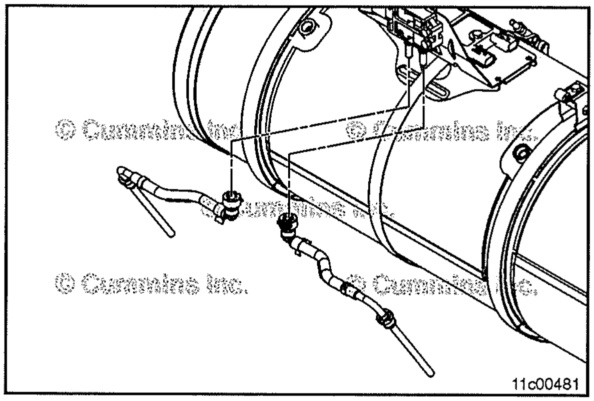


WARNING

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

- Disconnect the batteries.See equipment manufacturer service information.





Remove

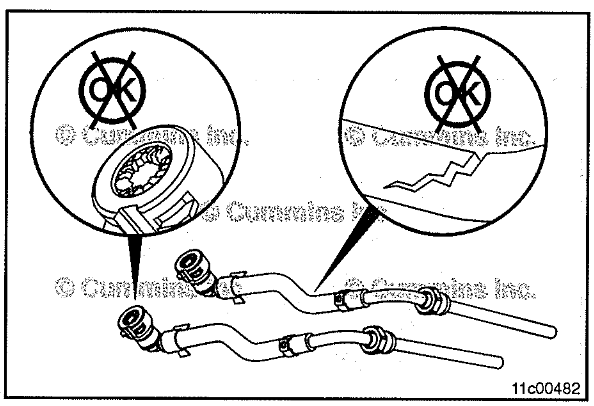
WARNING
During regeneration, exhaust gas temperature can reach 800 °C [1500°F], and exhaust system surface temperature can exceed 700 °C [1300°F], which is hot enough to ignite or melt common materials, and to burn people. The exhaust and exhaust components can remain hot after the vehicle has stopped 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.

CAUTION
The aftertreatment diesel particulate filter differential pressure sensor will not operate properly if the differential pressure sensor tubes are not connected to the correct port. Mark the differential pressure sensor tube connection port locations before disconnecting.

NOTE: The mounting location of the aftertreatment diesel particulate filter differential pressure sensor varies with exhaust aftertreatment orientation.

If equipped with a diesel particulate filter mounted aftertreatment differential pressure sensor:

- Loosen the aftertreatment diesel particulate filter differential pressure sensor tube nuts.
- Remove the p-clips or tube clamp mounting capscrews, if necessary.



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.

Inspect the inside of the tube.

If the tube is partially clogged, saturate the inside of the tube with a mineral based solvent, or equivalent.

Carefully clean debris from the mouth of the tube. Make sure to **not** damage the tube.

If the tube is fully clogged or otherwise unable to be cleaned, the tube **must** be replaced.

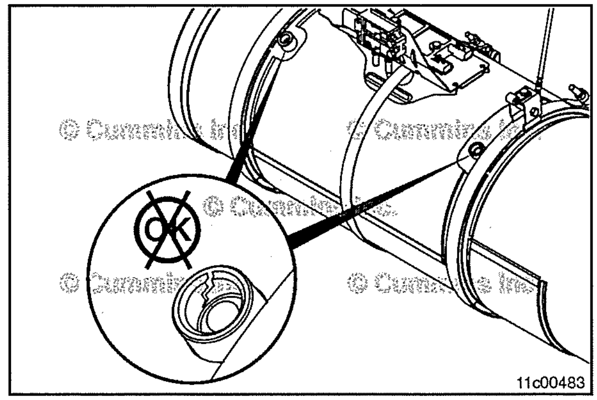
Clean the tube with safety solvent.

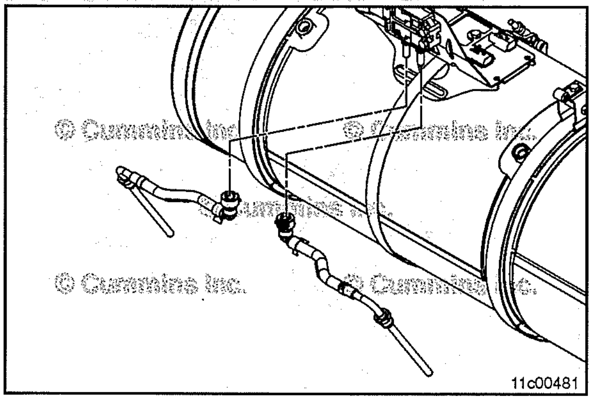
Dry the tube with compressed air.

Check the tube for cracks and thread damage. Replace the tube if damage is found.

Inspect the inside of the threaded bosses on the aftertreatment canister.

Clean debris from the inside of the threaded bosses, while being careful to **not** damage the threads.





Install

CAUTION

The aftertreatment diesel particulate filter differential pressure sensor will not operate properly if the differential pressure sensor tubes are not connected to the correct port. Install the differential pressure sensor tubes as noted during disassembly.

CAUTION

The aftertreatment system must be installed so the aftertreatment diesel particulate filter differential pressure sensor tubes slope downward to drain condensation away from the differential pressure sensor.

NOTE: In vertical aftertreatment orientations, an aftertreatment diesel particulate filter differential pressure sensor tube support is present. Be sure the aftertreatment diesel particulate filter differential pressure tube is seated in the support clip.

Apply a coating of Loctite™ 80209, 51002, 76732, copper or silver grade, or equivalent, to the threads on the aftertreatment diesel particulate filter differential pressure sensor tubes prior to assembly. Do **not** allow the Loctite™ to get inside the aftertreatment diesel particulate filter differential pressure sensor tubes. This can cause a blockage.

Loctite™ anti-seize minimum temperature range specifications: 870°C [1600°F].

Install the aftertreatment diesel particulate filter differential pressure sensor tubes on the aftertreatment system.

NOTE: Be sure the aftertreatment diesel particulate filter differential pressure sensor tubes are **not** making contact with each other or any other vehicle components prior to tightening the aftertreatment diesel particulate filter differential pressure sensor tube nuts.

Tighten the upstream aftertreatment diesel particulate filter differential pressure sensor tube nut.

Torque Value: 31 N•m [23 ft-lb]

Tighten the downstream aftertreatment diesel particulate filter differential pressure sensor tube nut.

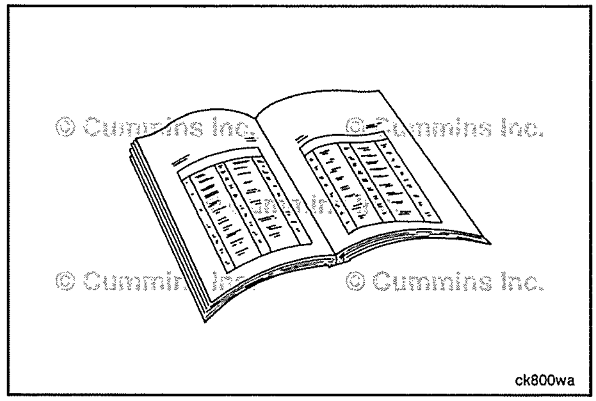
Torque Value: 17 N•m [150 in-lb]

If equipped with diesel particulate filter mounted aftertreatment differential pressure sensor:

- Install the p-clip, or the tube clamp that holds the aftertreatment diesel particulate filter differential pressure sensor tube on the aftertreatment system, if necessary.

Torque Value: 14 N•m [124 in-lb]

Finishing Steps



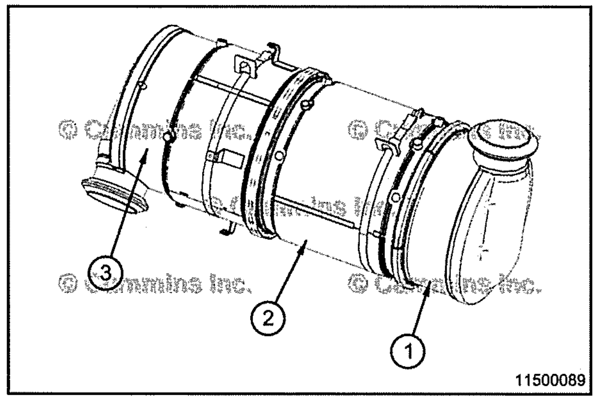
WARNING

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 batteries.See equipment manufacturer service information.
- Operate the vehicle on a dynamometer or perform a road test with the engine at rated load for a minimum of 5 minutes to be sure the aftertreatment system is performing properly.
- Check for fault codes and exhaust leaks.

Aftertreatment Diesel Oxidation Catalyst (011-049)

General Information



WARNING

The material captured in a partial flow diesel particulate filter and/or a diesel particulate filter may contain elevated concentrations of metals. Primarily zinc, molybdenum, and possibly polynuclear aromatic hydrocarbons, that may be regulated. These materials must be characterized, handled, and disposed of according to applicable local regulations. In addition, due to the presence of the above-listed chemicals and other potentially toxic components such as oxides of calcium, zinc, phosphorous, silicon, sulfur, and iron, exhaust filter maintenance must be completed only by appropriately trained personnel.

Due to the number of exhaust aftertreatment applications, this procedure is generic. **Not** all illustrations within this procedure will represent all applications.

The exhaust aftertreatment is composed of three sections. These sections are:

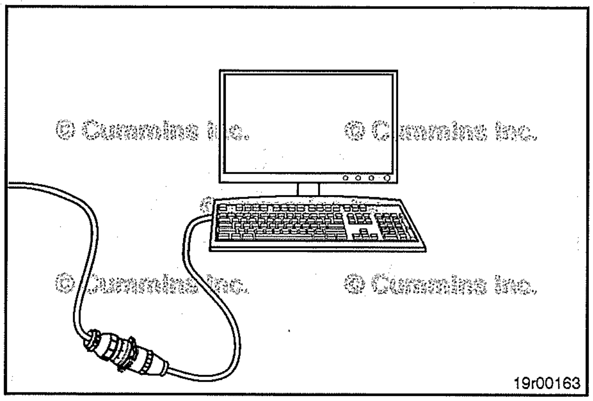
1 Aftertreatment diesel oxidation catalyst (DOC)

2 Aftertreatment diesel particulate filter (DPF)

3 Outlet.

NOTE: The aftertreatment DOC is integrated into the inlet of the exhaust aftertreatment system.

NOTE: If the aftertreatment DPF or aftertreatment diesel oxidation catalyst is being replaced due to progressive damage from engine oil or fuel, clean the tailpipe from the turbocharger outlet to the aftertreatment diesel oxidation catalyst.



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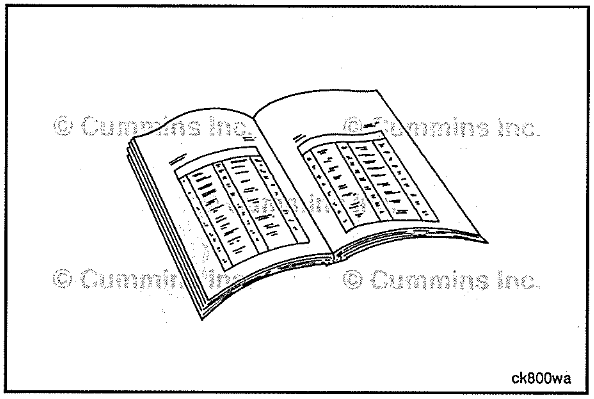
Test

CAUTION

If an engine progressive damage malfunction has sent fuel or oil to the diesel particulate filter or the diesel oxidation, do not perform an aftertreatment diesel particulate filter regeneration test until the aftertreatment diesel oxidation catalyst and diesel particulate filter are inspected.

To test the diesel oxidation catalyst, use INSITE™ electronic service tool to perform the Aftertreatment Diesel Particulate Filter Regeneration Test. The efficiency of the diesel oxidation catalyst will be tested.

If a malfunction in the catalyst system is detected, fault codes will become active during the test. Follow the appropriate fault code troubleshooting tree.



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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

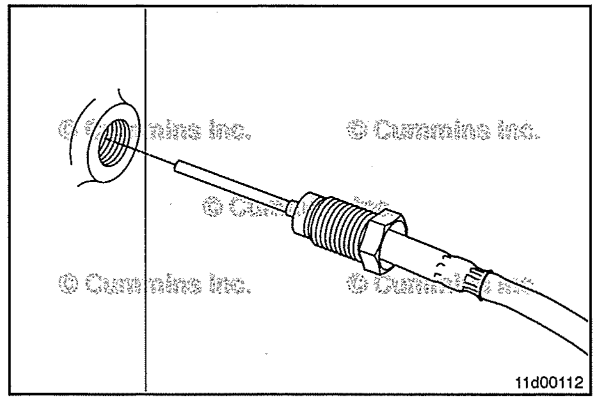
During regeneration, exhaust gas temperature can reach 800 °C [1500°F], and exhaust system surface temperature can exceed 700 °C [1300°F], which is hot enough to ignite or melt common materials, and to burn people. The exhaust and exhaust components can remain hot after the vehicle has stopped moving. 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.

- Disconnect the batteries. See equipment manufacturer service information.
- Disconnect the OEM wiring harness from the DPF differential pressure sensor. Refer to Procedure 019-443 in Section 19.
- Disconnect the OEM wiring harness from the exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.

Disassemble

Remove the aftertreatment DOC intake temperature sensor probe and aftertreatment DPF intake temperature sensor probes. Refer to Procedure 019-449 in Section 19.

NOTE: The aftertreatment DOC intake temperature sensor probe and aftertreatment DPF intake temperature sensor probe **must** be removed prior to aftertreatment DOC removal or damage to the sensor wiring and sensor probe will occur.



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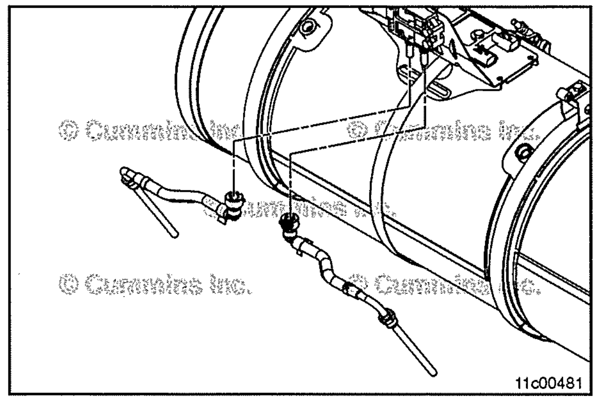
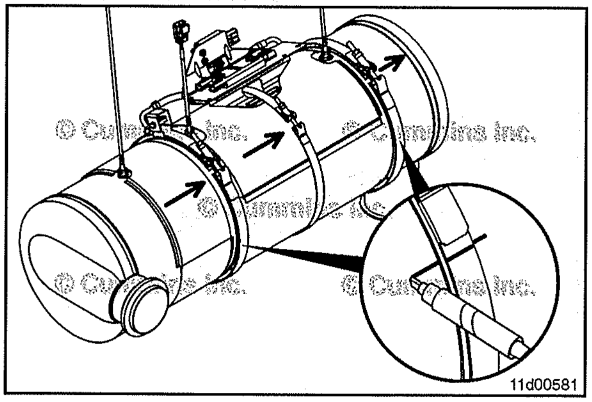
Remove the DPF inlet differential pressure sensor tube (1) from the diesel oxidation catalyst. Refer to Procedure 011-047 in Section 11.

NOTE: The DPF inlet differential pressure sensor tube **must** be removed prior to aftertreatment DOC removal or damage to the sensor tube will occur.



11c00481



Remove

WARNING

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

CAUTION

The aftertreatment diesel oxidation catalyst elements contained in the aftertreatment system are made of brittle material. Do not drop or strike the side of the aftertreatment system as damage to the aftertreatment diesel oxidation catalyst element can result.

CAUTION

Do not use an air tool to remove the V-band clamp nut. An air tool will damage the threads. Apply thread lubricant to the V-band clamp threads prior to nut removal.

Draw an orientation reference line across each of the V-band clamps, aftertreatment canister sections, and connection points to the tailpipe. This will aid in linking up sections and V-band clamps to their original orientation during installation.

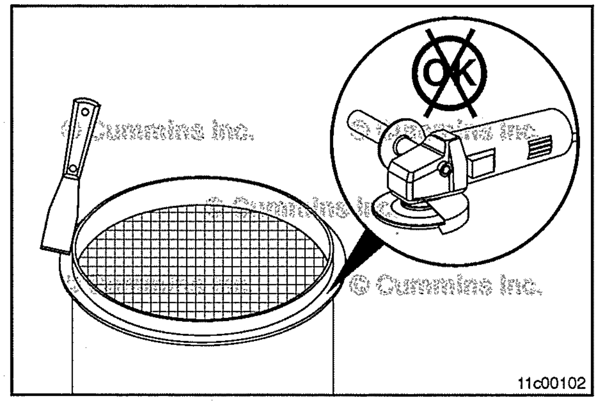
NOTE: If necessary, remove additional mounting hardware to remove the aftertreatment DOC from the vehicle.

Remove the V-band clamps from the inlet and outlet of the aftertreatment DOC.

Separate the component sections by approximately 45 mm [1.77 in] to allow removal over the gasket retainer rings.

Remove and discard the gaskets.

Clean and Inspect for Reuse



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

CAUTION
Do not use a grinder or abrasive air tool to remove residual gasket material, as this can damage the flange and cause the connection to leak.

CAUTION
Do not use an open flame to burn off soot accumulation from the face of the aftertreatment diesel particulate filter.

CAUTION
Do not scrape off soot accumulation from the face of the aftertreatment diesel particulate filter.

CAUTION
Do not steam clean the inlet of the diesel oxidation catalyst as damage to the aftertreatment diesel oxidation catalyst can result.

Remove any residual gasket material from the flanges on the aftertreatment DPF, DOC, and catalyst inlet with a putty knife.

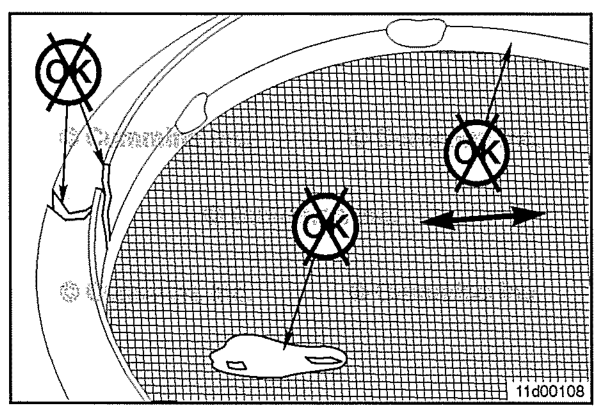
NOTE: Avoid dropping fragments of gasket material into the aftertreatment DPF and catalyst.

Inspect the exhaust gas temperature sensor boss threads for damage.

If thread damage is found on the exhaust gas temperature sensor boss threads, a helicoil **must** be used for repair.

NOTE: If the aftertreatment DPF is being inspected due to progressive damage that introduced engine oil or excessive fuel into the exhaust, inspect the tailpipe from the turbocharger outlet to the aftertreatment DOC.

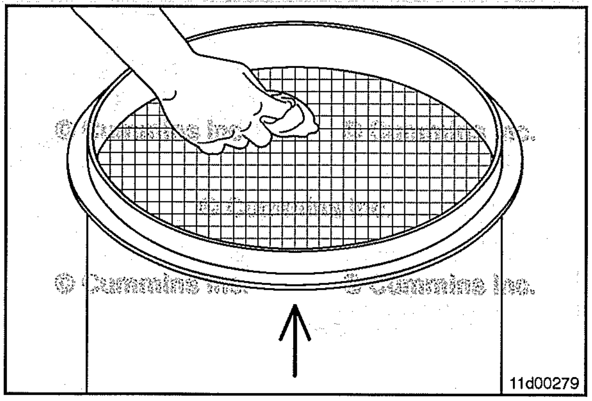
If a trail of engine oil or fuel can be seen exiting the turbocharger outlet, steam clean the tailpipe between the turbocharger and the aftertreatment DOC.



If the aftertreatment DOC section has shifted, moved, or is loose inside the canister, replace the aftertreatment DOC section.

Refer to the Aftertreatment Diesel Oxidation Catalyst and Aftertreatment Diesel Particulate Filter Reuse Guidelines, Bulletin 4021600, to inspect the inlet and outlet faces of the aftertreatment diesel oxidation catalyst for signs of damage.

Replace the aftertreatment DOC, if it is damaged.

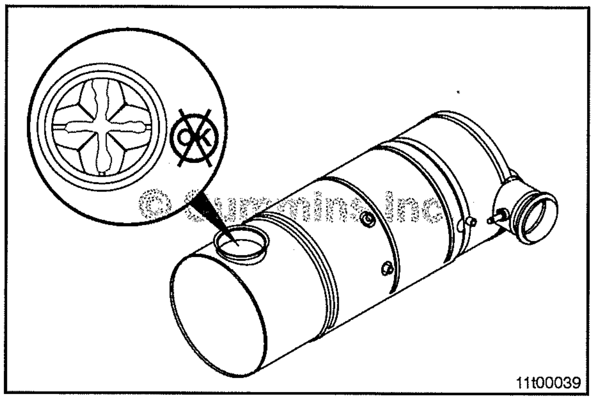


⚠WARNING⚠

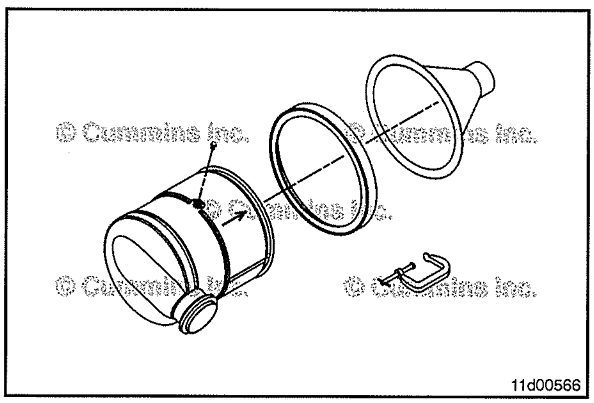
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Inspect the outlet of the aftertreatment DOC for loose debris and soot. Use a rag to wipe off any soot. Use a HEPA vacuum to remove any remaining loose debris.

NOTE: Use a vacuum bag, such as a drywall dust bag, to capture the soot that is removed.



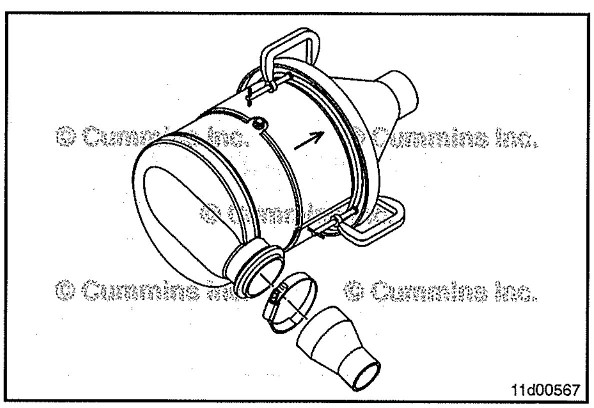
Inspect the aftertreatment DOC insulation for damage.



Attach the Cummins® aftertreatment DPF cleaning machine cone, Part Number 4918849, to the outlet side of the aftertreatment DOC with the adapter ring, Part Number 4918846. Evenly space four to five spring clamps or C-clamps around the circumference of the aftertreatment DOC to seal the cone and adapter ring to the aftertreatment DOC.

Service tool kit, Part Number 4918876, contains the cones and rings needed for this procedure.

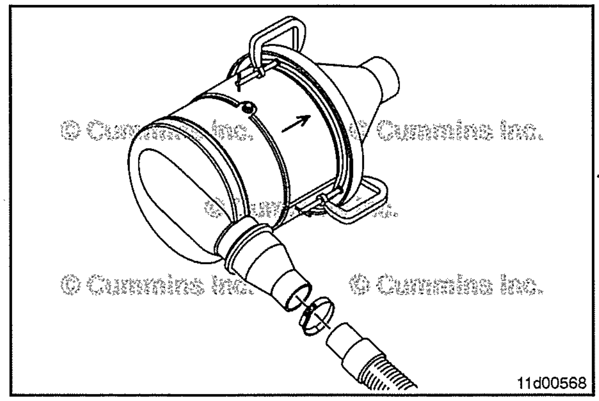
Install a Cummins® threaded plastic plug, Part Number 4919495, into the exhaust gas temperature sensor port on the DOC. This will prevent air from escaping the DOC.



Obtain a 51 to 102 mm [2 to 4 in] rubber pipe reducer.

Attach the vacuum hose to the 51 mm [2 in] end of the pipe reducer. Install the larger end of the reducer to the inlet of the DOC.

Use tape to seal any open ports.



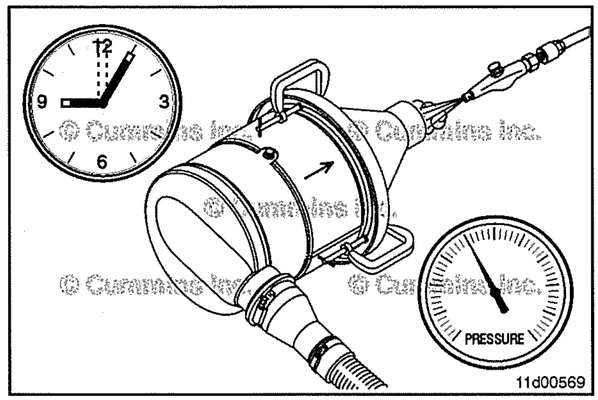
⚠CAUTION⚠

Use only a rubber-tipped air gun near the catalyst material. Damage will result if a metal air gun strikes the catalyst material.

Adjust the air supply for a rubber-tipped air gun to 621 kPa [90 psi].

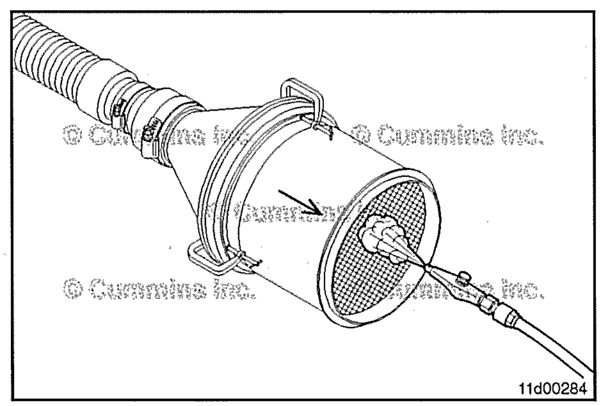
Switch on the vacuum. The vacuum and service tool kit is properly installed if the air flow through the aftertreatment DOC is opposite the exhaust flow. Exhaust flow is indicated by the arrow drawn on the canister of the DOC prior to removal.

Blow compressed air across the outlet face of the aftertreatment DOC for approximately 5 minutes.



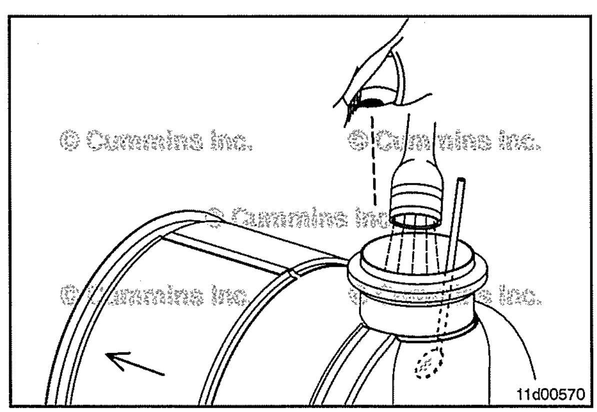
After 5 minutes, remove the aftertreatment DPF cleaning machine cone and continue blowing compressed air into the outlet of the DOC for an additional 10 to 15 minutes. Maintain a 13 to 25 mm [1/2 to 1 in] distance between the air gun and the DOC face. Use a sweeping motion across the entire face of the DOC and attempt to blow air through every cell.

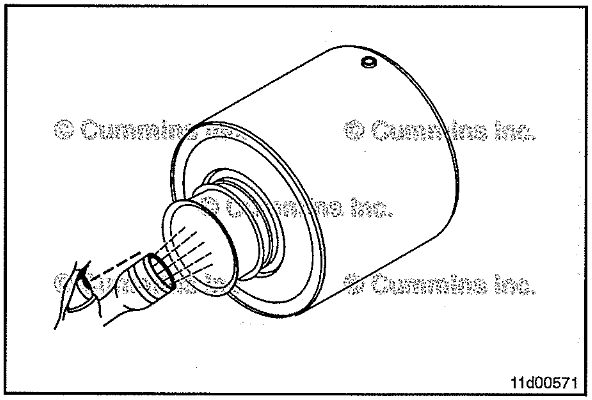
Allow the vacuum to operate for 1 minute after blowing out the aftertreatment DOC. After the vacuum is switched off, disconnect the cleaning machine cone and inspect the cells of the DOC.



For side-in configurations:

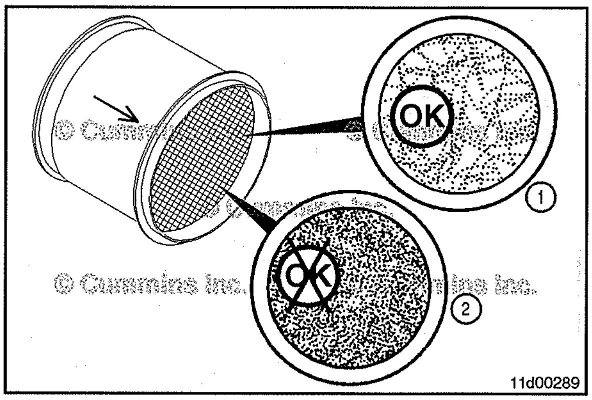
Place an inspection mirror into the inlet of the DOC and shine a flashlight on the mirror to inspect the cells of the inlet face.





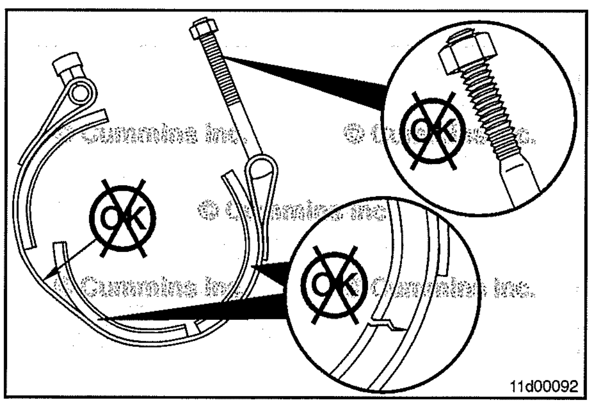
For end-in configurations:

Use a flashlight to inspect the inlet face of the DOC.



Upon inspection, if less than 50 percent of the cells are blocked (1), the aftertreatment DOC can be reused. If more than 50 percent of the cells remain blocked (2), repeat the cleaning procedure.

NOTE: It should **not** take more than two attempts to clean the face of the DOC.



Inspect the V-band clamps and aftertreatment DOC mounting straps for signs of overextension. The V-band **must not** be bent or otherwise damaged.

Replace the V-band clamps or aftertreatment DOC mounting straps if damage is found.

Install

⚠CAUTION⚠

Do not use an air tool to tighten the V-band clamp. An air tool will damage the threads.

Install new gaskets on the inlet and outlet of the exhaust gas aftertreatment DOC.

Apply a coat of anti-seize compound on the threads of the V-band clamps and Torca™ clamps.

Install the aftertreatment DOC.

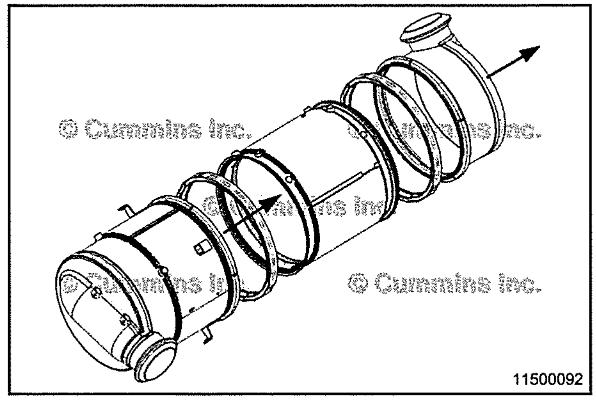
Tighten the V-band clamp used to secure the aftertreatment DOC to the aftertreatment DPF.

Torque Value: 20 N•m [177 in-lb]

Tighten the V-band clamp used to secure the inlet of the aftertreatment DOC to the exhaust pipe.

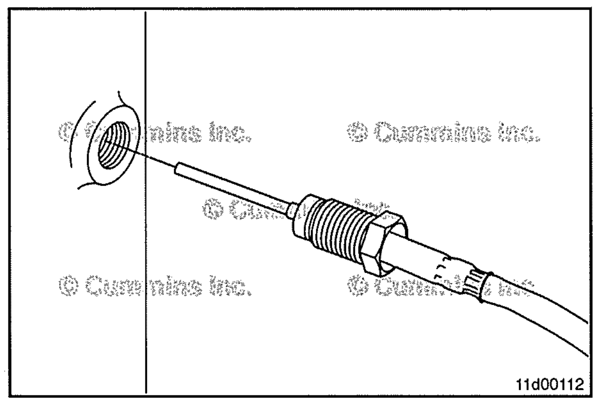
Torque Value: 13.5 N•m [119 in-lb]

If necessary, install any additional mounting hardware that was used to secure the aftertreatment DOC to the vehicle.

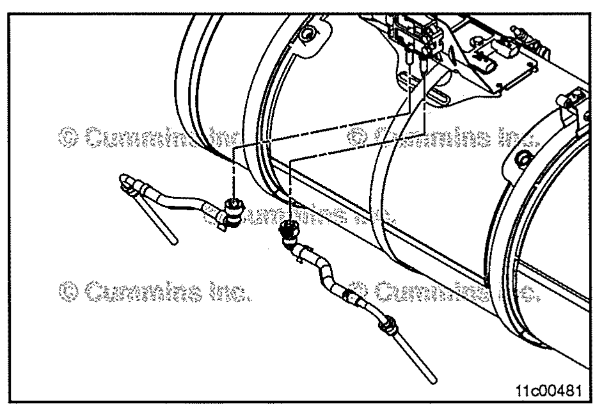


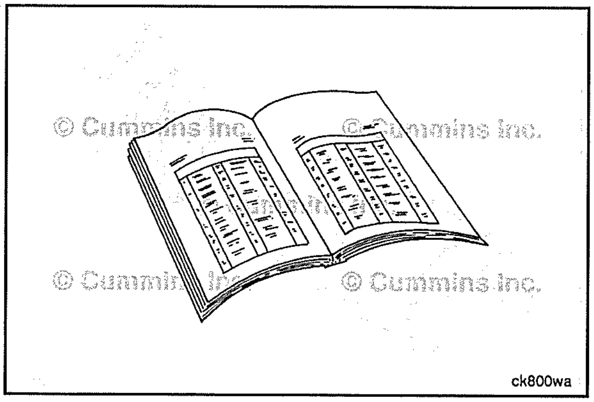
Assemble

Install the exhaust gas temperature sensor probes. Refer to Procedure 019-449 in Section 19.



Install the DPF differential pressure sensor tube. Refer to Procedure 011-047 in Section 19.



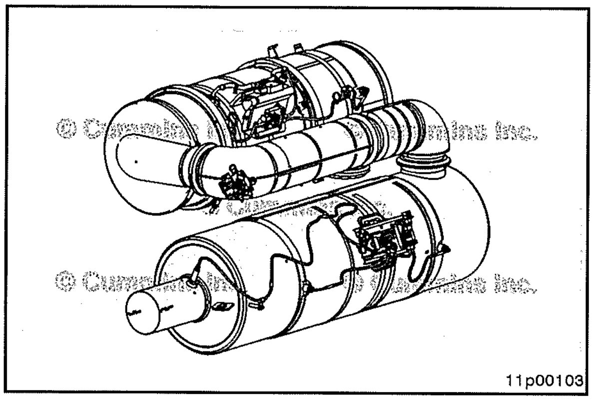


Finishing Steps

⚠ 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 OEM wiring harness to the DPF differential pressure sensor. Refer to Procedure 019-443 in Section 19.
- Connect the OEM wiring harness to the exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for fault codes and exhaust leaks.

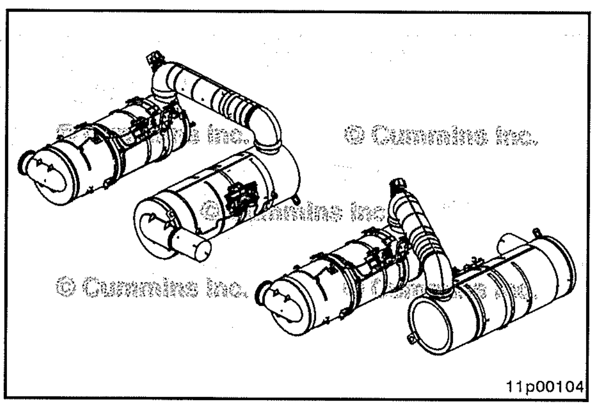


Aftertreatment System (011-050)

General Information

The aftertreatment system configuration will vary depending on the vehicle type and/or manufacturer. Some of the more common aftertreatment configurations are:

- Switchback - the DPF and SCR assembly are side-by-side so that the aftertreatment system can fit in a small area such as underneath the side steps of the vehicle.



- Horizontal - the DPF and SCR assemblies are on opposite sides of the chassis.
- Crossover - the DPF and SCR assemblies are on opposite sides of the chassis.

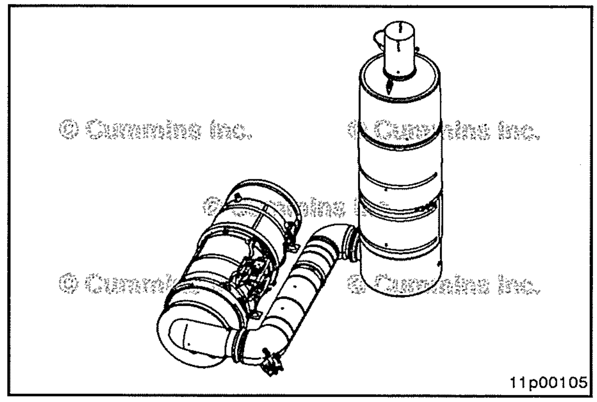
- Horizontal to Vertical - the DPF assembly is horizontal and then transitions to a vertical SCR assembly.

NOTE: The illustration is depicting some common arrangements.

For some aftertreatment systems, if required, the entire aftertreatment system can be removed as a complete assembly. See equipment manufacturer service information.

In many cases the aftertreatment system **must** be removed component by component. See the appropriate procedures in the section for removal and installation information.

Use the following procedure for more detailed information about the aftertreatment system. Refer to Procedure 011-999 in Section F.



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Exhaust System Diagnostics (011-056)

General Information

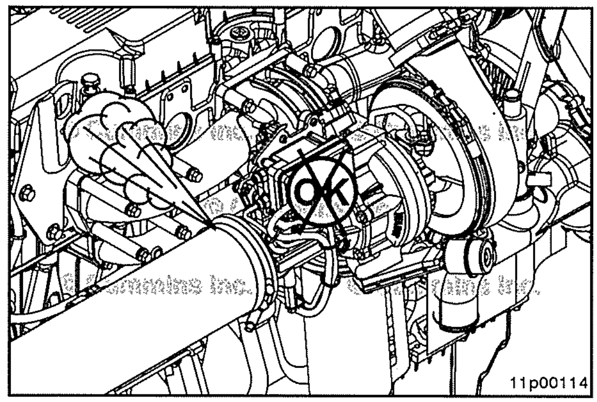
The following procedure contains troubleshooting steps and information regarding the aftertreatment system.

Leaks in the exhaust system can cause exhaust odor or white smoke.

Inspect the exhaust piping for leaks, cracks, and loose connections. Refer to Procedure 010-024 in Section 10.

Tighten the exhaust clamps, if necessary. See equipment manufacturer service information for the correct torque value.

It may be necessary to perform a stationary (parked or non-mission) regeneration to locate exhaust leaks. Refer to Procedure 014-016 in Section 14.



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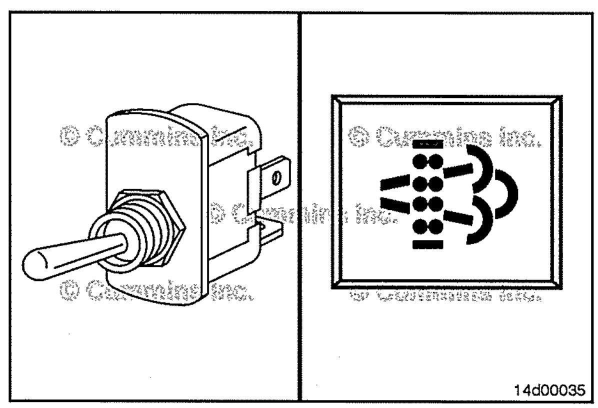
The ambient temperature affects the length of time it will take to perform a stationary (parked or non-mission) regeneration because the engine **must** work harder to increase the exhaust temperatures to the appropriate levels in cold ambient temperatures.

In cold ambient temperatures (approximately -18°C [0°F] or colder), stationary (parked or non-mission) regeneration may take longer to complete. In extremely cold ambient temperatures, stationary (parked or non-mission) regeneration may **not** complete.

In these cases, it may be necessary to warm the engine to operating temperature before starting the stationary (parked or non-mission) regeneration, or to move the vehicle to a location with higher ambient temperatures.



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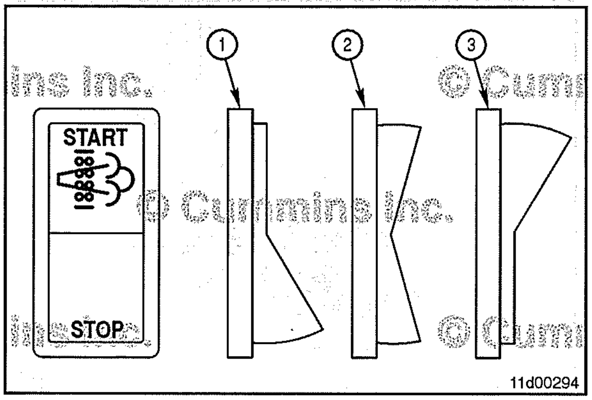


The vehicle manufacturer has the option of installing two switches that control aftertreatment function: the start switch and the permit switch.

The start switch (called the Diesel Particulate Filter Regeneration Start Switch in INSITE™ electronic service tool) is used to start a stationary (parked or non-mission) regeneration. The vehicle manufacturer may also see this switch as a "stationary regeneration switch," "start switch," "non-mission regeneration," or "parked regeneration switch".

The permit switch (called the Diesel Particulate Filter Permit Switch in INSITE™ electronic service tool) is used to allow the operator to disable active regeneration, if necessary. The vehicle manufacturer may also reference this switch as an "inhibit switch," "stop switch," or "disable switch".

The start switch can be hardwired to the engine control module (ECM), or it can be multiplexed over J1939 multiplexing.

If the start switch is hardwired, it shares an ECM pin with the diagnostic switch. When the switch is turned ON and the engine is OFF, the ECM interprets this signal as the diagnostic switch. When the switch is turned ON and the engine is operating, the ECM interprets this signal as the start switch.

If the start switch is J1939-multiplexed, the signal for this switch is broadcast over the J1939 data link.

A J1939-multiplexed start switch signal has priority over a hardwired start switch signal. Therefore, if the start switch is enabled over J1939, the hardwired signal is ignored by the engine ECM.

The default setting for the start switch is OFF. If the start switch is enabled to INSITE™ electronic service tool, but no switch is installed (either hardwired or J1939-multiplexed), the switch status will remain OFF.

The position of the start switch can be monitored with INSITE™ electronic service tool in the Data Monitor/Logger screen.

The default setting for the permit switch is enabled.

If the permit switch is enabled with INSITE™ electronic service tool, but no switch is installed (either hardwired or J1939 multiplexed), the switch status will remain OFF.

If the vehicle is operated for an extended period of time with the permit switch OFF, fault codes for the above normal levels of aftertreatment diesel particulate filter (DPF) soot load may result (Fault Codes 1921, 1922, and 2639).

If the aftertreatment DPF soot load reaches an above normal level (Fault Code 1921, 1922, and 2639), and the permit switch is OFF, the ECM will log Fault Code 2777. The ECM will also log Fault Code 2777 if the ECM is requesting active regeneration of the aftertreatment and the permit switch is OFF.

If the permit switch is multiplexed, and therefore enabled, in the J1939 section of Features and Parameters in INSITE™ electronic service tool, it **must** also be enabled in the aftertreatment section of Features and Parameters in INSITE™ electronic service tool. If it is **not**, regeneration will be inhibited.

The position of the permit switch can be monitored with INSITE™ electronic service tool in the Data Monitor/Logger screen:

- When the permit switch is ON, active regeneration is allowed.
- When the permit switch is OFF, active regeneration is **not** allowed.

NOTE: If there is no permit switch installed and the permit switch is disabled in the J1939 section and the aftertreatment section of Features and Parameters in INSITE™ electronic service tool, the permit switch status in the Data Monitor/Logger screen will show the permit switch is OFF, but active regeneration will be allowed.

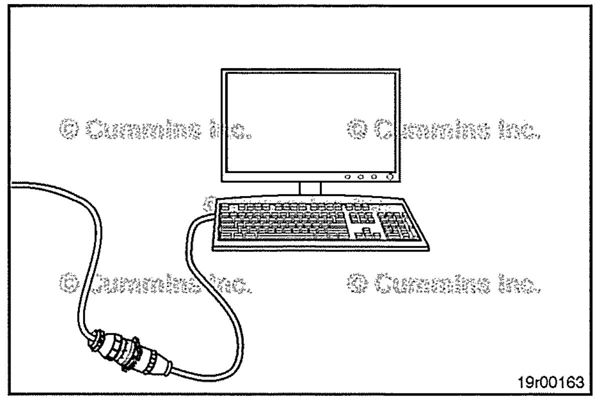
NOTE: This step describes possible incorrect aftertreatment exhaust gas temperature sensor wiring conditions.

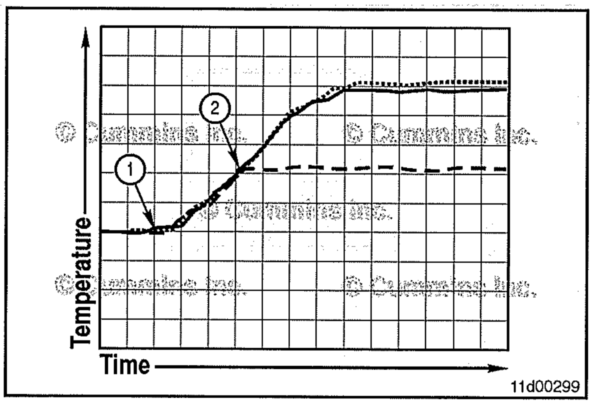
The aftertreatment sensors link to the ECM over J1939. See the appropriate Fault Code Troubleshooting Manual to diagnose and troubleshoot fault codes.

To verify the OEM wiring harness and the temperature sensors, use INSITE™ electronic service tool to monitor the following parameters with the engine operating. Verify that they increase from room temperature.

- Aftertreatment diesel oxidation catalyst (DOC) intake temperature
- Aftertreatment DPF intake temperature
- Aftertreatment DPF outlet temperature
- Aftertreatment selective catalytic reduction (SCR) intake temperature
- Aftertreatment SCR outlet temperature.

If any of the parameters do **not** show a temperature as expected, check the aftertreatment wiring and connections to the sensor(s). Check aftertreatment exhaust gas temperature sensors for damage.





When performing a stationary (parked or non-mission) regeneration, monitor the exhaust temperatures in the aftertreatment to determine why a stationary (parked or non-mission) regeneration will **not** complete.

Possible causes for stationary (parked or non-mission) regenerations that will **not** complete include:

- Misassembled OEM wiring harness
- A plugged aftertreatment DOC
- A malfunctioning turbocharger.

A normal stationary (parked or non-mission) regeneration will follow the pattern shown.

- The dashed line is for the aftertreatment DOC inlet temperature sensor.
- The dotted line is for the aftertreatment DPF inlet temperature sensor.
- The solid line is for the aftertreatment DPF outlet temperature sensor.

When the stationary (parked or non-mission) regeneration begins (1), all three temperatures should be approximately the same, and should increase at the same rate.

The wiring to the aftertreatment temperature sensors appears to be correct in this example because they all read approximately the same temperature at the beginning of the stationary (parked or non-mission) regeneration and increase at the same rate.

Aftertreatment injection begins when all three temperatures reach approximately 288°C [550°F] (2).

Once aftertreatment injection begins, the aftertreatment DOC inlet temperature may vary slightly, but will typically remain between 260 and 399°C [500 and 750°F].

The aftertreatment DPF inlet and outlet temperatures will increase to approximately 482 to 649°C [900 to 1200°F]. The temperatures may vary during the stationary (parked or non-mission) regeneration as the amount of fuel injected during aftertreatment injection is changed to maintain a constant temperature.

The aftertreatment DPF inlet and outlet temperatures will remain at this temperature for the duration of the stationary (parked or non-mission) regeneration.

This graph illustrates a stationary (parked or non-mission) regeneration where the inlet of the aftertreatment DOC is blocked.

- The dashed line is for the aftertreatment DOC inlet temperature sensor.
- The dotted line is for the aftertreatment DPF inlet temperature sensor.
- The solid line is for the aftertreatment DPF outlet temperature sensor.

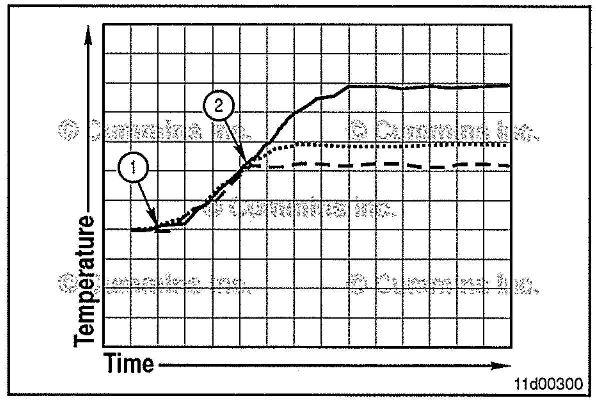
In this condition, the engine speed will increase to the stationary (parked or non-mission) regeneration speed of 1000 rpm.

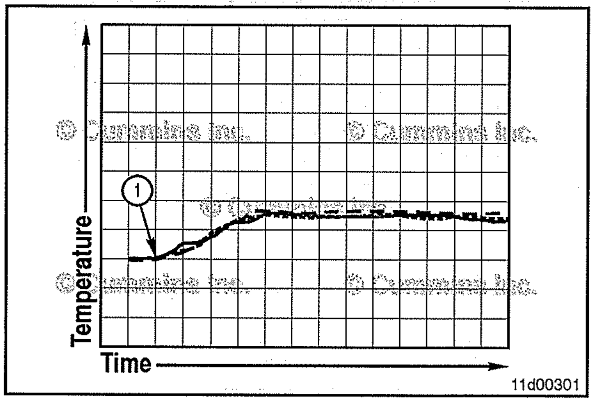
Raising the aftertreatment temperature to the aftertreatment injection temperature may take longer to complete than normal if the inlet to the aftertreatment DOC is plugged, restricting some of the exhaust flow.

Once aftertreatment injection begins (2), the aftertreatment DPF inlet and outlet temperatures will differ greatly due to the plugged aftertreatment DOC being unable to oxidize the injected fuel. The aftertreatment DPF has some capability to oxidize the injected fuel, but can **not** maintain this condition without damaging the filter material over time. It is possible that white smoke would be present from the vehicle tailpipe during this condition.

The wiring to the aftertreatment temperature sensors appears to be correct in this example because they all read approximately the same temperature at the beginning of the stationary (parked or non-mission) regeneration and they increase at the same rate.

The possible cause of this condition is a plugged aftertreatment DOC. Use the following procedure to inspect the aftertreatment DOC. Refer to Procedure 011-049 in Section 11.





This graph illustrates a stationary (parked or non-mission) regeneration where the engine can **not** build enough heat to start aftertreatment injection.

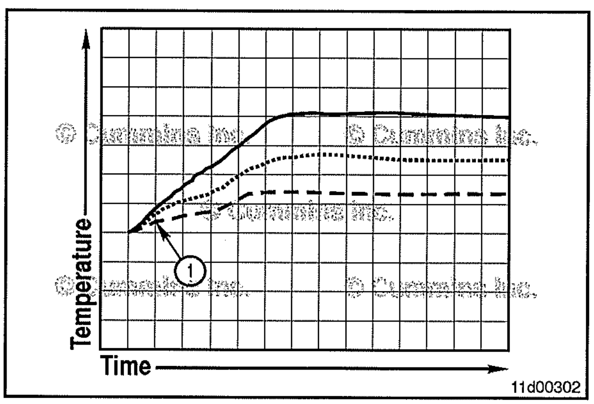
- The dashed line is for the aftertreatment DOC inlet temperature sensor.
- The dotted line is for the aftertreatment DPF inlet temperature sensor.
- The solid line is for the aftertreatment DPF outlet temperature sensor.

The engine speed will likely increase to the stationary (parked or non-mission) regeneration speed of 1000 rpm, but because the aftertreatment temperatures do **not** increase enough to start aftertreatment injection, the stationary (parked or non-mission) regeneration will **not** complete.

The wiring to the aftertreatment temperature sensor appears to be correct in this example because they all read approximately the same temperature for the same conditions.

Possible causes of this issue include:

- Malfunctioning exhaust pressure regulator. Refer to Procedure 011-105 in Section 11.
- A malfunctioning turbocharger. Refer to Procedure 010-033 in Section 10.
- Low ambient temperatures. Move the vehicle to a location with higher ambient temperatures.



This graph illustrates a stationary (parked or non-mission) regeneration where the wiring to the aftertreatment temperature sensors is incorrect.

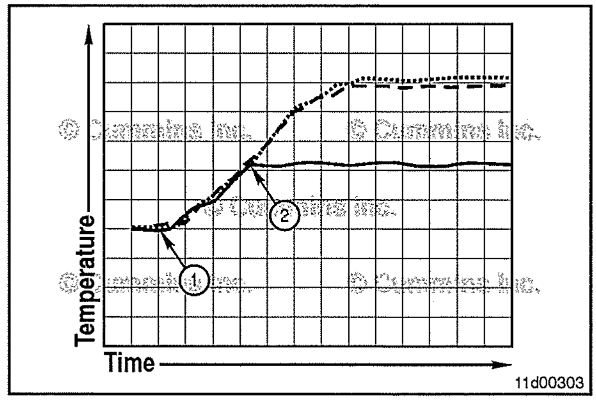
- The dashed line is for the aftertreatment DOC inlet temperature sensor.
- The dotted line is for the aftertreatment DPF inlet temperature sensor.
- The solid line is for the aftertreatment DPF outlet temperature sensor.

In this condition, the engine speed will increase to the stationary (parked or non-mission) regeneration speed of 1000 rpm.

Aftertreatment injection will **not** occur in this condition because the aftertreatment DOC inlet temperature does **not** reach the required temperature. Because aftertreatment injection is **not** occurring, the aftertreatment temperatures should **not** read differently.

The possible cause of this condition is an incorrectly assembled aftertreatment wiring harness. See the Aftertreatment Exhaust Gas Temperature Sensor Wiring part of this procedure. Check aftertreatment exhaust gas temperature sensors for damage.

This graph illustrates a stationary (parked or non-mission) regeneration where the OEM wiring to the aftertreatment DOC inlet temperature sensor and the aftertreatment DPF outlet temperature sensor are reversed.

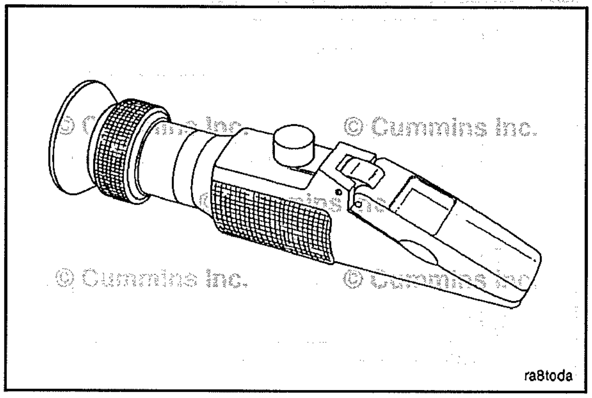


- The dashed line is for the aftertreatment DOC inlet temperature sensor.
- The dotted line is for the aftertreatment DPF inlet temperature sensor.
- The solid line is for the aftertreatment DPF outlet temperature sensor.

In this condition, the engine speed will increase to the stationary regeneration speed of 1000 rpm.

Aftertreatment injection may occur in this condition (2). However, the aftertreatment DOC inlet temperature increases after aftertreatment injection begins, while the aftertreatment DPF outlet temperature remains constant.

The possible cause of this condition is that the OEM wiring to the aftertreatment DOC inlet temperature sensor and the aftertreatment DPF outlet temperature sensor are reversed. See the Aftertreatment Exhaust Gas Temperature Sensor Wiring part of this procedure. Check aftertreatment exhaust gas temperature sensors for damage.



Test

NOTE: This section of the procedure provides information for testing the diesel exhaust fluid (DEF) concentration.

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 that does not meet the specifications provided or to operate the vehicle/equipment with no diesel exhaust fluid.

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..

CAUTION
Never add water or any other fluid besides what is specified to the DEF tank. The aftertreatment system may be damaged.

The correct concentration of DEF is critical to the engine and aftertreatment system for correct performance.

Cummins Inc. is **not** responsible for malfunctions or damage resulting from what Cummins Inc. determines to be abuse or neglect. This includes, but is **not** limited to: operation without correctly specified DEF, lack of maintenance of the aftertreatment system, improper storage or shutdown practices, or unauthorized modifications of the engine and aftertreatment system. Cummins Inc. is also **not** responsible for malfunctions caused by incorrect DEF, water, dirt, or other contaminants in the DEF. Use the Cummins® DEF refractometer, Part Number 4919318, to test the concentration of the DEF. Follow the instructions provided with the service tool.

NOTE: The concentration of the DEF **must** be 32.5 ± 0.7 by weight.

If the DEF concentration does **not** meet this specification, drain the DEF tank, flush the tank with distilled water, and fill the tank with new and/or known good DEF. Check the DEF concentration.

Concentration of the DEF 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 DEF tank.

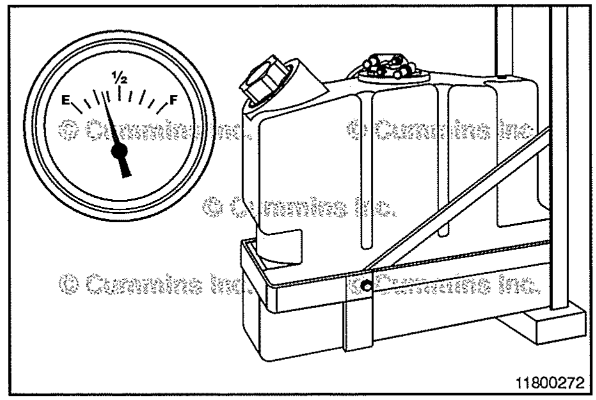
Contamination/Incorrect Fluid

DEF can become contaminated by the following situations:

- If equipped, the aftertreatment DEF tank coolant heating system malfunctions, allowing coolant to mix with the DEF.
- The aftertreatment DEF tank cap is missing or damaged, or the tank vent malfunctions.
- The aftertreatment DEF tank is filled with the incorrect fluid.

In the event that the DEF becomes contaminated, inspect the DEF to determine the most likely source.

Obtain a sample from the DEF tank and pour the sample into an appropriate container. Make sure to get a sample from the highest fluid level.

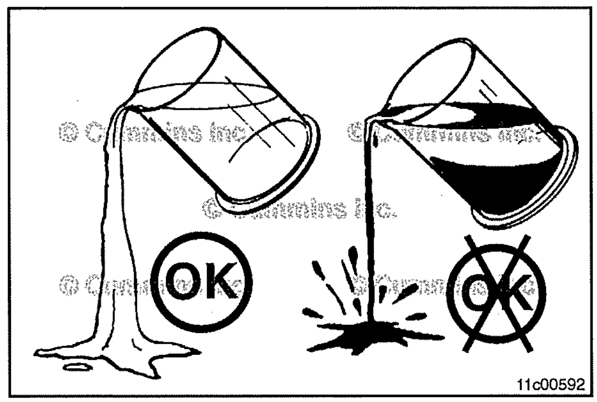


Petroleum based liquids, such as, but **not** limited to:

- Diesel fuel
- Hydraulic fluid
- Brake fluid.

Because DEF is largely composed of water, petroleum based liquids will separate from the DEF and rise to the top. Look for separation of the fluids, as well as characteristic smells.

If the DEF is contaminated, follow the steps detailed later in this procedure.



Non-petroleum based liquids, such as, but **not** limited to:

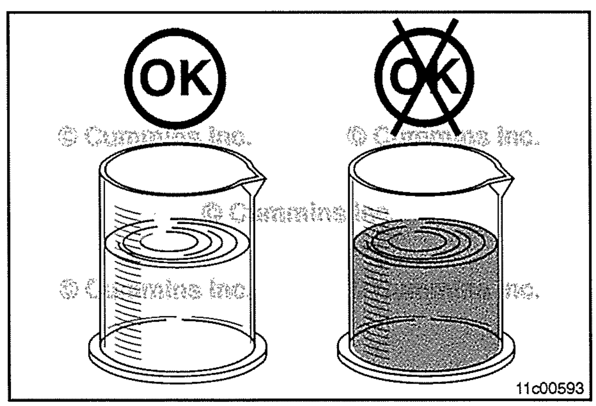
- Water
- Coolant
- Windshield washer fluid.

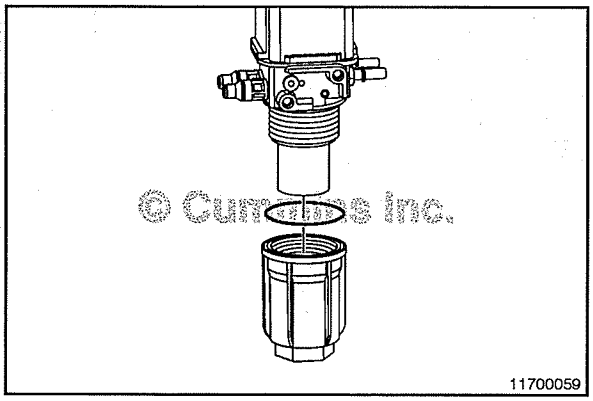
If water has been added, the DEF will remain clear. As a result, the DEF will become diluted, reducing the concentration level.

NOTE: If **only** water has been added to the DEF tank, drain the DEF tank, flush with distilled water, and fill the tank with new and/or known good DEF. Check the DEF concentration after completing the refill. Follow the instructions in the Test section of this procedure.

For other non-petroleum based liquids that may have been added to the DEF, typically those fluids have coloring and will mix with DEF. If the DEF has a color tint to it, look for other fluids used on the vehicle that may match, such as coolant or windshield washer fluid.

If the DEF is contaminated, follow the steps detailed later in this procedure



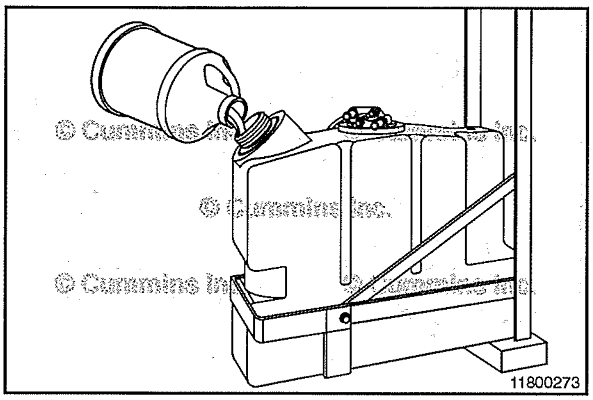


NOTE: Use INSITE™ electronic service tool to view and troubleshoot any fault codes that occur during the following steps. See the applicable Fault Code Troubleshooting Manual. Refer to Procedure 205-001 in Section L.

If the DEF has been contaminated, remove the aftertreatment DEF dosing unit filter. Refer to Procedure 011-060 in Section 11. Inspect the filter for signs that the contaminated fluid went through the dosing system.

If the contaminated fluid did **not** go through the dosing system, drain the DEF tank and flush with distilled water. Replace the DEF in the tank filter. See equipment manufacturer service information for specific information on servicing the DEF tank.

After the DEF tank has been cleaned, fill the tank with new and/or known good DEF. Check the DEF concentration after completing the refill. Follow the instructions in the Test section of this procedure.



NOTE: Any discarded contaminated fluids and/or parts **must** be disposed of according to local area ordinances.

If the contaminated fluid did go through the dosing system:

1 Drain the DEF tank, flush with distilled water, and replace the in tank DEF filter. See equipment manufacturer service information for specific information on servicing the DEF tank.

2 Replace the aftertreatment DEF dosing unit filter. Refer to Procedure 011-060 in Section 11.

3 Remove all of the aftertreatment DEF lines and flush with distilled water. See equipment manufacturer service information on the handling of contaminants in the aftertreatment DEF lines. Install the aftertreatment DEF lines.

4 Fill the aftertreatment DEF tank with distilled water.

5 Perform the INSITE™ electronic service tool DEF Doser Pump Override Test. Repeat the test until the distilled water runs clear.

6 Drain the distilled water from the DEF tank and refill with new and/or known good DEF. Check the DEF concentration. Follow the instructions in the Test section of this procedure.

7 Replace the aftertreatment DEF dosing unit filter again. Refer to Procedure 011-060 in Section 11.

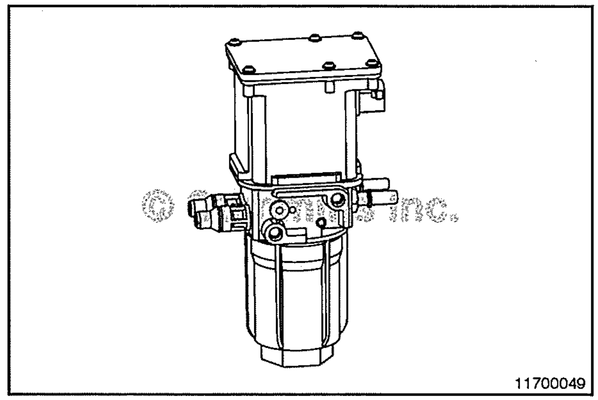
8 Perform the INSITE™ electronic service tool DEF Doser Pump Override Test. Test the performance and spray pattern of the aftertreatment DEF dosing valve.

9 Perform a stationary (parked or non-mission) regeneration. Refer to Procedure 014-016 in Section 14.

10 Road test the vehicle for 30 minutes to verify system operation.

Aftertreatment Diesel Exhaust Fluid Dosing Unit (011-058)

General Information



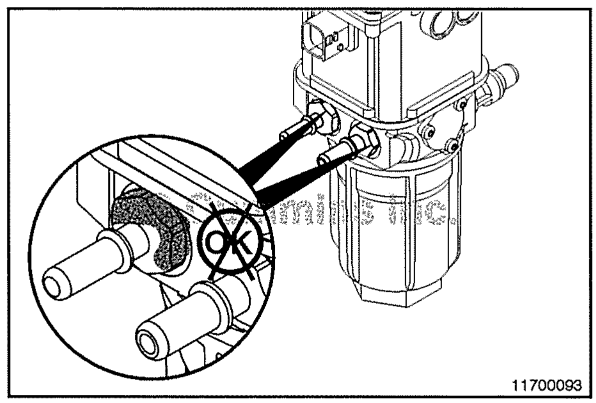
The aftertreatment diesel exhaust fluid (DEF) dosing unit draws DEF from the aftertreatment DEF tank, pressurizes the DEF, and delivers the DEF to the aftertreatment DEF dosing valve. Any unused DEF is then routed back to the aftertreatment DEF tank. Reference the following procedure for further information on the aftertreatment DEF dosing system. Refer to Procedure 011-999 in Section F.

The DEF dosing unit has two engine coolant connections to allow engine coolant to flow through the DEF dosing unit housing. This allows the engine coolant to thaw the DEF dosing unit and to prevent it from freezing during operation. The coolant supply and return connections are interchangeable. They connect the aftertreatment DEF dosing unit to the engine cooling system

Use the following procedure for information on handling incorrect or contaminated DEF. Refer to Procedure 011-056 in Section 11.

The aftertreatment DEF dosing unit has a serviceable filter. Refer to Procedure 011-060 in Section 11.

Initial Check

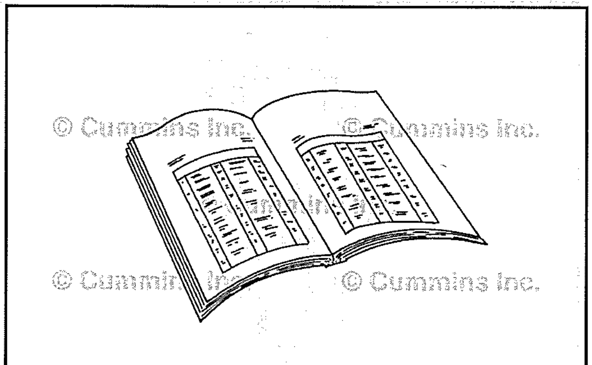


There is always a chance of residual pressure being present. Open fittings slowly to allow any pressure to bleed off before removing any connections.

Check the DEF lines to and from the dosing unit for signs of leakage. DEF forms a white deposit around leaky fittings.

If white deposits are found, inspect the DEF line connection fittings for damage. See equipment manufacturer service informaion.

Check around the aftertreatment DEF dosing unit filter cap for white deposits.



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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

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

WARNING

The diesel exhaust fluid (DEF) line connecting the aftertreatment diesel exhaust fluid dosing unit to the aftertreatment diesel exhaust fluid 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.

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

There is **always** a chance of residual pressure being present. Open fittings slowly to allow any pressure to bleed off before removing any connections.

- Disconnect the batteries. See equipment manufacturer service informaion.
- Drain the engine coolant. Refer to Procedure 008-018 in Section 8.

NOTE: The DEF lines are connected to the dosing unit by quick release fittings that could vary among vehicle manufacturers. See equipment manufacturer service informaion. for the detailed removal process.

- Disconnect the DEF lines and electrical connector in the following order to reduce the possibility of accidental DEF contamination of the electrical connector:

1 Inlet: DEF supply to the aftertreatment DEF dosing unit.

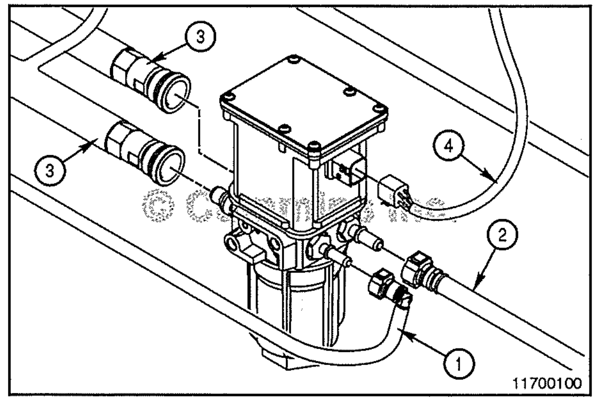
2 Outlet: DEF supply to the aftertreatment DEF dosing valve.

3 Coolant connectors.

4 4-pin electrical connector.

The 4-pin electrical connector can be removed by sliding the yellow portion of the connector outward. The connector will then begin to rise and disconnect from the DEF supply module.

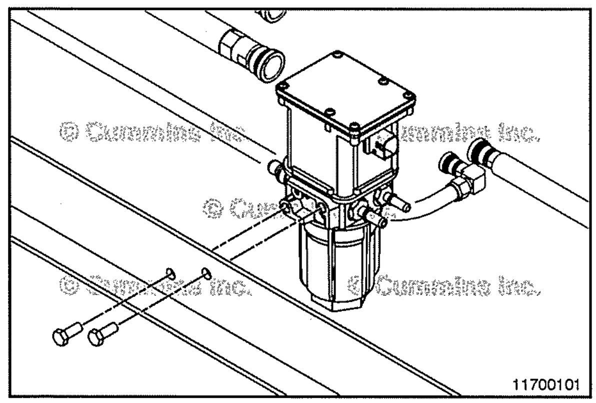
- Cap the DEF and electrical connectors of the aftertreatment DEF dosing unit to prevent contamination and DEF leakage.



Remove

Remove the two mounting capscrews.

Remove the aftertreatment DEF dosing unit.



Disassemble

NOTE: The aftertreatment DEF dosing unit should **only** be disassembled if a symptom has been identified that indicates further investigation is required.

Remove the DEF connector(s). Make sure the o-ring(s) are attached to the connector(s) and are **not** stuck inside the DEF dosing unit.

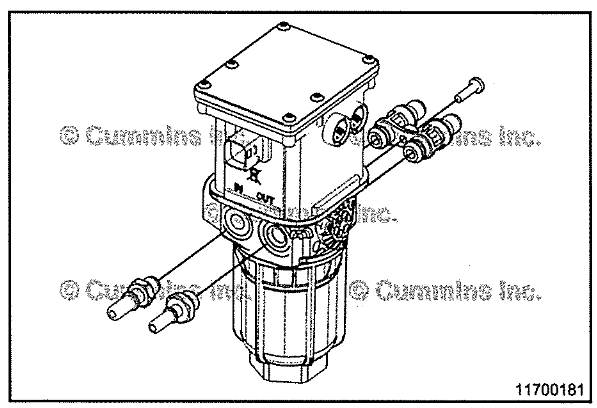
Remove the inlet (gray) DEF connector and inspect for debris. Use a M5 screw. While turning **clockwise** pull to remove the inlet connector screen filter from the pump housing.

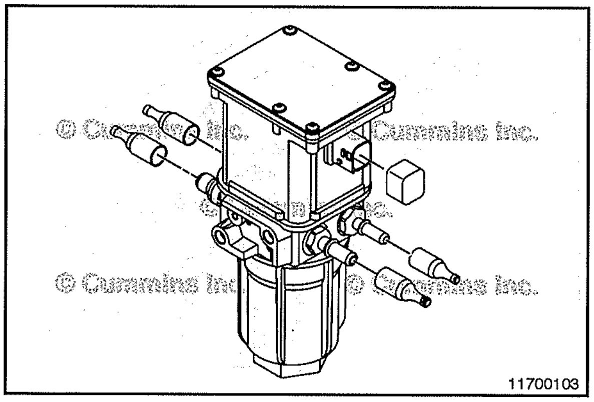
Discard the inlet screen.

Remove the outlet (silver) DEF connector.

Remove the screw of the coolant connector.

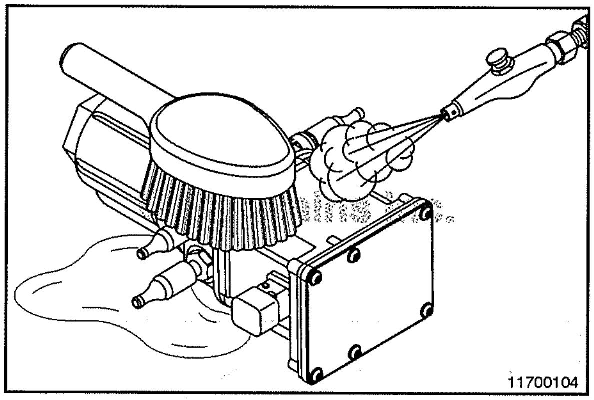
Remove the coolant connectors. The coolant connector is a one-piece assembly.





Clean and Inspect for Reuse

Install protective caps on the fluid connector(s) and the electrical connector on the aftertreatment DEF dosing unit.



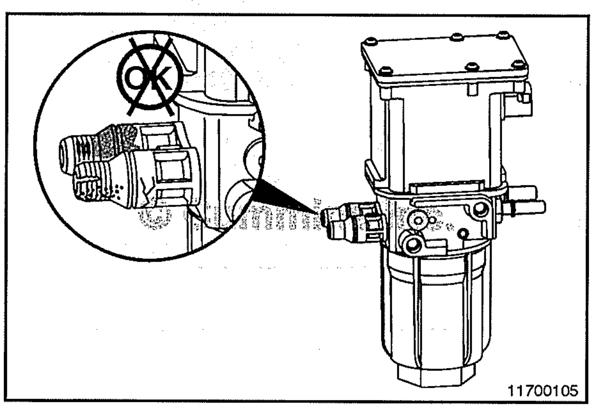
WARNING

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

NOTE: This unit is **not** serviceable. Do not open the case.

Clean the aftertreatment DEF dosing unit using **only** warm water and a soft bristled brush.

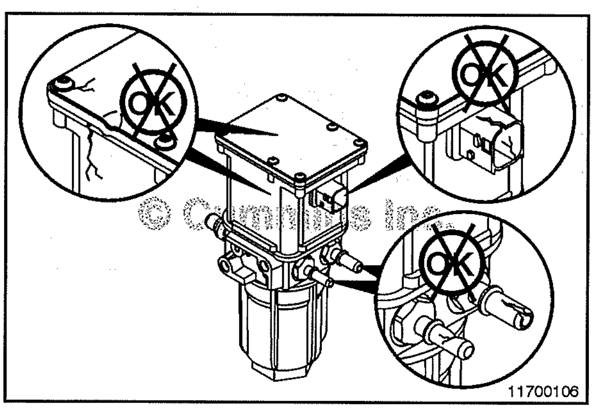
Thoroughly clean the areas surrounding the inlet connector, outlet connector, and main filter cap.



If corrosion is found, the coolant can be contaminated and/or the concentration incorrect. Check the coolant. For specifications, refer to service bulletin, Cummins® Coolant Requirements and Maintenance, Bulletin 3666132.

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

If the pitting and/or corrosion can **not** be removed with the abrasive pad, replace the coolant connector



Inspect the outside of the unit. If there are any cracks or other damage to the exterior of the case or electrical connectors, replace the dosing unit.

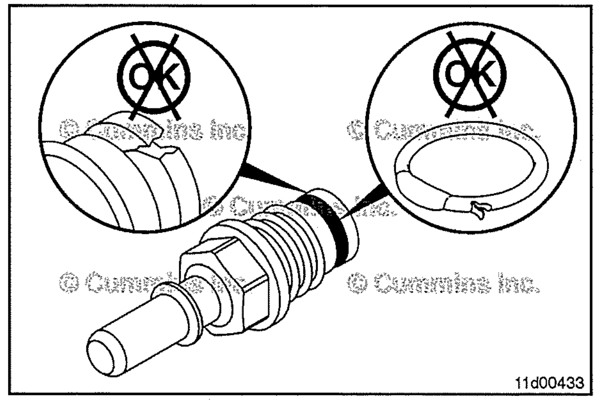
If there are any cracks or other damage to the DEF quick disconnect connectors, replace the DEF quick disconnect connectors.

Use the following procedure if the aftertreatment DEF dosing unit filter cap is damaged. Refer to Procedure 011-060 in Section 11.

Inspect the DEF line connection ports for cracks or pitting.

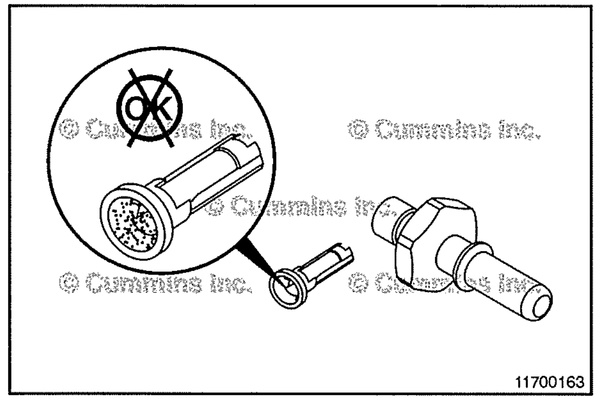
If the aftertreatment DEF dosing unit connectors were removed, inspect for cracks and broken o-rings.

Replace the aftertreatment DEF dosing unit connectors or o-rings, if damaged.



The DEF inlet connector on the aftertreatment DEF dosing unit has an incorporated serviceable filter screen.

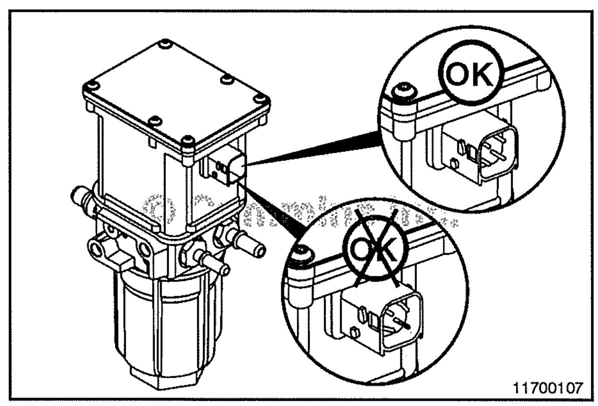
If debris is found in the inlet connector filter screen, inspect the aftertreatment DEF tank filter. See equipment manufacturer service information.

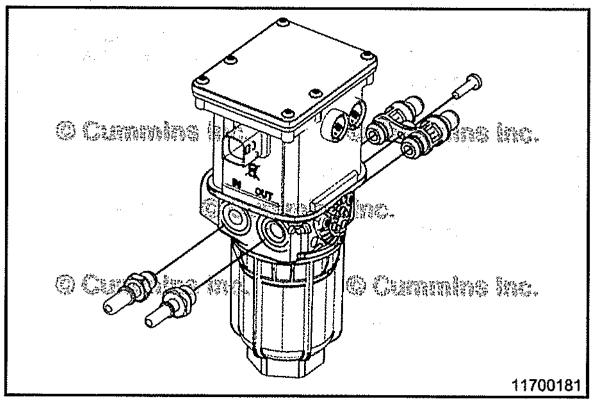


Inspect the electrical connection of the aftertreatment DEF dosing unit for signs of corrosion and debris buildup.

If the pins are heavily corroded or damaged, replace the aftertreatment dosing unit.

If the electrical connector on the aftertreatment DEF dosing unit is damaged, also inspect the 4-pin electrical connector wiring harness. See equipment manufacturer service informaion.





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Assemble

NOTE: The inlet and outlet connectors are **not** interchangeable and can **only** be installed one way due to thread and length restraints.

Install a new DEF inlet screen filter.

Install a new DEF inlet connector (grey).

Torque Value: 14 N•m [124 in-lb]

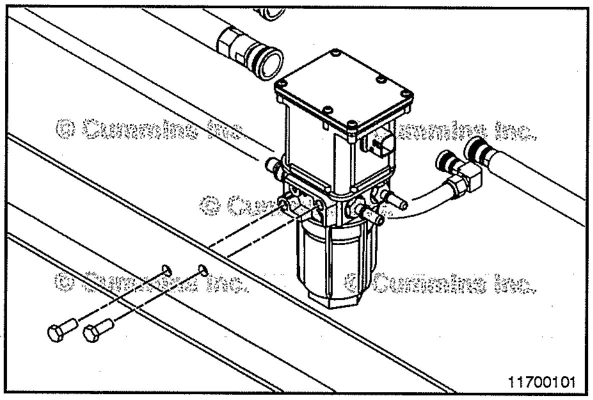
Install a new DEF outlet connector (silver).

Torque Value: 20 N•m [177 in-lb]

Install the coolant connectors.

Push the coolant connectors into the cavities. Tighten the coolant fittings capscrew.

Torque Value: 6 N•m [53 in-lb]



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Install

NOTE: Make sure the aftertreatment DEF dosing unit remains free from contamination during installation to the vehicle. To reduce the possibility of false DEF leak reports, use a clean, damp cloth to wipe away any DEF that spilled during the repair process.

Attach the aftertreatment DEF dosing unit to the original equipment manufacturer (OEM) mounting bracket and secure with the two capscrews.

Torque Value: 18 N•m [159 in-lb]

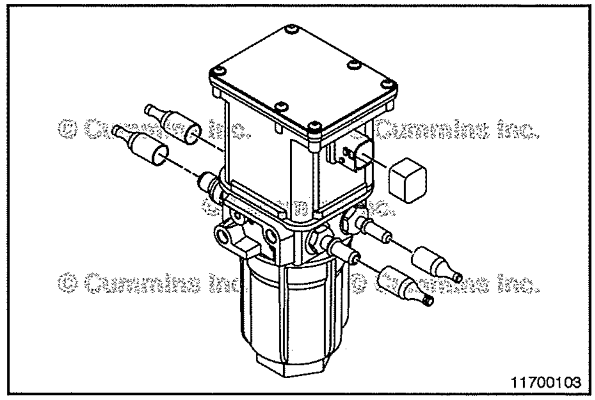
NOTE: DEF forms a white residue when allowed to dry. This residue can prevent proper sealing of the fittings when the DEF line is re-installed. Before making the DEF line connection:

- Dissolve DEF residue off the DEF line fittings with distilled water.
- Inspect the DEF line fitting o-rings for cuts or damage. Replace the DEF lines if there are any damage to the o-rings.
- Lubricate the DEF line fittings with a drop of synthetic grease such as Super Lube®.
- Remove the caps from the electrical and DEF connectors.
- Connect the DEF lines to the aftertreatment DEF dosing unit in the following order to reduce the possibility of contamination of the electrical connector. The DEF lines will snap when locked into place.

1 Inlet: DEF supply to the aftertreatment DEF dosing unit.
2 Outlet: DEF supply to the aftertreatment DEF dosing valve.
3 Coolant connectors.

- Install the electrical connector first. DEF will cause the electrical connector pins to corrode.
- The 4-pin electrical connector can be installed by sliding the yellow portion of the connector inward. The connector will lower and lock onto the aftertreatment DEF dosing unit.

Lightly tug on the connectors to make sure they are secured.

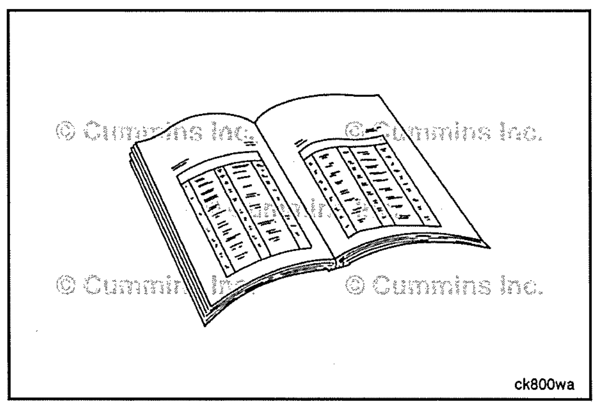


Finishing Steps

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.

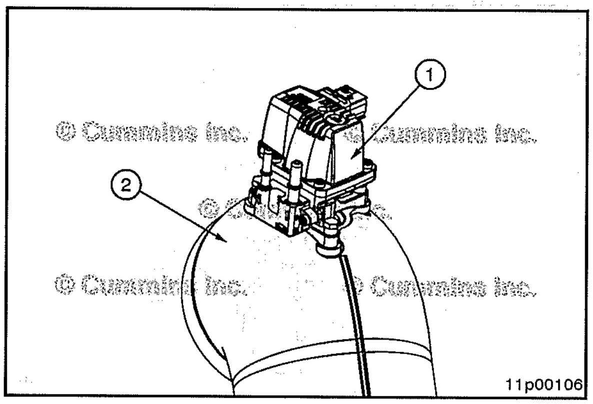
CAUTION
Do not use the flow test portion of INSITE™ electronic service tool DEF Doser Pump Override Test to check the system for leaks. This will spray DEF into the exhaust system which is at a temperature too low to evaporate, resulting in deposit formations in the exhaust system.

- Fill the engine with coolant. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. See equipment manufacturer service informaion.
- Operate the engine and check for leaks.

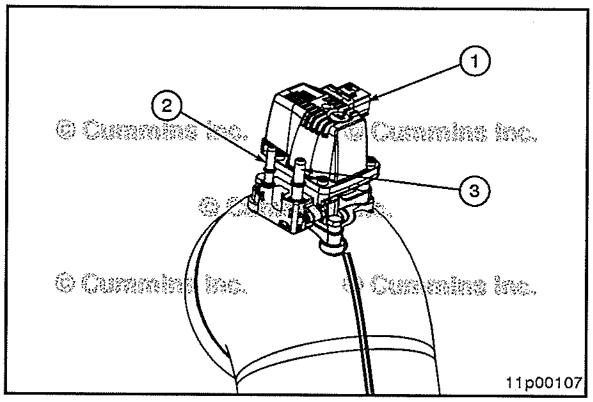


Aftertreatment Diesel Exhaust Fluid Dosing Valve (011-059)

General Information

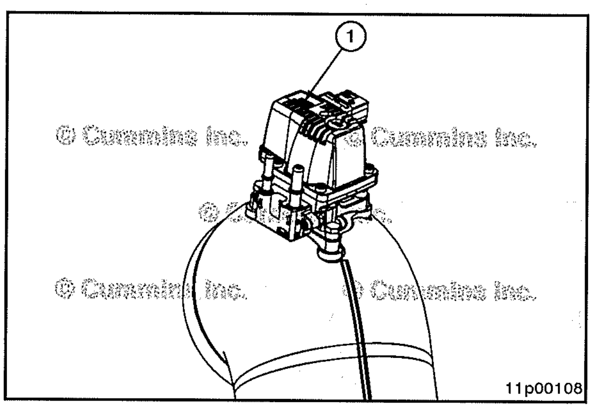


The aftertreatment DEF dosing valve (1) is used to spray diesel exhaust fluid (DEF) into the exhaust flow. The aftertreatment DEF dosing valve is located on the aftertreatment decomposition tube (2).



There are three primary connections on the aftertreatment DEF dosing valve.

1 8 pin electrical connection
2 DEF supply line which connects the aftertreatment dosing valve to the aftertreatment DEF dosing unit
3 DEF return line which connects the aftertreatment dosing valve to the aftertreatment DEF tank.

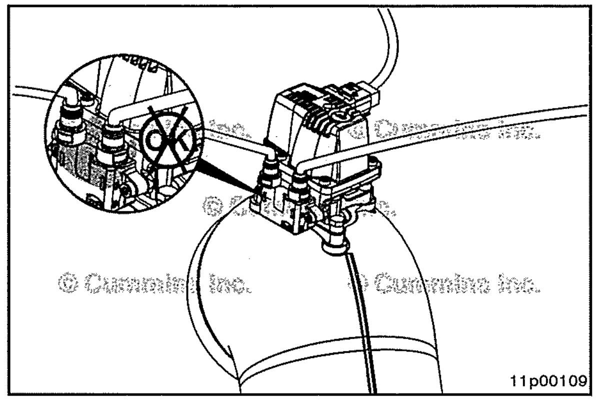


There are two different types of dosing valves, 12V and 24V, depending on the application. Check to make sure the correct part number (1) is used. The connections are the same between the two different dosing valves.

For further information on the operation of the aftertreatment DEF dosing valve. Refer to Procedure 011-999 in Section F.

For information on handling incorrect or contaminated DEF. Refer to Procedure 011-056 in Section 11.

Initial Check



CAUTION

Do not use the flow test portion of INSITE™ electronic service tool DEF Doser Pump Override Test to check the system for leaks. This will spray DEF into the exhaust system at temperatures too low to evaporate, resulting in deposit formations in the exhaust system.

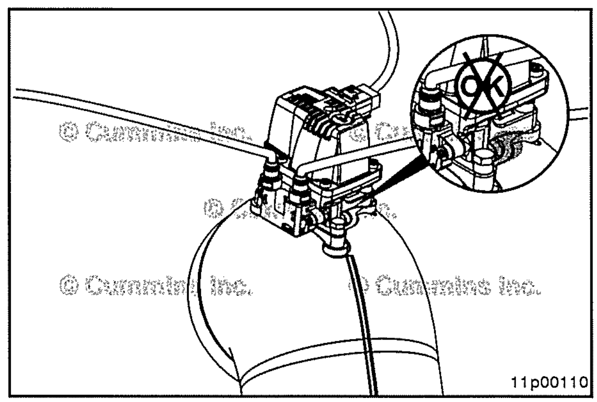
NOTE: DEF deposits could possibly be left over from a previous DEF spill or repair. Verify active leaks before replacing any components.

Inspect the area around the DEF line connection location at the aftertreatment DEF dosing valve.

Inspect for signs of leaks and/or white deposits.

Due to deposit buildups possibly masking the source of the leak, it can be necessary to remove the deposits and clean the area with warm water.

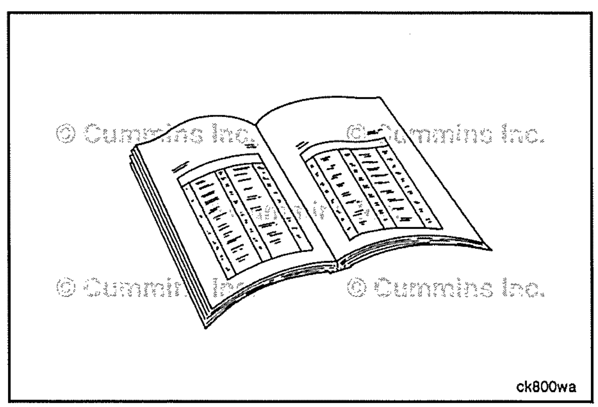
Once the source of the DEF leaks and/or deposits are identified, see the Clean and Inspect for Reuse section of this procedure.



Inspect the body and around the base of the aftertreatment DEF dosing valve. Check for signs of exhaust leaks and white deposits.

If leaks and/or deposits are identified, see the Clean and Inspect for Reuse section of this procedure.

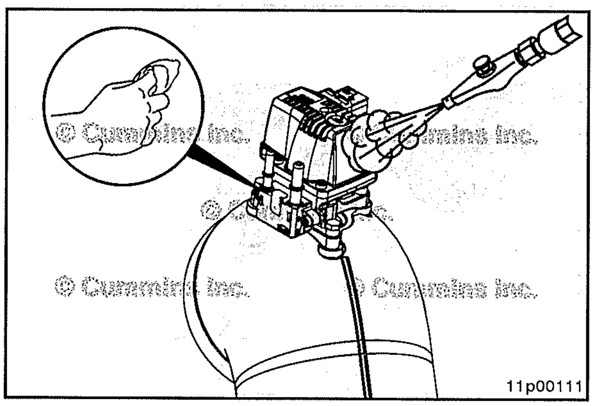
Preparatory Steps



WARNING

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

- Disconnect the batteries. See equipment manufacturer service information.



⚠WARNING⚠

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

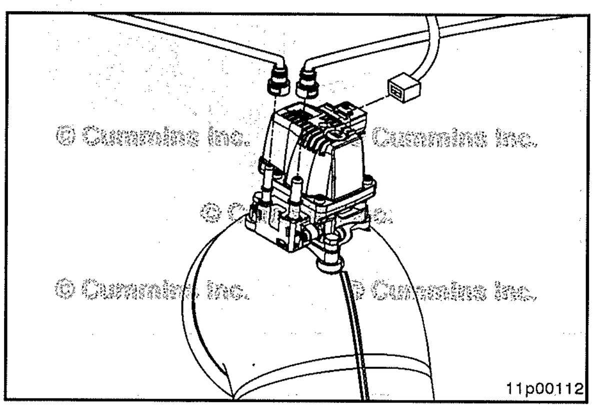
⚠WARNING⚠

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.

Use compressed air to remove any debris from around the aftertreatment DEF dosing valve and connections.

Remove any debris trapped in the gaps between the aftertreatment DEF dosing valve and the mounting face on the aftertreatment decomposition tube, so that debris does **not** fall into the decomposition chamber upon removal of the aftertreatment DEF dosing valve.

If there are any white deposits on the DEF line connection, remove them by wiping with a clean shop towel soaked in warm water.



⚠WARNING⚠

The diesel exhaust fluid (DEF) line connecting the aftertreatment diesel exhaust fluid dosing unit to the aftertreatment diesel exhaust fluid 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.

⚠CAUTION⚠

Care should be taken when handling and/or disconnecting the DEF line from the aftertreatment DEF dosing valve. The DEF supply line connector of the aftertreatment DEF dosing valve can be easily damaged.

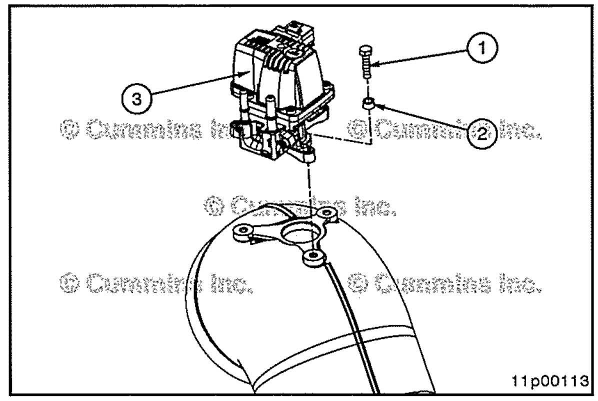
Disconnect the connections at the aftertreatment DEF dosing valve in the following order:

Place a small plastic container under the aftertreatment DEF dosing valve to catch any residual DEF prior to disconnecting the DEF supply line.

1. Disconnect the DEF line. See equipment manufacturer service information.
2. Pull the yellow locking tab on the connector to disconnect the aftertreatment wiring harness from the dosing valve.

After the electrical connection is disconnected, cover the connection on the aftertreatment DEF dosing valve with electrical tape to prevent DEF from getting into the electrical connection.

Remove

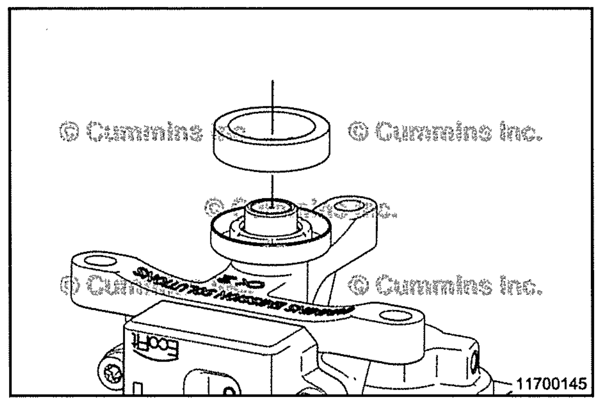


⚠CAUTION⚠
Do not set the aftertreatment DEF dosing valve down on the spray area of the aftertreatment DEF dosing valve. Damage can occur.

- Remove capscrews (1).
- Remove spacers (2).
- Remove aftertreatment DEF dosing valve (3).

NOTE: A small amount of DEF deposits is normal if observed on the aftertreatment DEF dosing valve face and around the isolator of the aftertreatment DEF dosing valve.

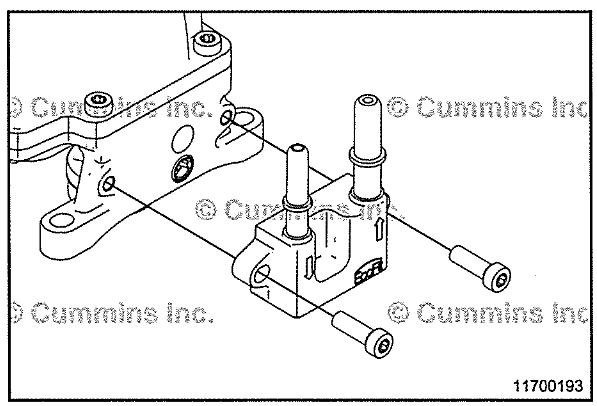
Plug the aftertreatment DEF lines with plugs from Aftertreatment Clean Care Kit, Part Number 5299193, to reduce the possibility of debris entering the system.



Use a pick to carefully remove the dosing valve nozzle gasket.

Discard the gasket.

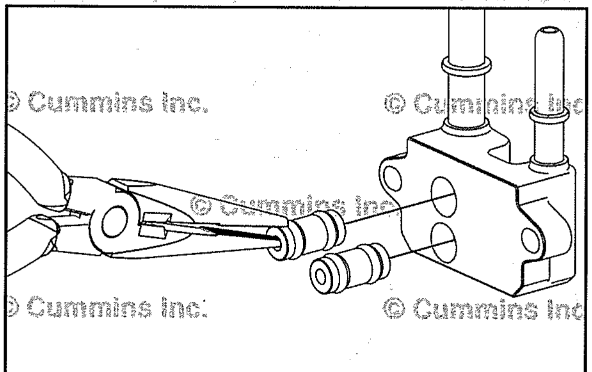
Disassemble



⚠CAUTION⚠
A small amount of dirt and debris can be very harmful to the DEF dosing system. Dirt or other foreign objects must not get into the DEF dosing valve.

Use a T-25 Torx™ socket drive to remove the capscrews from the dosing valve connector manifold.

Discard the capscrews.



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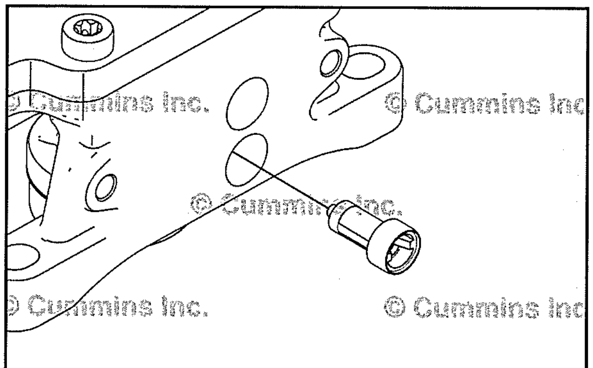
Remove the connector cylinders with needle nose pliers.

Discard the connector cylinders.



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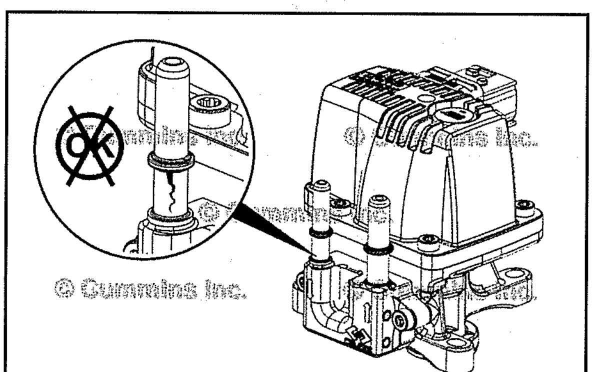
Use a pick to remove the filter from the dosing valve connector manifold.

Discard the filter.



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Clean and Inspect for Reuse

NOTE: Do **not** remove any component from the dosing valve other than the dosing valve nozzle gasket. The dosing valve is **not** a serviceable part.

If leaks/deposits are found at the DEF dosing valve joints between the valve and the valve assembly body during the Initial Check section of this procedure, replace the aftertreatment DEF dosing valve.

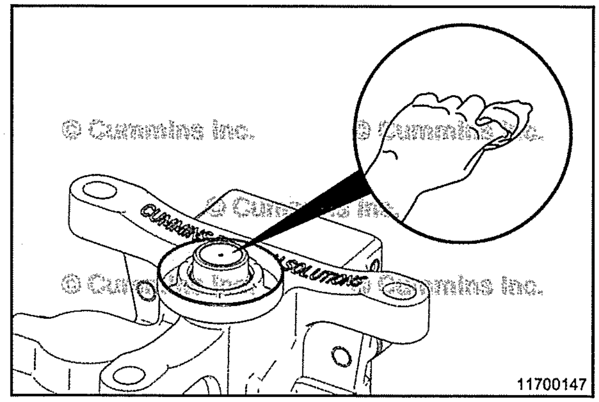
If leaks/deposits are found at the DEF line connection during the Initial Check section of this procedure, inspect the DEF line connection port for cracks or pitting.

If damage/corrosion is found, also inspect the DEF line connection. See equipment manufacturer service information.

Inspect the electrical connection and pins for damage/ corrosion. Refer to Procedure 019-361 in Section 19.

If damage/corrosion is found, inspect the electrical connector and pins on the vehicle harness. See equipment manufacturer service information.

Replace the aftertreatment DEF dosing valve if damage is found.



CAUTION

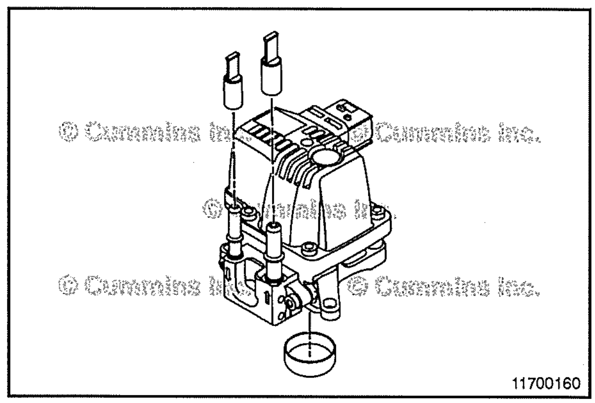
Use only warm water to clean the tip of the aftertreatment DEF dosing valve. The use of a wire wheel or brass brush or any other abrasive medium will cause permanent damage to the aftertreatment DEF dosing valve.

Use a clean shop cloth soaked in warm water to dissolve and wipe DEF deposits away on the dosing valve tip.

Inspect the dosing valve tip for cracks or other damage. Replace if damage is found.

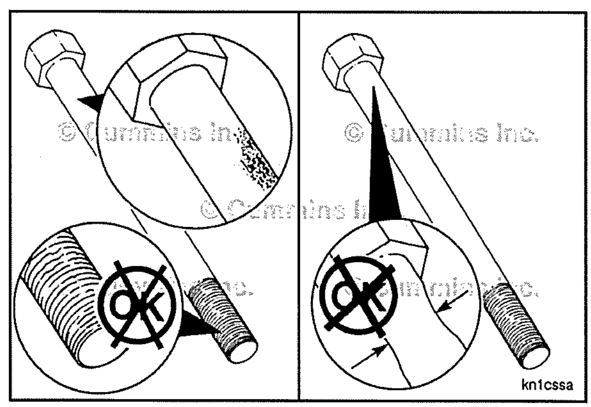
If leaks/deposits are found at the base of the aftertreatment DEF dosing valve during the Initial Check section of this procedure, inspect the following:

- The bottom of the aftertreatment DEF dosing valve around the gasket sealing surface for signs of heavy corrosion, pitting, and/or surface damage. Replace the aftertreatment DEF dosing valve if damage is found.
- The aftertreatment DEF dosing valve mounting surface on the decomposition chamber.



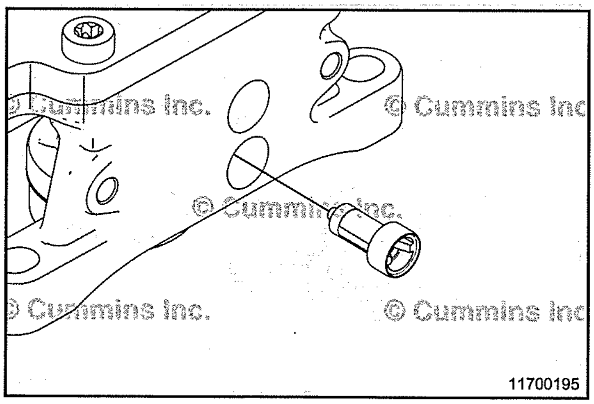
If replacing the aftertreatment DEF dosing valve, make sure to transfer the protective caps from the replacement aftertreatment DEF dosing valve to the old aftertreatment DEF dosing valve prior to putting it in the core return box.

Make sure to fill out any requested information (engine serial number (ESN), hours, and vehicle identification number (VIN)).



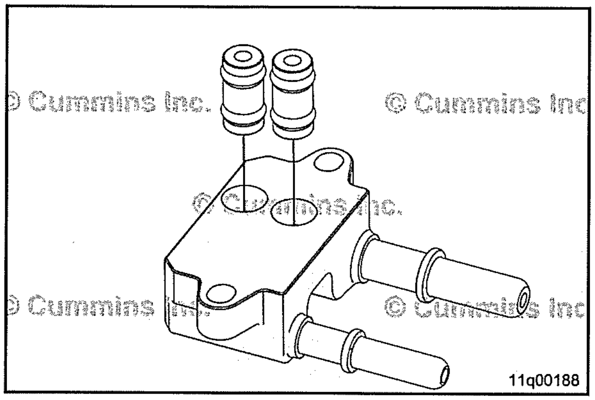
Inspect the capscrews for damaged threads or corroded surfaces.

Replace if damage is found.



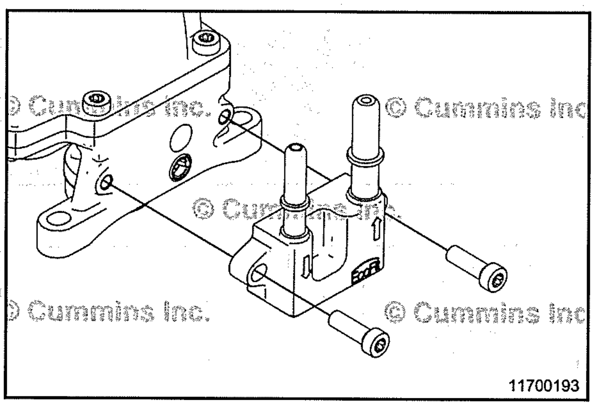
Assemble

Install a new dosing valve filter in the bottom hole of the valve assembly. The filter will **only** fit in bottom hole.



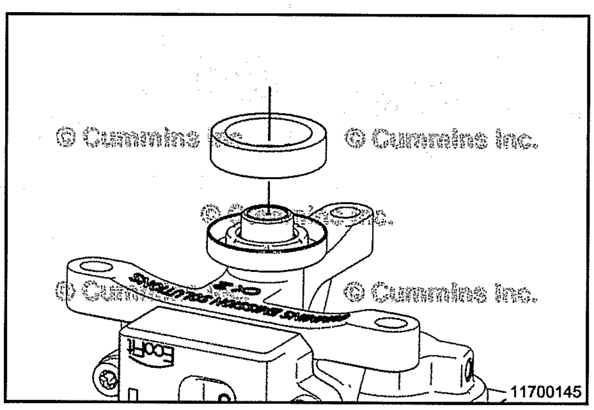
Apply synthetic grease onto the o-rings.

Install new connector cylinders into the connector manifold. Make sure to push the cylinders until they contact the bottom of the connector manifold. The cylinders are identical and can go in either hole.



Install the connector manifold onto the dosing valve assembly using two new Torx™ capscrews.

Torque Value: 8 N•m [71 in-lb]



Install

Install a new dosing valve nozzle gasket onto the doser tip.

Remove any protective caps.

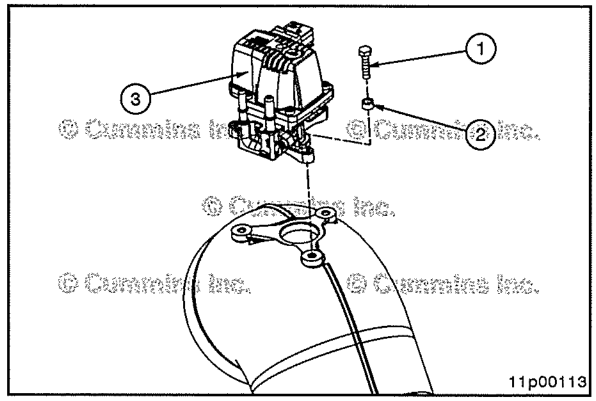
Make sure the aftertreatment DEF dosing valve spray port is free of debris.

Apply a coat of high temperature anti-seize compound to the threads of the aftertreatment DEF dosing valve mounting capscrews.

Use the following steps to install the dosing valve.

- Install dosing valve (3).
- Install spacers (2),
- Install capscrews (1)

Torque Value: 10 N•m [89 in-lb]



Finishing Steps

⚠CAUTION⚠

Do not use the flow test portion of INSITE™ electronic service tool Diesel Exhaust Fluid Doser Pump Override Test to check the system for leaks. This will spray DEF into the exhaust system at temperatures too low to evaporate, resulting in deposit formations in the exhaust system.

Remove any protective caps and/or covers from the electrical, coolant, and DEF ports just prior to making the connection.

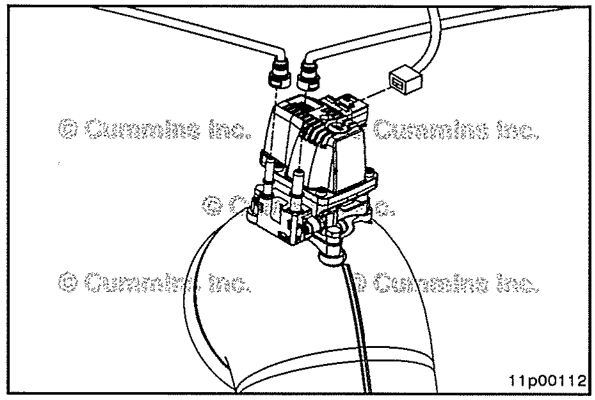
1 Slide the 8 pin electrical connector onto the dosing valve and secure it with the yellow locking tab.

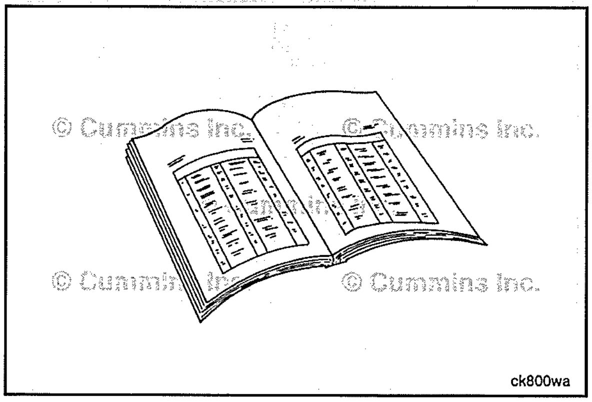
2 Connect the DEF line. See equipment manufacturer service information.

NOTE: DEF forms a white residue when allowed to dry. This residue can prevent proper sealing of the fittings when the DEF line is installed. Before making the DEF line connection:

- Dissolve DEF residue off the DEF line fittings with distilled water.
- Inspect the DEF line fitting o-rings for cuts or damage. Replace the DEF lines if there is any damage to the o-rings.
- Lubricate the DEF line fittings with a drop of synthetic grease.

Once all connections are made, give each a slight pull to make sure they are securely installed.



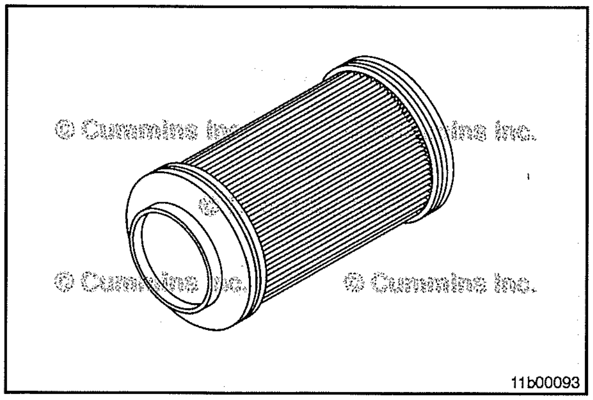


ck800wa

WARNING

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



11b00093

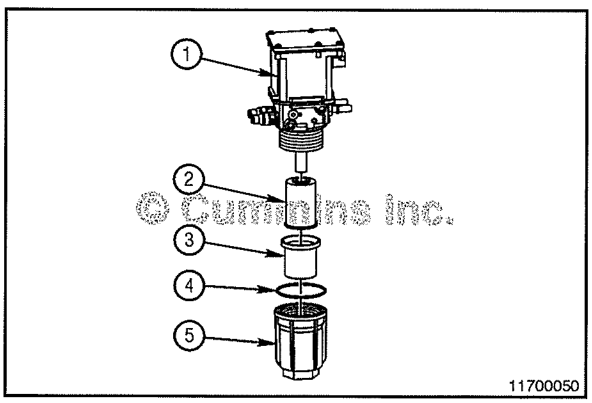
Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter (011-060)

General Information

The aftertreatment 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 malfunction to either the aftertreatment DEF dosing unit or the aftertreatment DEF dosing valve. The aftertreatment DEF dosing unit filter is a maintenance item.

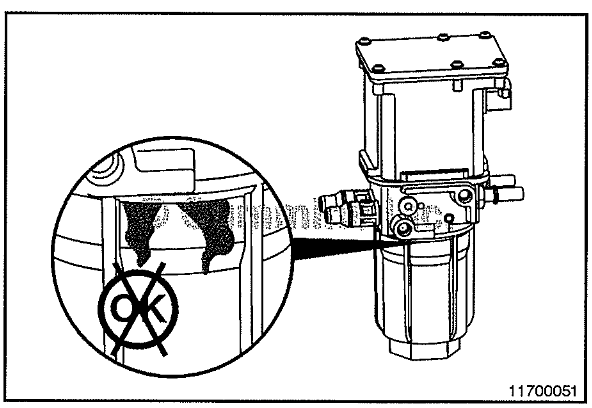
For handling incorrect or contaminated DEF, contact a Cummins® Authorized Repair Location.



11700050

The aftertreatment DEF dosing unit consists of the following components:

1. Aftertreatment DEF dosing unit
2. Aftertreatment DEF dosing unit element
3. Aftertreatment DEF dosing unit frost protection membrane
4. Aftertreatment DEF dosing unit filter o-ring
5. Aftertreatment DEF dosing unit filter housing.



11700051

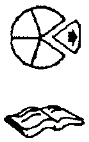
Initial Check

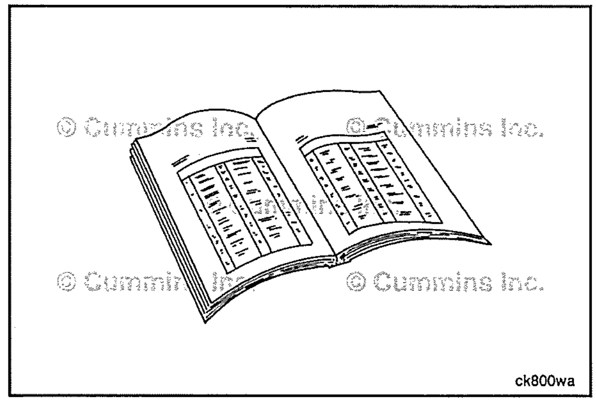
Locate the aftertreatment DEF dosing unit on the vehicle. Inspect the black plastic filter housing.

Inspect the area around the seal and filter housing for signs of leakage.

DEF leaks leave a white deposit. If deposits are found, see the Clean and Inspect for Reuse section of 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 diesel exhaust fluid dosing unit to the aftertreatment diesel exhaust fluid 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.

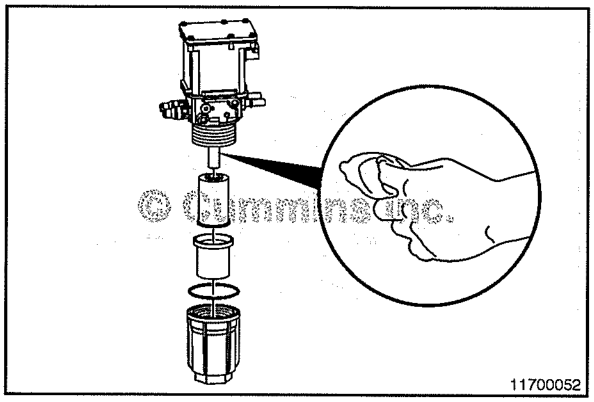
⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

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

- Disconnect the batteries. See equipment manufacturer service information.

NOTE: The dosing unit around the filter housing **must** be cleaned using a clean damp cloth, warm water, and a mild detergent.

- Use a clean damp cloth to remove any contamination, to reduce the risk of contaminants entering the DEF dosing unit.



Remove

⚠CAUTION⚠

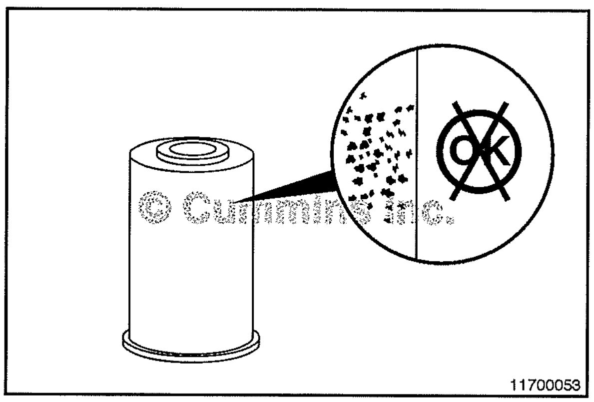
A small amount of dirt and debris can be very harmful to the DEF dosing system. Dirt or other foreign objects must not get into the DEF dosing unit.

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

- Use a 46 mm socket to remove the DEF filter housing.
- Remove and discard the o-ring.

NOTE: In the next step, the frost protection membrane will be removed. A small amount of DEF could leak.

- Remove the frost protection membrane and inspect. A small amount of DEF could leak out of it.
- Remove the filter element from the unit by twisting, while pulling. Absorb the dripping DEF with a dry clean lint-free cloth and dry the unit.
- Discard the o-ring, frost protection membrane, and filter element.



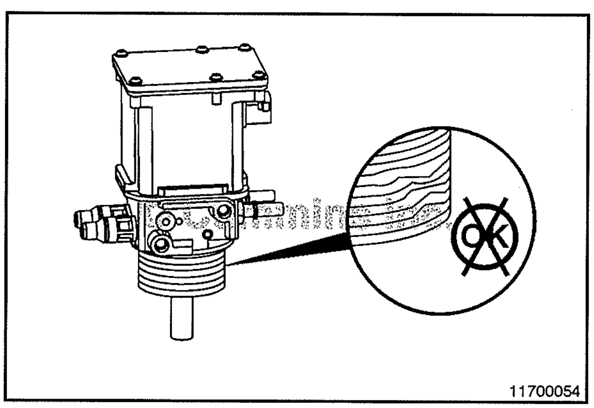
If there is the possibility that contaminated DEF has gone through the DEF dosing system, check the DEF filter prior to discarding it.

Check the diesel exhaust filter for evidence of contaminated DEF. Use visual and aroma characteristics of the filter to determine if contaminated fluid has passed through the dosing system.

Use the following procedure for further information on contaminated DEF. Refer to Procedure 011-056 in Section 11.

Inspect the DEF filter for debris. If debris is evident, also check:

- DEF tank filter. See equipment manufacturer service information.
- The aftertreatment DEF dosing unit inlet connector. Refer to Procedure 011-058 in Section 11.



Clean and Inspect for Reuse

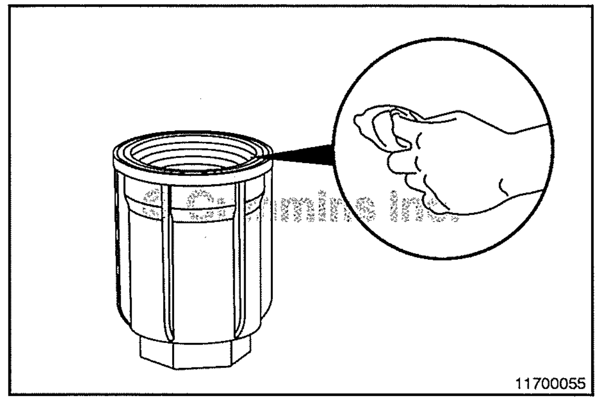
Inspect the aftertreatment DEF dosing unit threads. This is especially important if the aftertreatment DEF dosing unit cap was damaged.

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

Be sure the frost protection membrane groove is clean and free of debris. Clean using a clean damp cloth, warm water, and a mild detergent.

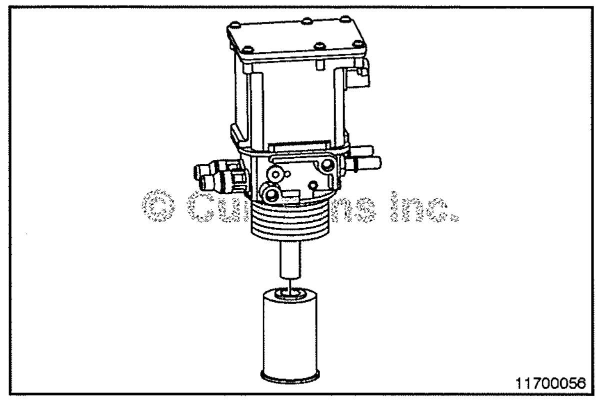
NOTE: Never operate the vehicle with the DEF filter or filter housing removed.

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



Install

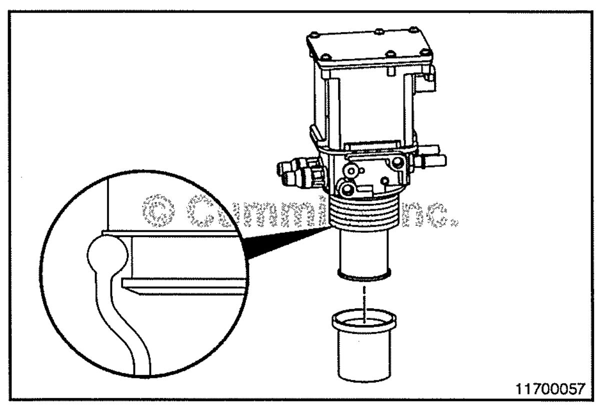
Slide the filter element onto the DEF dosing unit. Push up on the filter to make sure it is fully seated.



Slide the filter element onto the DEF dosing unit and make sure it is seated.

Put the frost membrane over the filter element.

NOTE: The sealing bead of the frost protection membrane **must** sit completely in the groove of the pump housing.



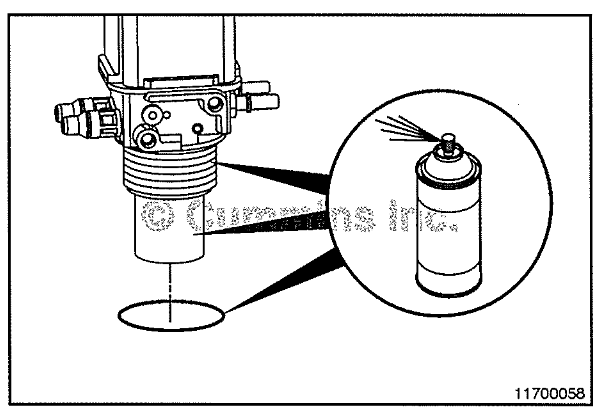
NOTE: The provided lubricant **must** be used when installing the filter housing.

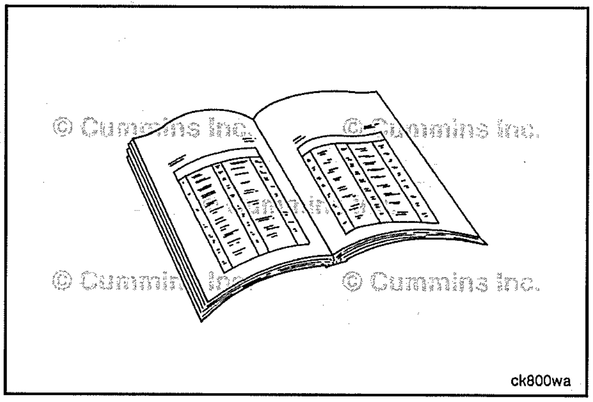
Spray the threads on the pump housing and sealing bead of the frost protection membrane with Bio Lube

Put the o-ring into the groove on the filter housing. The groove **must** be free of dirt and foreign particle.

Install and tighten the filter housing with a socket.

Torque Value: 80 N•m [59 ft-lb]





Finishing Steps

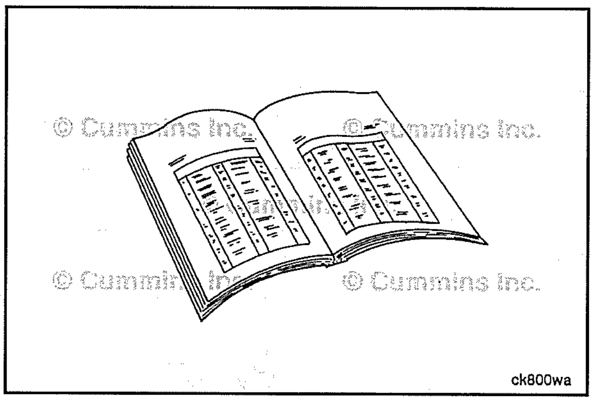
WARNING

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.

CAUTION

Do not use the flow test portion of the INSITE™ electronic service tool Diesel Exhaust Fluid Doser Pump Override Test to check the system for leaks. This will spray diesel exhaust fluid into the exhaust system at to low of temperatures to evaporate, resulting in deposit formations in the exhaust system.

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

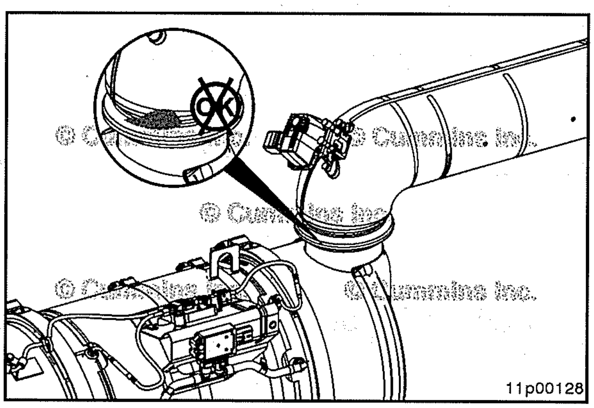


Aftertreatment Decomposition Tube (011-062)

General Information

Different vehicles require different aftertreatment configurations.

Refer to Procedure 011-999 in Section F for more information.

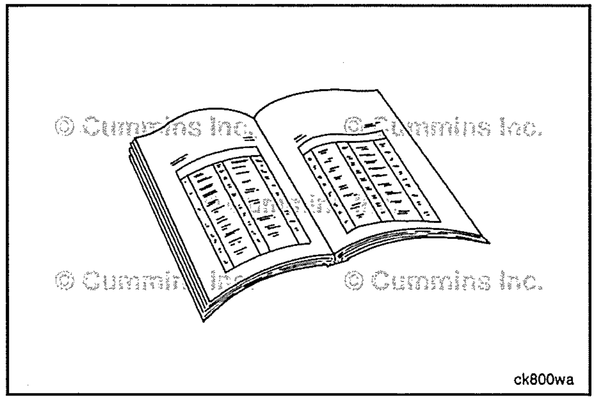


Initial Check

Inspect the joints for exhaust or diesel exhaust fluid (DEF) leaks.

If leaks are found, see the Clean and Inspect for Reuse section of this procedure.

Preparatory Steps


ck800wa

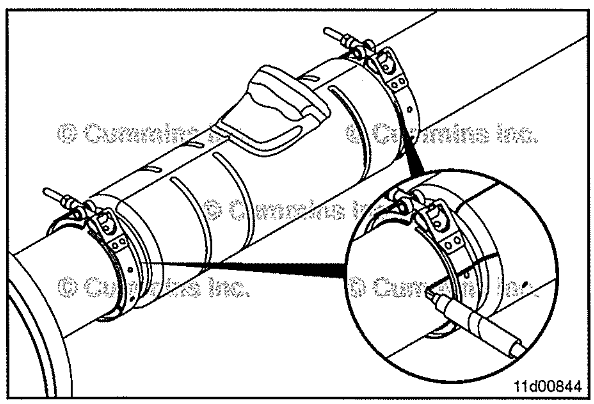
⚠WARNING⚠
During regeneration, exhaust gas temperature can reach 800 °C [1500°F], and exhaust system surface temperature can exceed 700 °C [1300°F], which is hot enough to ignite or melt common materials, and to burn people. The exhaust and exhaust components can remain hot after the vehicle has stopped 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.

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

⚠CAUTION⚠
The aftertreatment DEF dosing valve is a fragile item. Use great care when handling this part. Avoid putting stresses on the fluid connectors as damage to the component may result.

- Clean with compressed air.
- Disconnect the aftertreatment DEF dosing valve electrical connector, coolant lines, and DEF line. Refer to Procedure 011-059 in Section 11.

Remove


11d00844

⚠CAUTION⚠
Do not use an air tool to remove the V-band clamp nut. An air tool will damage the threads. Apply thread lubricant to the V-band clamp threads prior to nut removal.

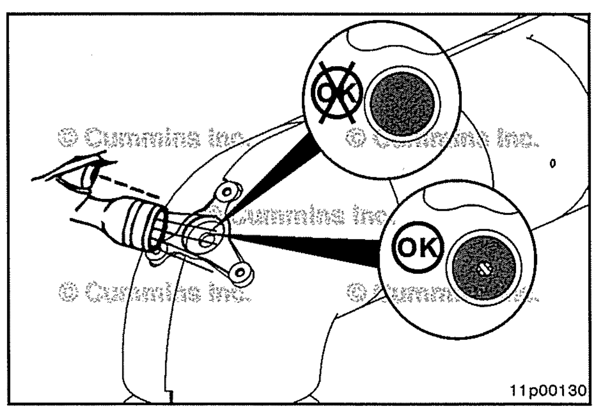
Mark the orientation.

Remove the exhaust clamps from the aftertreatment decomposition tube.

Remove the aftertreatment decomposition tube.

Discard the gaskets.

Clean and Inspect for Reuse



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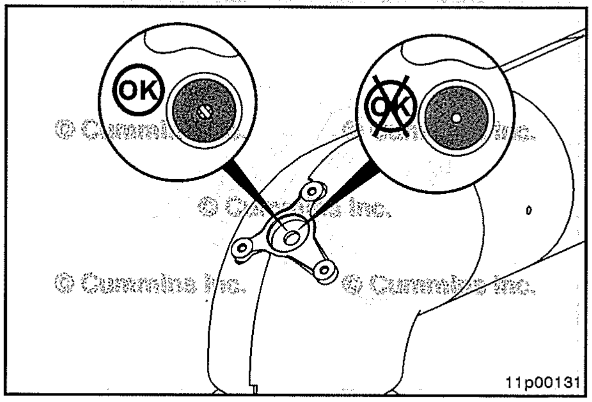
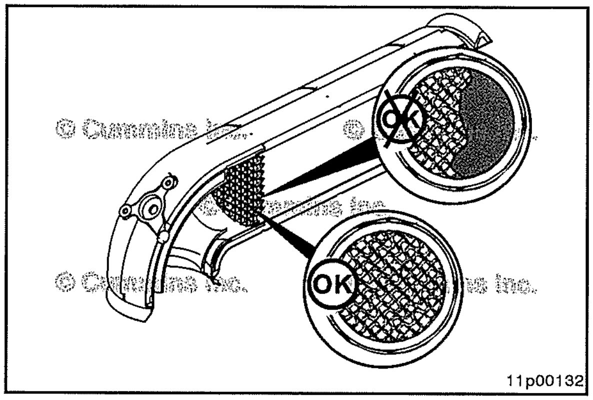
NOTE: If fault codes indicated to check for DEF deposits, clean the decomposition tube regardless of the steps below.

Remove the aftertreatment DEF dosing valve. Refer to Procedure 011-059 in Section 11.

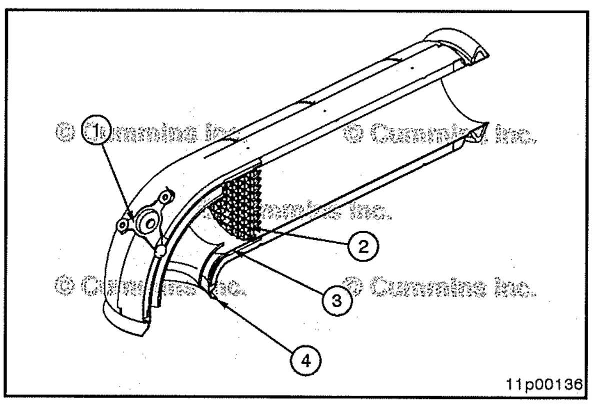
Inspect the spray port for blockages.



Inspect the spray chamber for blockages. Three holes in deposit formation are common. Make sure the DEF has a free flow path.

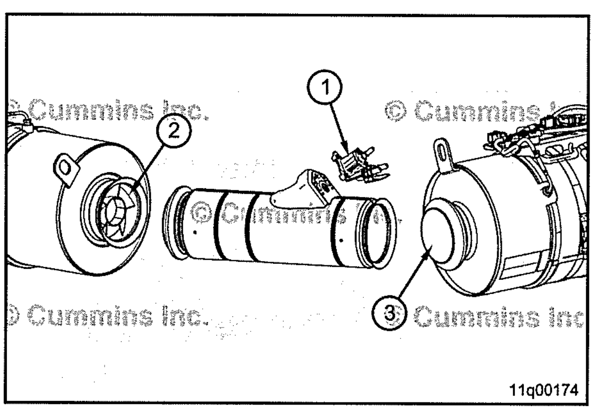


Inspect the aftertreatment decomposition tube for tears or damage. Inspect for more than 50 percent blockage by DEF deposits.



Inspect the aftertreatment dosing valve mount, mixer, insulation, and welded joints for tears or other damage.

Light surface corrosion or rust is common. Clean with an abrasive pad.



If the DEF deposits are blocking free flow:

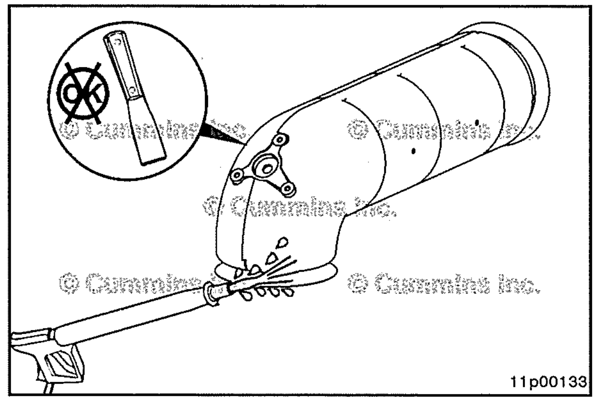
- Inspect the aftertreatment dosing valve (1). Refer to Procedure 011-059 in Section 11.
- Inspect the selective catalytic reduction catalyst inlet. (2) Refer to Procedure 011-036 in Section 11.
- Inspect the diesel particulate filter outlet (3). Refer to Procedure 011-041 in Section 11.
- Inspect the exhaust pipe connected to the decomposition tube.

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

CAUTION
Do not use a metallic object to clean the aftertreatment decomposition tube. This will scratch the surface of the aftertreatment decomposition tube which may cause future excessive DEF deposits.

Remove deposits. Use a non-metallic object and high-pressure water. Do **not** submerge. Do **not** use solvents.

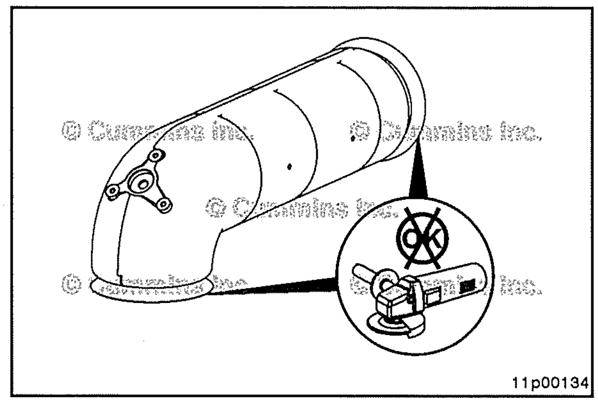
Some small deposits remaining is common.



Inspect the exhaust flanges for corrosion or other damage.

Use an abrasive pad to remove any residual gasket material.

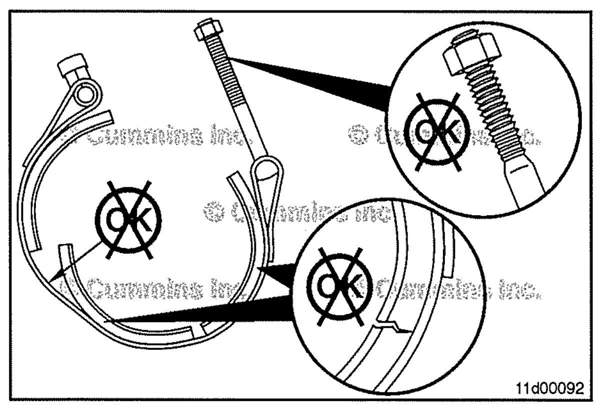
Do **not** grind on the flange surface.



Inspect the V-band clamps and mounting straps for signs of over-extension.

The band **must not** be bent or damaged.

Inspect the V-band clamp and mounting strap threads for damage.

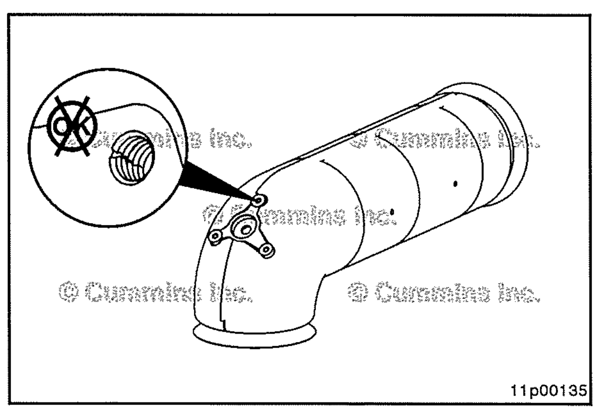


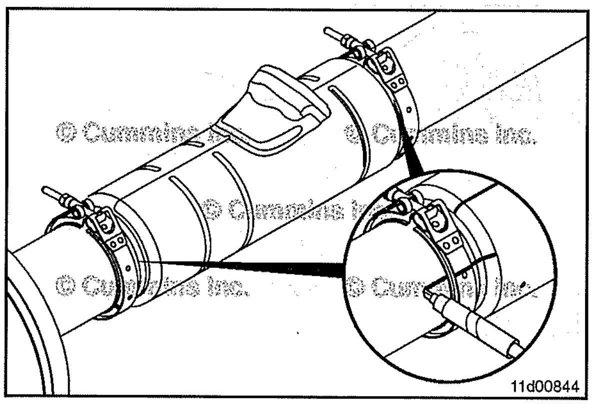
CAUTION
Do not use a metallic object to clean the aftertreatment decomposition tube dosing valve mounting area. Damage to the gasket/isolator sealing surface area can result.

Inspect the aftertreatment DEF dosing valve mounting area.

Clean with an abrasive pad and water.

Check the threaded capscrew holes for damaged threads. If threads are damaged, repair with M6 x 1 wire coil inserts.





Install

⚠CAUTION⚠

Do not use an air tool to tighten the V-band clamp. An air tool will damage the threads.

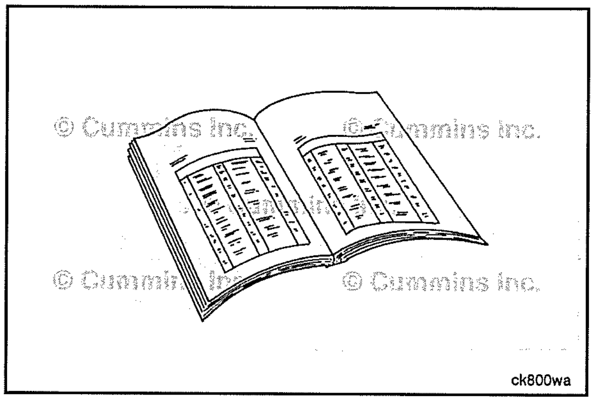
Install the aftertreatment DEF dosing valve. Refer to Procedure 011-059 in Section 11.

Install the aftertreatment decomposition tube. Use new gaskets. Align with the marked orientations.

Align the tube and clamps. Apply anti-seize to the clamp threads.

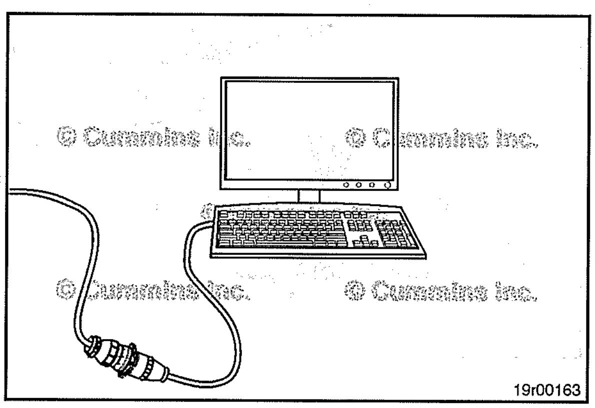
Install the clamps.

Torque Value: 14 N•m [124 in-lb]



Finishing Steps

- Connect the aftertreatment DEF dosing valve electrical connector, coolant lines, and DEF line. Refer to Procedure 011-059 in Section 11.
- Start the engine and check for leaks.
- If DEF deposits were removed, complete a stationary exhaust system cleaning. Refer to Procedure 014-015 in Section 14.



Aftertreatment Diesel Exhaust Fluid Dosing Unit Override Test (011-063)

General Information

The purpose of this test is to run the aftertreatment diesel exhaust fluid (DEF) dosing system through a dosing cycle and check the:

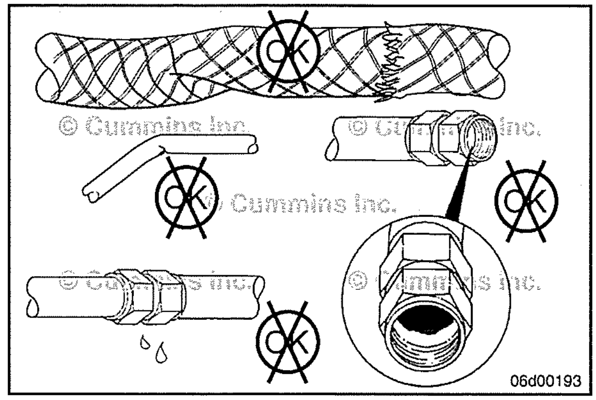
- Aftertreatment DEF dosing valve spray characteristics
- Amount of DEF delivered in a specified time (5 minutes).

The test can be accessed through INSITE™ electronic service tool under engine control module (ECM) Diagnostic Tests. Follow the on-screen instructions to perform the test.

Initial Check

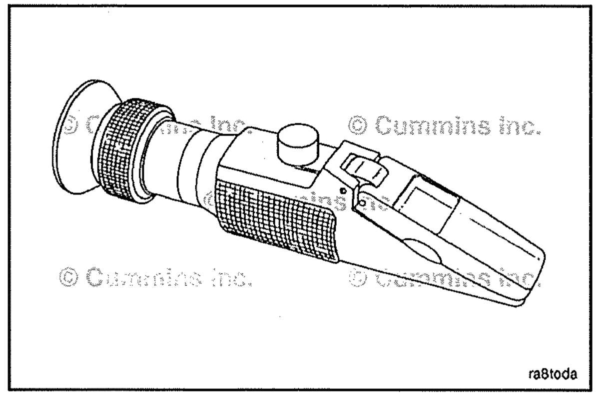
Check for any leaks, blockages, or restrictions in the DEF line between the aftertreatment DEF dosing unit and the aftertreatment DEF dosing valve.

Repair as necessary. See equipment manufacturer service information.



Check that there is an adequate amount of DEF in the DEF tank prior to starting this test.

Check the concentration and quality of the DEF. Refer to Procedure 011-056 in Section 11.



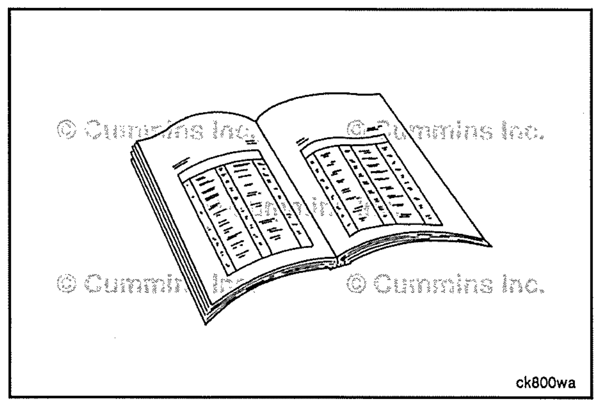
Preparatory Steps

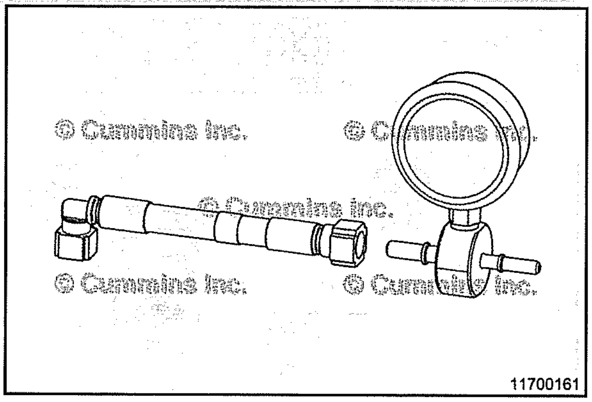
WARNING

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: Low battery voltage can cause the dosing volume to be low. Check the batteries. See equipment manufacturer service information.

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the aftertreatment DEF dosing valve. Refer to Procedure 011-059 in Section 11.





11700161

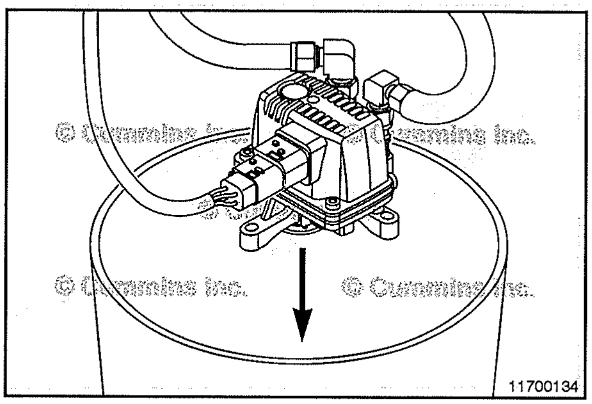
Setup

CAUTION

Care should be taken when handling and/or disconnecting the aftertreatment DEF line from the aftertreatment DEF dosing valve.

Install the Cummins® pressure gauge tool kit, Part Number 5299005, between the DEF pressure line and the DEF dosing valve inlet connector.

Connect the electrical connection to the DEF dosing valve.



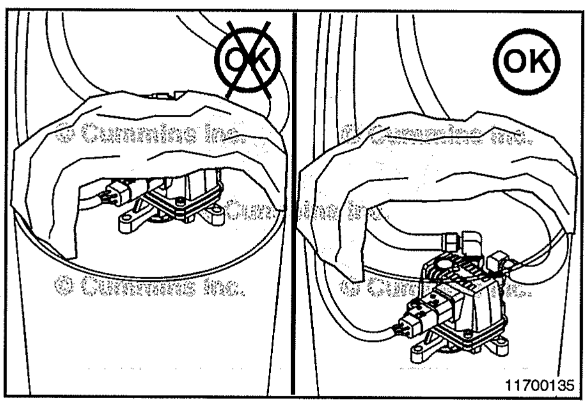
11700134

NOTE: It may be easier to capture the DEF in a clean container and transfer the DEF to the measuring device for the final measurement.

Obtain a clear plastic container (large enough to hold the aftertreatment DEF dosing valve) and a graduated beaker, Part Number 4919139, or equivalent. A measuring cup that is marked in milliliters (ml) or ounces (oz) can also be used.

The measuring device **must** be capable of measuring between 0 ml [0.0 oz] and 500 ml [17.0 oz] in 5 ml [0.34 oz] increments

Place the aftertreatment DEF dosing valve into the container.



11700135

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.

NOTE: When the test is started, the dosing system will first prime. This is a normal operating characteristic.

When the test is being performed, the aftertreatment DEF dosing valve will spray a very fine mist of DEF. To prevent fine mist from escaping into the air and to make sure of an accurate measurement, place a clean shop towel or cover over the valve and container.

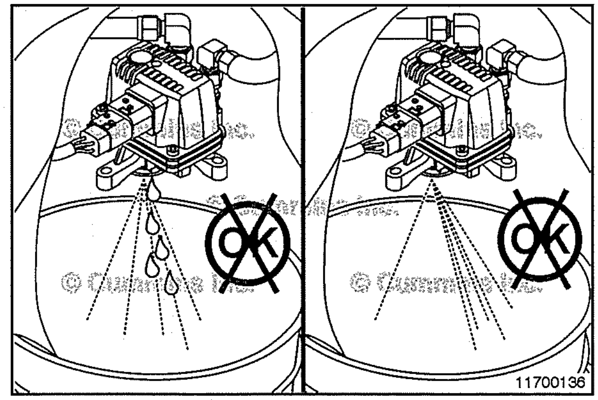
When the test begins, briefly monitor the spray pattern of the DEF exiting the aftertreatment DEF dosing valve. Check for:

- Signs of larger drops and/or dripping DEF from the tip.
- Spray pattern that is **not** symmetrical (sprays more to one side).

If either of these symptoms is noted, stop the test and inspect the aftertreatment DEF dosing valve tip. Refer to Procedure 011-059 in Section 11.

After cleaning, run the test again and monitor the spray pattern. If the problem persists, replace the aftertreatment DEF dosing valve. Refer to Procedure 011-059 in Section 11.

NOTE: If a leak at the DEF dosing valve tip is suspected, then the Aftertreatment Diesel Exhaust Fluid System Leak Test may be used to confirm the symptom. Refer to Procedure 011-080 in Section 11.



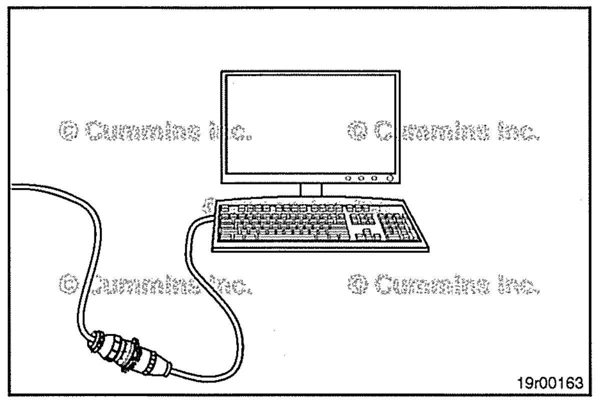
Flow Test

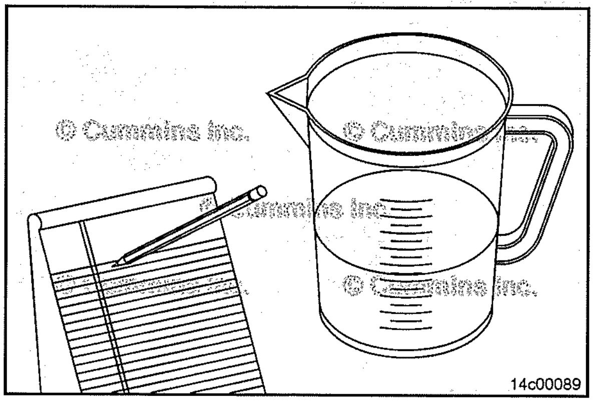
NOTE: Prior to performing this test, if **not** already directed by a fault code troubleshooting tree, view and troubleshoot any fault codes with INSITE™ electronic service tool. See QSG12 CM2350 G110 Fault Code Troubleshooting Manual, Bulletin 4367324.

- Turn the keyswitch ON.
- Connect INSITE™ electronic service tool.
- Locate the Diesel Exhaust Fluid Doser Pump Override Test under ECM Diagnostic Tests.
- Follow the on-screen instructions to perform the test.

INSITE™ electronic service tool will start the test and will inject the DEF for 5 minutes. INSITE™ electronic service tool will automatically disable the injector at the end of the test. If the test needs to be stopped before finishing, click the Stop button.

Observe the pressure gauge reading during the flow test. Follow the troubleshooting direction of the troubleshooting tree directing this test.





After the test is complete (test runs for 5 minutes.), measure the amount of DEF sprayed into the container. Pour the DEF into the graduated beaker, Part Number 4919139, or equivalent.

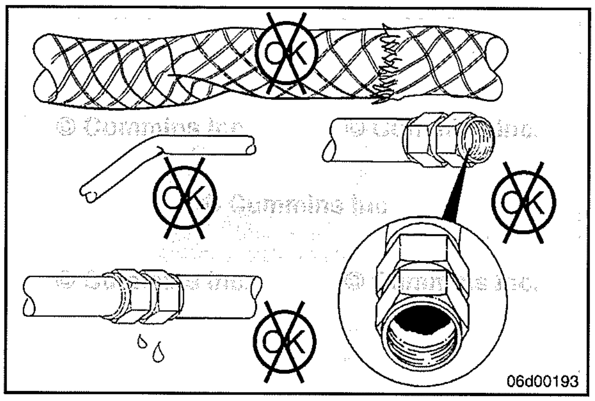
Perform the test three times. The amount of DEF measured for each test **must** be within specification.

Aftertreatment Diesel Exhaust Fluid Dosing Valve Volume Specifications

ml		fl-oz
270	MIN	9.1
330	MAX	11.2

NOTE: Do **not** pour the DEF back into the DEF tank. Dispose of the DEF in accordance with local environmental regulations.

NOTE: Inspect the collected sample of DEF for signs of debris or contamination.



NOTE: Low battery voltage can cause the dosing volume to be low. Check the batteries. See equipment manufacturer service information. View and troubleshoot any fault codes with INSITE™ electronic service tool. See QSG12 CM2350 G110 Fault Code Troubleshooting Manual, Bulletin 4367324.

If the amount of DEF is **not** within specification, check for leaks, blockages, or restrictions in the DEF line between the aftertreatment DEF dosing unit and the aftertreatment DEF dosing valve.

Use the following as a guide if the amount of DEF is still **not** within specification for one or more of the three tests:

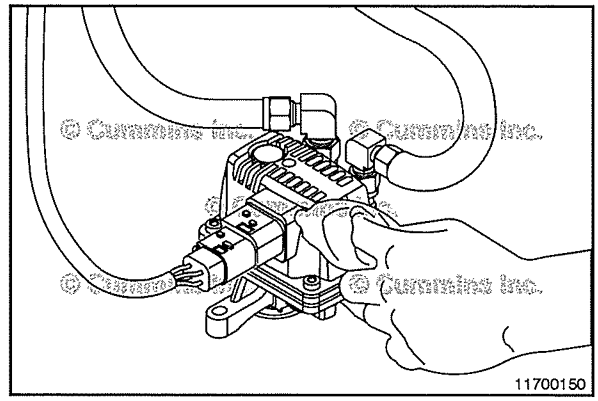
- Clean the DEF dosing valve if one or more of the test results is below 270 ml [9.1 oz].
- Replace the DEF dosing valve if one or more of the test results is above 330 ml [11.2 oz].
- Replace the DEF dosing valve if the test results vary with both below-specification and above-specification conditions. This could be an erratic valve with intermittent malfunction and **must** be replaced. Refer to Procedure 011-059 in Section 11.

NOTE: The aftertreatment DEF dosing valve may have been plugged by debris. Inspect the aftertreatment DEF dosing unit filter for signs of contamination and debris prior to installing the new aftertreatment DEF dosing valve. Refer to Procedure 011-060 in Section 11.

⚠CAUTION⚠
Do not submerge the aftertreatment diesel exhaust fluid (DEF) dosing valve in solvent or water. Damage to the aftertreatment diesel exhaust fluid (DEF) dosing valve will result.

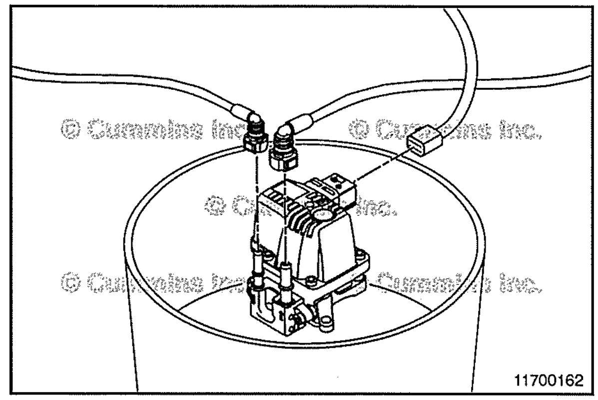
After the test is complete, a light coating of DEF will cover the aftertreatment DEF dosing valve, DEF line, and electrical line.

Prior to disconnecting anything, use a clean shop towel soaked in warm water to wipe the coating of DEF from the components.


11700150

NOTE: Clean any service tools used for this test with warm, distilled water before storage.

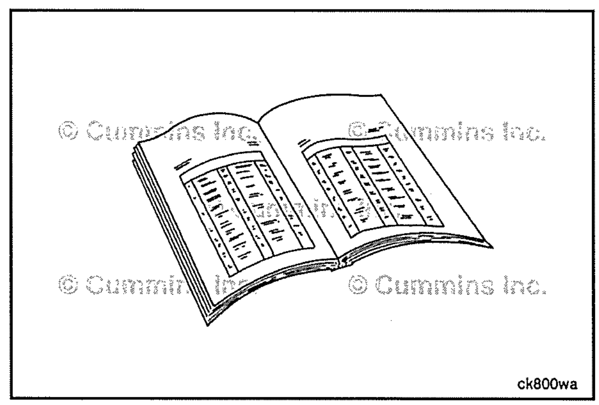
Disconnect the electrical and DEF lines. Refer to Procedure 011-059 in Section 11.


11700162

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 aftertreatment DEF dosing valve. Refer to Procedure 011-059 in Section 11.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

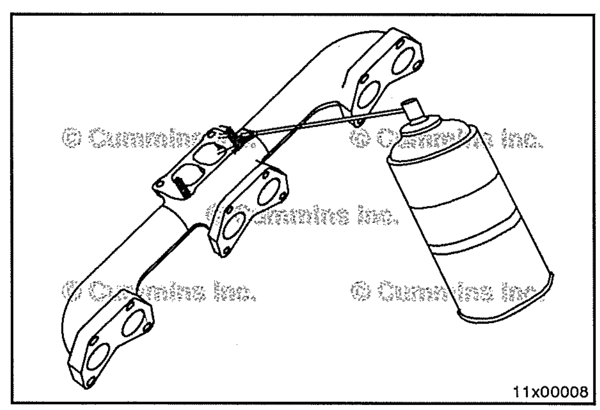

ck800wa

Exhaust Manifold Turbocharger Mounting Stud Replacement (011-073)

Remove

Apply penetrating oil, Part Number 2892116 or equivalent, to the base of the turbocharger mounting stud to be removed.

Multiple applications of the penetrating oil may be necessary to free the turbocharger mounting stud. See equipment manufacture service information.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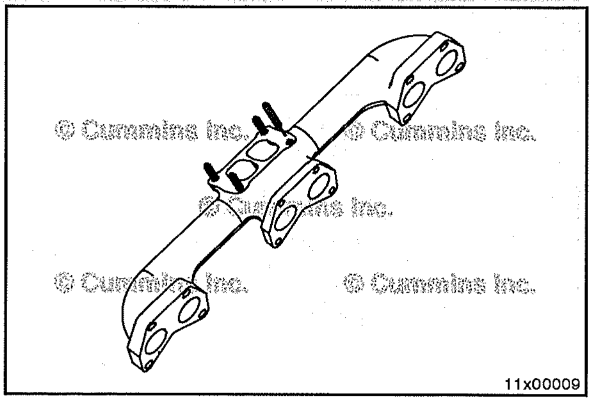
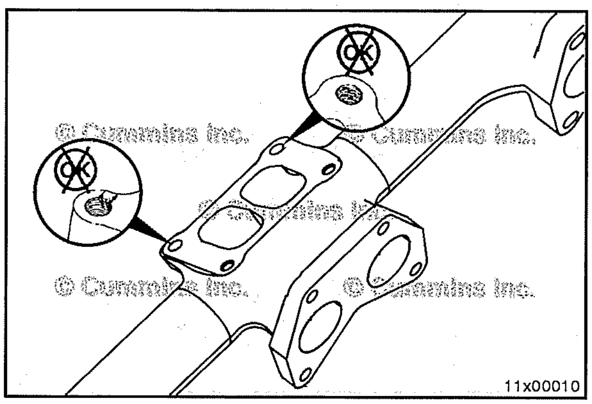


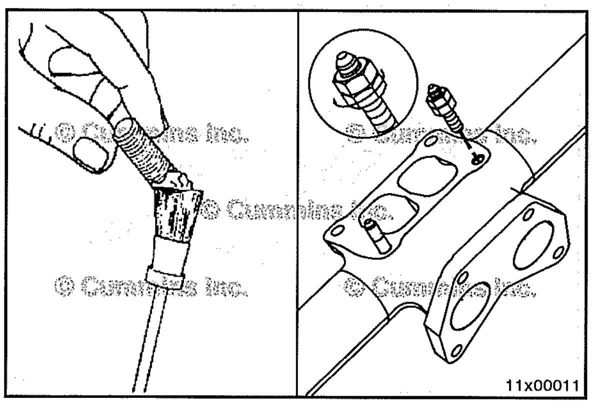
Use a standard stud extractor to remove the turbocharger mounting stud(s) from the exhaust manifold.



Inspect for Reuse

Inspect for damaged threads in the turbocharger mounting stud holes.

Inspect the manifold sections for cracks or other damage.



Install

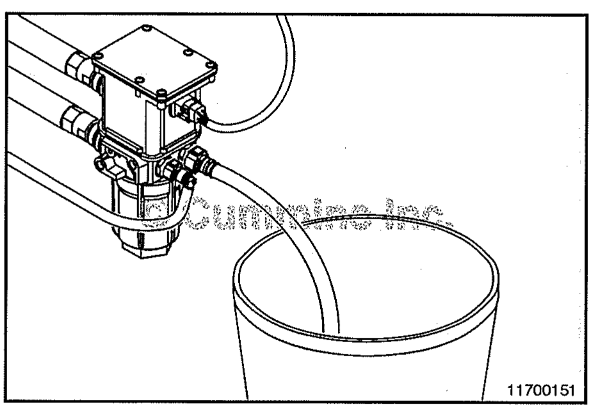
NOTE: Install the shorter threaded end of the turbocharger mounting stud in the exhaust manifold flange.

Apply a coat of anti-seize compound, Part Number 3824879 or equivalent, to the threads.

Install the studs in the mounting flange.

Use two mounting nuts locked together to tighten the studs.

Torque Value: 20 N•m [177 in-lb]



Air in the Diesel Exhaust Fluid (011-075)

Setup

Remove the aftertreatment diesel exhaust fluid (DEF) dosing unit pressure line from the DEF dosing unit outlet connector.

Install the DEF extension line, Part Number 4919574, from the Aftertreatment Diesel Exhaust Fluid (DEF) Doser Shutoff Valve Test Kit, Part Number 4919573.

Obtain a container suitable for collection of the DEF that exits the aftertreatment DEF dosing valve supply line. A 3.8 liter [1 gal] bucket is recommended.

Measure

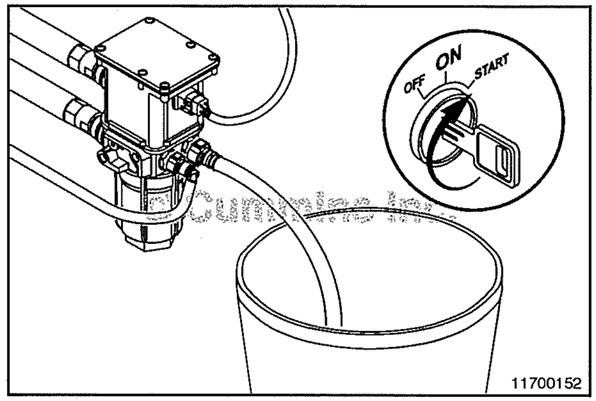
Route the outlet of the DEF extension line into the collection container.

Turn the keyswitch to the ON position and connect INSITE™ electronic service tool.

Select the Diesel Exhaust Fluid Doser Pump Override test under the ECM Diagnostic Tests menu.

This test will attempt to prime the dosing system. During this test, DEF will be drawn from the tank and pumped through the DEF extension line.

NOTE: Once the test is initiated it will continue to pump DEF, even when attempting to stop the test with INSITE™ electronic service tool. To stop the test, it is necessary to turn the keyswitch to the OFF position.



Observe the DEF flow exiting the DEF extension line while the Override Test is running.

Shake the DEF supply line fittings at the DEF tank connector and the DEF dosing unit inlet connector during the test to detect an intermittent DEF connection for air leaking.

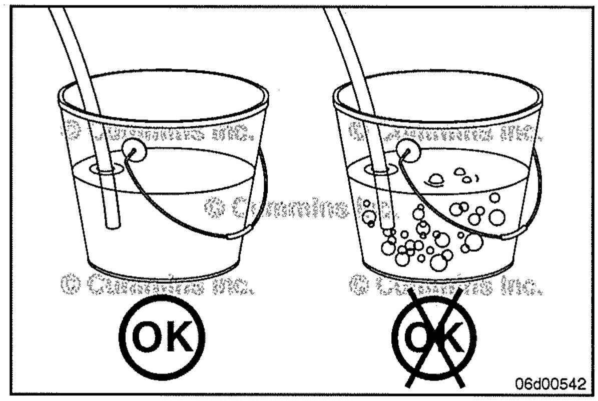
Air bubbles are an indication of a leak that allows air to enter the dosing system. If bubbles are present, check the following components for damage or leaks:

- Aftertreatment DEF dosing unit fittings
- Aftertreatment DEF dosing unit supply line
- Aftertreatment DEF tank assembly
- Aftertreatment DEF tank fittings.

Repair or replace any damaged components.

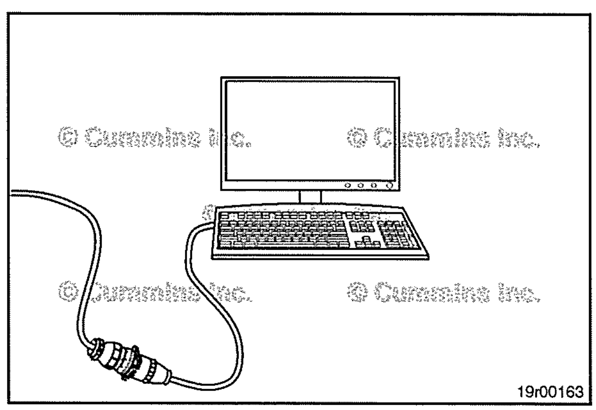
If no damage is noticed on the above components, replace the DEF supply line and re-run the Air in the Diesel Exhaust Fluid test. Air bubbles can be caused by internal sealing rings of DEF supply lines connectors. See equipment manufacturer service information.

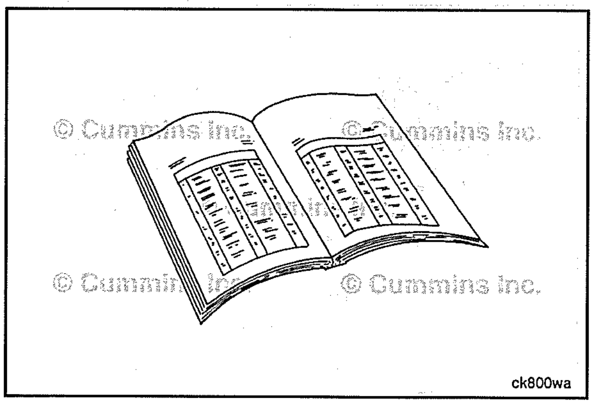
NOTE: When changing the DEF suction line, use a hand-held vacuum pump to remove an air block in suction line when the system can **not** prime.



Turn the keyswitch to the OFF position to end the test.

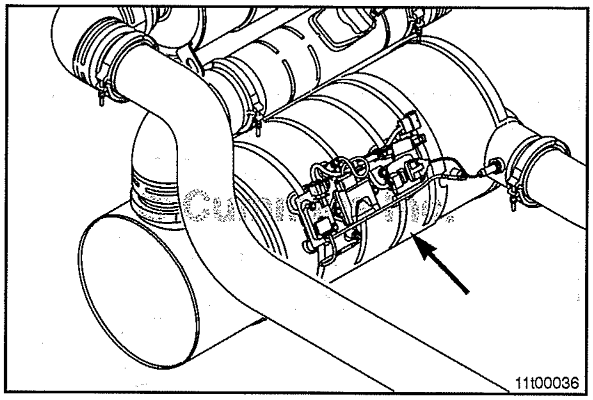
NOTE: If this test is run for an extended period of time, Fault Code 1682 will become active. Limit the test time to 5 minutes or less.





Finishing Steps

- Remove the aftertreatment DEF extension line.
- Connect that aftertreatment DEF dosing unit pressure line.
- Discard the collected DEF. Dispose of the collected DEF in accordance with local environmental regulations.
- Operate the engine and check for leaks.

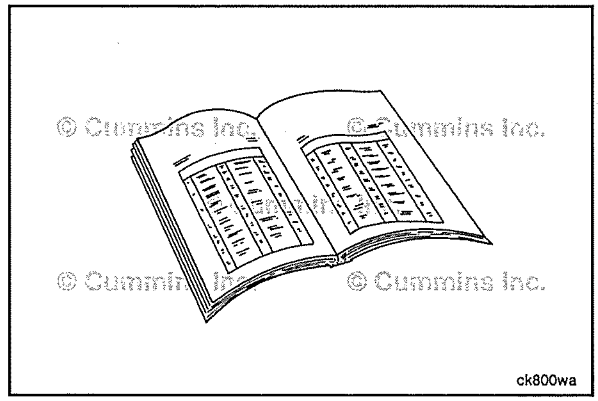


Aftertreatment SCR Catalyst Temperature Sensor Interface Module Mounting Bracket (011-076)

General Information

NOTE: Due to the number of different exhaust aftertreatment applications, this procedure has been written to be generic. **Not** all illustrations within this procedure will represent the application being serviced.

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.

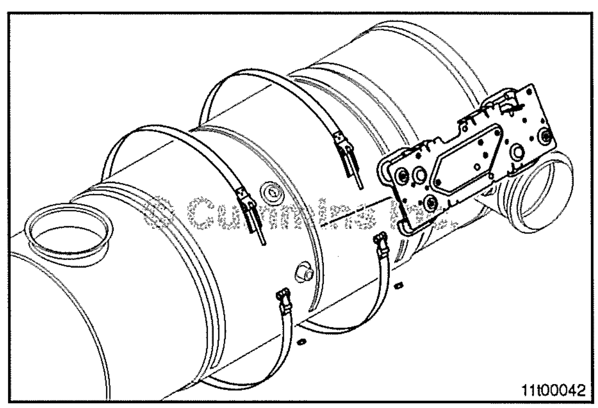
⚠WARNING⚠
The exhaust and exhaust components can remain hot after the engine has been shut down or secured. To avoid the risk of fire, property damage, burns or other serious personal injury, allow the exhaust system to cool before beginning this procedure or repair and make sure that no combustible materials are located where they might come in contact with hot exhaust or exhaust components.

⚠CAUTION⚠
The catalyst elements contained in the aftertreatment system are made of brittle material. Do not drop or strike the side of the aftertreatment system, as damage to the catalyst element can result.

- Disconnect the batteries. See equipment manufacturer service information.
- Mark the orientation and location of the bracket before it is removed, to aid the installation.
- Remove aftertreatment outlet NOx sensor. Refer to Procedure 019-451 in Section 19.
- Remove aftertreatment exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.

NOTE: The aftertreatment SCR catalyst temperature sensor interface module **must** be oriented in the same location when it is installed. Pay special attention to this orientation.

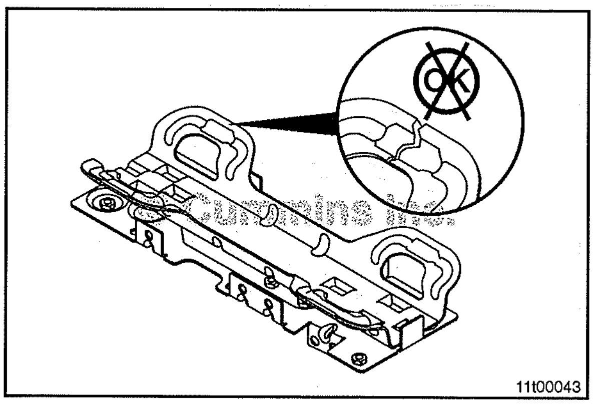
Remove



Make a reference mark on the mounting bracket and SCR to ensure proper orientation during install.

Remove the nuts on the aftertreatment SCR catalyst temperature sensor interface module mounting bracket straps.

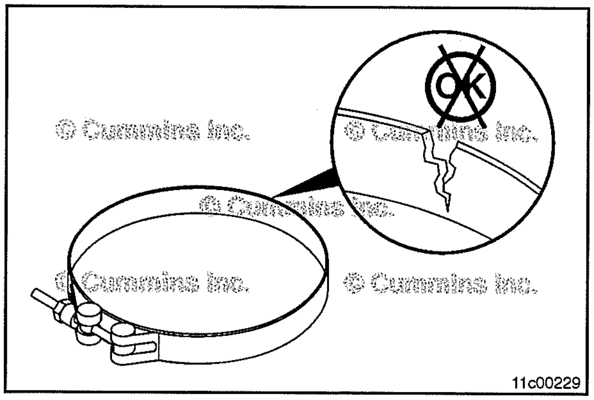
Remove the aftertreatment SCR catalyst temperature sensor interface module mounting bracket from the SCR catalyst body.



Clean and Inspect for Reuse

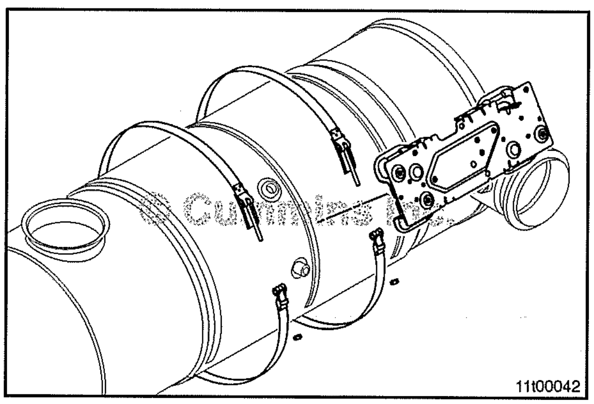
Inspect the aftertreatment SCR catalyst temperature sensor interface module mounting bracket for cracks, damaged threads, or broken studs.

Replace the aftertreatment SCR catalyst temperature sensor interface module mounting bracket if it is damaged.



Inspect the aftertreatment SCR catalyst temperature sensor interface module mounting bracket straps for cracks, damaged threads, or bends.

Replace the aftertreatment SCR catalyst temperature sensor interface module mounting bracket straps if they are damaged.



Install

NOTE: Make sure the aftertreatment SCR catalyst is oriented so the aftertreatment SCR catalyst temperature sensor interface module mounting bracket is installed in the same orientation noted during removal.

Install the aftertreatment SCR catalyst temperature sensor interface module mounting bracket and straps. Make sure to align the mounting bracket by using the reference mark that was made during removal.

Apply a coating of anti-seize compound, Part Number 3824879, or equivalent, to the threads of the aftertreatment SCR catalyst temperature sensor interface module mounting bracket straps.

Tighten the nuts on the aftertreatment SCR catalyst temperature sensor interface module mounting bracket straps.

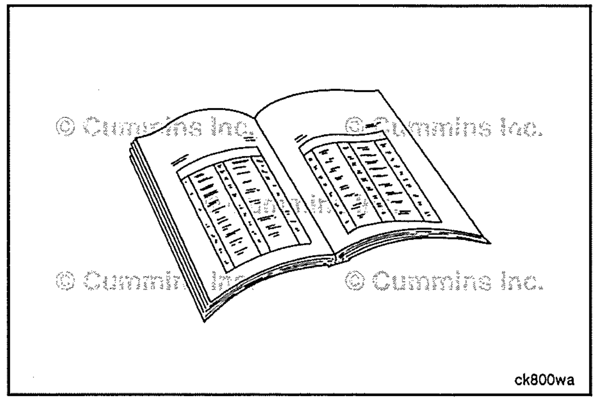
Torque Value: 7 N•m [62 in-lb]

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 aftertreatment exhaust gas temperature sensor. Refer to Procedure 019-449 in Section 19.
- Install aftertreatment outlet NOx sensor. Refer to Procedure 019-451 in Section 19.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for proper operation.

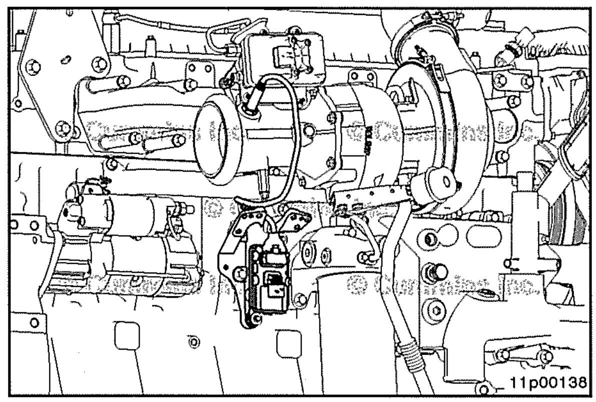


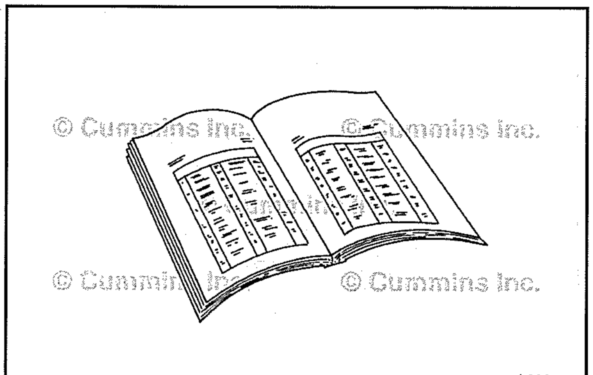
Aftertreatment Intake NOx Sensor Bracket (011-079)

General Information

The aftertreatment intake NOx sensor bracket is located on the engine block, just below the turbocharger.

The aftertreatment intake NOx sensor is a one-piece unit made up of two parts, a small module with a wire connection to the metal sensor body that sits in the exhaust system. The parts **must not** be separated.





ck800wa

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

The exhaust and exhaust components can remain hot after the engine has been shut down or secured. 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 might come in contact with hot exhaust or exhaust components.

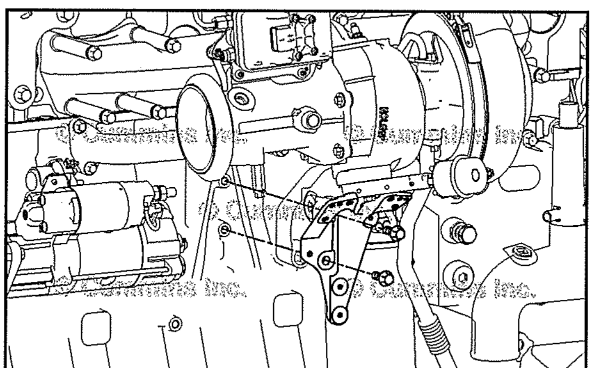
WARNING

The NOx sensor will stay hot to touch for long periods of time after the engine has been switched OFF, The NOx sensor will also be hot if the engine keyswitch is ON.

CAUTION

Do not underseal, coat, or paint any part of the NOx sensor.

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the aftertreatment intake NOx sensor heat shield. Refer to Procedure 019-463 in Section 19.
- Disconnect the aftertreatment intake NOx sensor and remove it from the bracket. Refer to Procedure 019-463 in Section 19.


11p00139

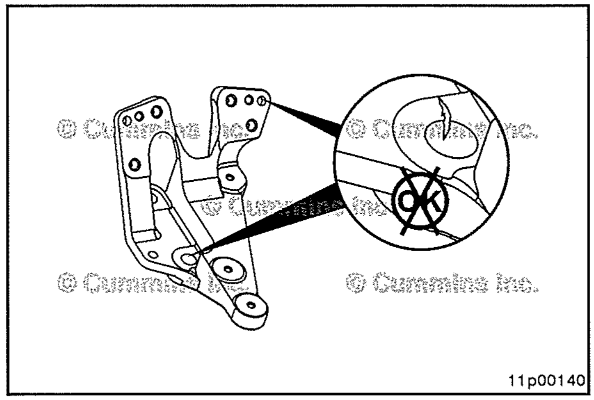
Remove

Remove the two mounting capscrews and aftertreatment intake NOx sensor bracket from the engine.

Clean and Inspect for Reuse

Inspect the aftertreatment intake NOx bracket for cracks or other damage.

Replace the aftertreatment intake NOx bracket if cracks or other damage is found.

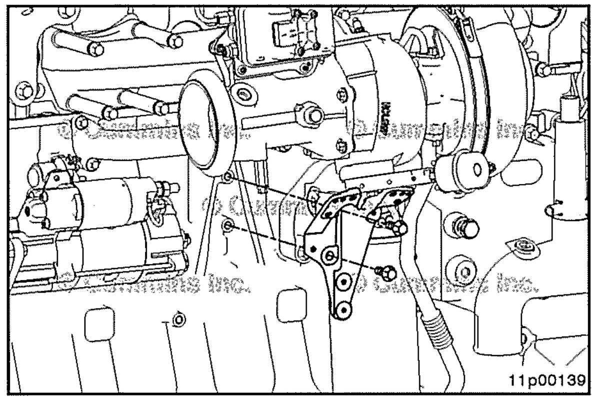


Install

Install the aftertreatment intake NOx sensor bracket onto the engine block using the two mounting capscrews.

Tighten the capscrews.

Torque Value: 47 N•m [35 ft-lb]

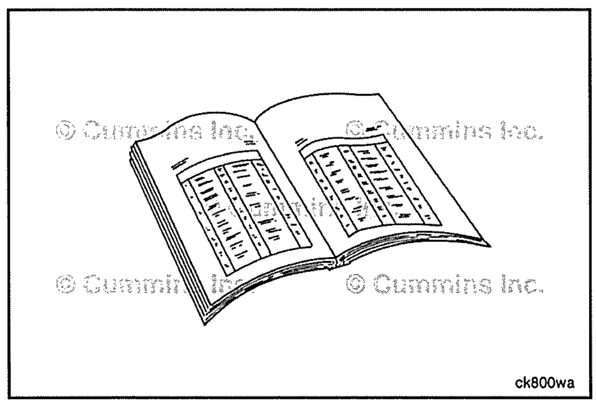


Finishing Steps

WARNING

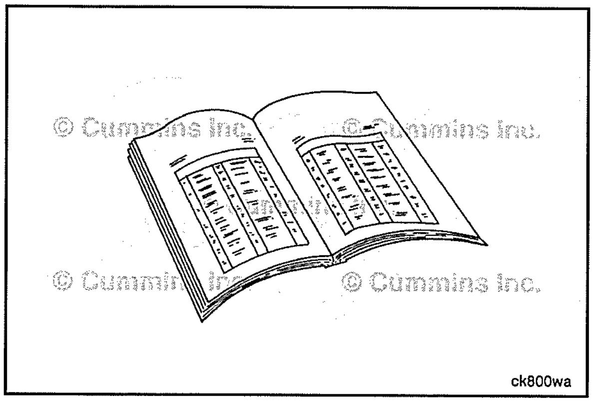
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Connect the aftertreatment intake NOx sensor and install it onto the bracket. Refer to Procedure 019-463 in Section 19.
- Install the aftertreatment intake NOx sensor heat shield. Refer to Procedure 019-463 in Section 19.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for proper operation.



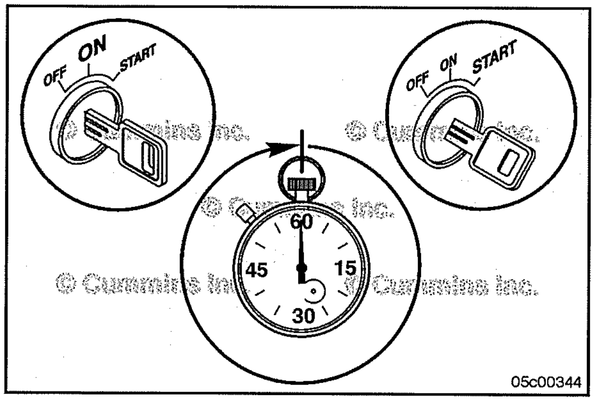
Aftertreatment Diesel Exhaust Fluid System Leak Test (011-080)

General Information



If the aftertreatment diesel exhaust fluid (DEF) dosing system has been serviced or repaired, it will be necessary to prime the DEF dosing system, to check for proper operation.

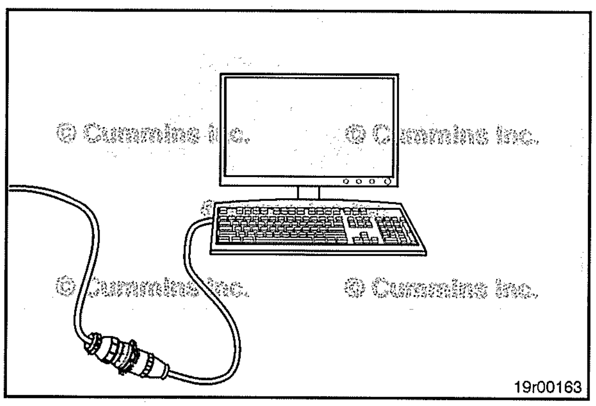
Setup



NOTE: It can be necessary to allow the aftertreatment system time to cool to allow for accessibility to check for leaking components.

- Make sure the DEF tank is full of DEF. See equipment manufacturer service information.
- Make sure the DEF is **not** frozen. If the DEF is frozen, it will be necessary to run the engine to allow the system to thaw.
- Make sure all DEF dosing system lines are properly connected to the DEF tank, DEF dosing unit, and DEF dosing valve. See equipment manufacturer service information.
- Connect INSITE™ electronic service tool.

Prime

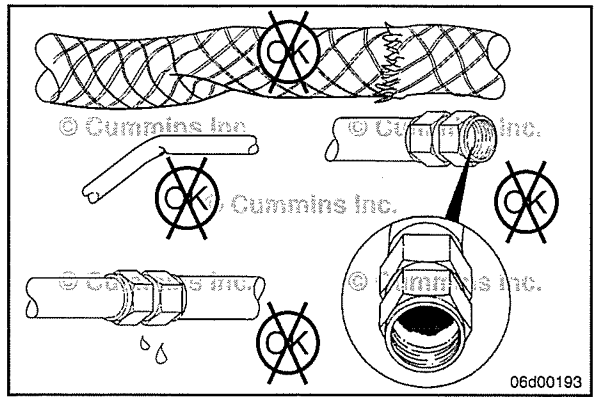


With the keyswitch ON and the engine **not** running, select the Aftertreatment Diesel Exhaust Fluid System Leak Test found under the engine control module (ECM) diagnostics test menu in INSITE™ electronic service tool.

This test will cause the DEF dosing unit to draw DEF from the tank and pressurize it in the DEF dosing unit pressure line. During this test, the dosing unit will continuously run and all unused DEF will return to the tank. An audible pumping noise will be noticeable during the test.

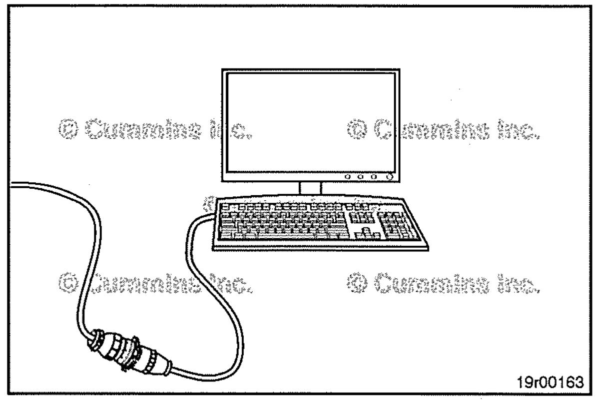
During the initialization of this test, a note will pop up on the screen, indicating that the system has reached a prime state.

Inspect



NOTE: If the system is unable to prime due to leaks, it will be necessary to turn the keyswitch OFF in order to stop the dosing unit. The dosing unit can **not** be stopped using INSITE™ electronic service tool.

While the test is running, inspect all DEF lines, fittings, and connections for external leaks. Repair and replace any leaking component(s). See one or more of the following documents. Refer to Procedure 011-058 in Section 11. Refer to Procedure 011-059 in Section 11. See equipment manufacturer service information.



If the system fails to prime, a key cycle will be required before attempting to run the Aftertreatment Diesel Exhast Fluid System Leak Test again.

NOTE: The Aftertreatment Diesel Exhaust Fluid System Leak Test can **only** be attempted twice consecutively. A key cycle will be required before attempting to run this test again after two attempts.

If the system is able to successfully prime, a pop-up message will appear in INSITE™ electronic service tool to notify the technician.

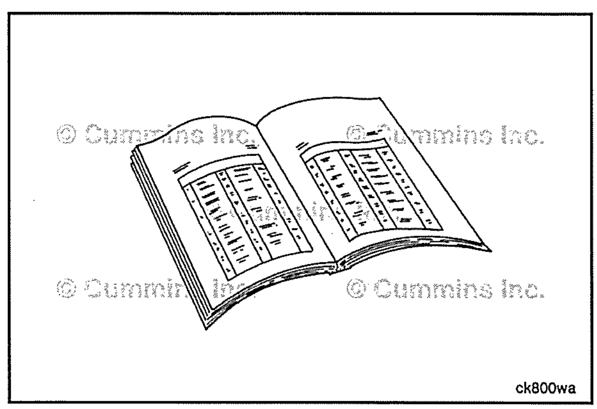
Upon completion of inspecting the lines, fittings, and connections for leaks, press the STOP button in INSITE™ electronic service tool. The dosing unit will then purge the system of DEF. An audible purging noise will be noticeable.

If the test is **not** STOPPED using INSITE™ electronic service tool, it will continue to pump for 20 minutes and then automatically purge the system of DEF.

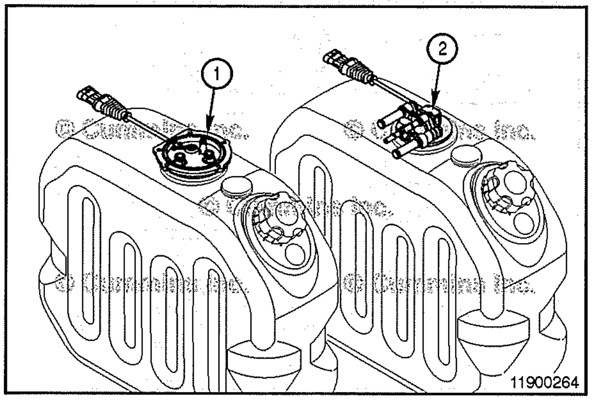
If the system can **not** build pressure, it will attempt to prime multiple times before flagging a fault code.

If any fault codes occur while running this test, see the appropriate fault code troubleshooting tree.

Finishing Steps



- Check for fault codes.

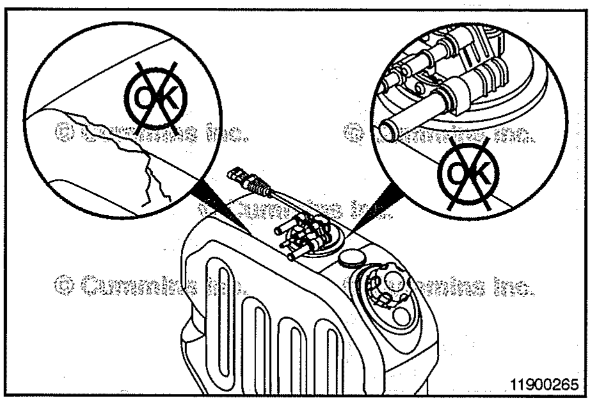


Aftertreatment Diesel Exhaust Fluid Tank (011-081)

General Information

The diesel exhaust fluid tank is used to store diesel exhaust fluid (DEF).

The DEF level **must** be checked daily. Top off DEF as necessary.



Initial Check

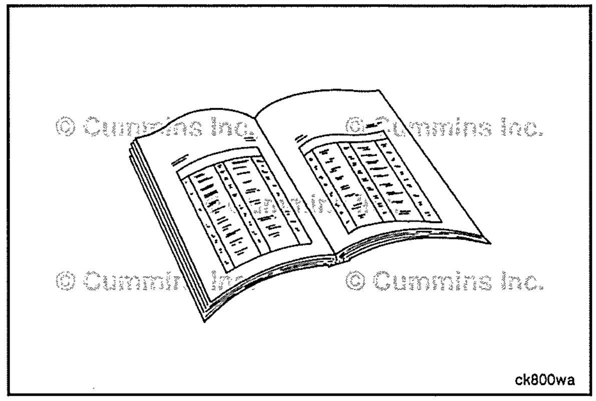
See equipment manufacturer service information.

Check the DEF tank for cracks, leaks, damage and buildup of DEF.

DEF leaks will leave a white deposit around the fittings or cracks.

Clean and replace as required.

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. See the Materials Safety Data Sheet (MSDS) for additional information.

⚠WARNING⚠

The coolant line(s) can be hot and under pressure. Do not disconnect the coolant lines while the engine is running or before the system has cooled down after engine shutdown. Heated coolant spray can cause personal injury. To reduce the possibility of personal injury, use eye and face protection, gloves and appropriate personal protective equipment.

⚠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.

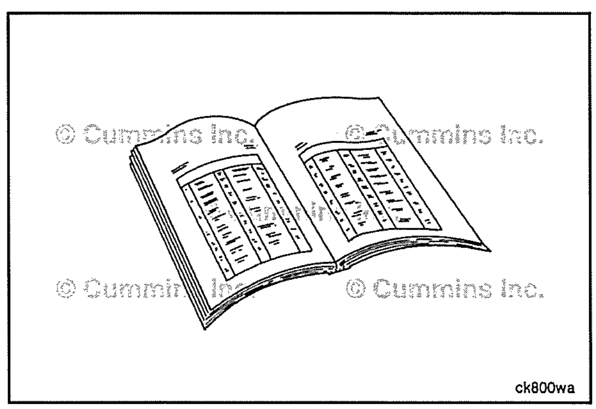
⚠CAUTION⚠

Always wear clean clothes and rubber gloves when working on the DEF tank. Contamination in the DEF tank may cause damage to the aftertreatment DEF dosing unit.

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 5 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.

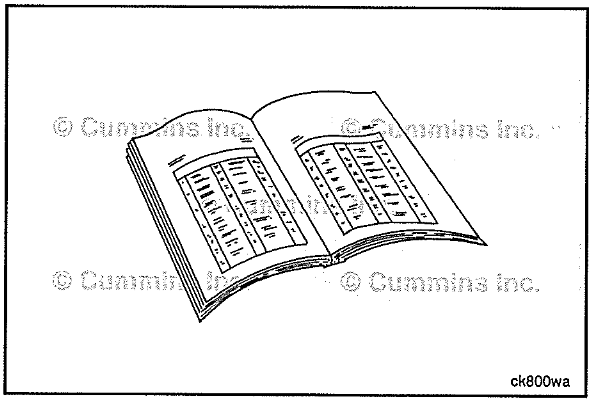
- Disconnect the batteries. See equipment manufacturer service information.

Drain



See equipment manufacturer service information.

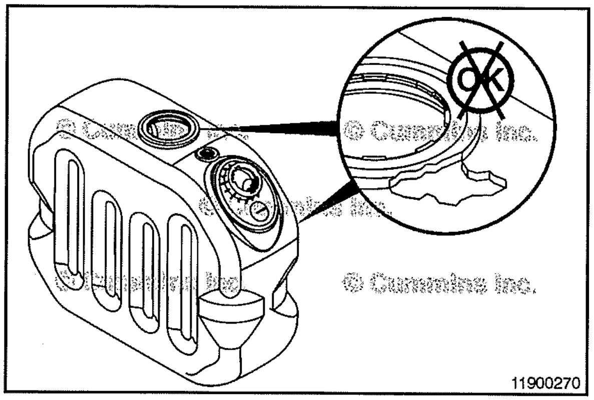
Drain the DEF and be sure that all the DEF and suspending contaminants are removed from the DEF tank.



Remove

See equipment manufacturer service information to remove the DEF tank.

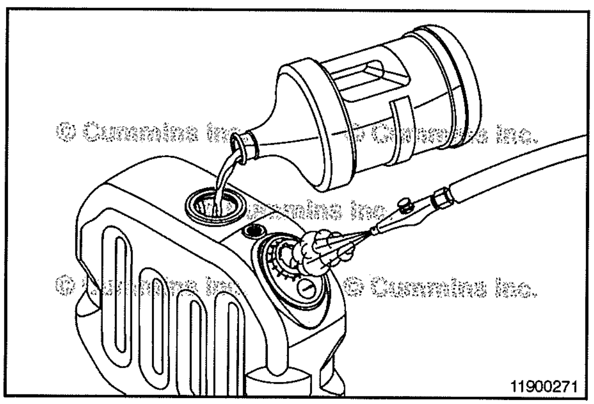
NOTE: Make certain not to damage the tank level and temperature sensor.



Clean and Inspect for Reuse

Inspect the DEF tank body for damage; replace the tank body if any damage is found.

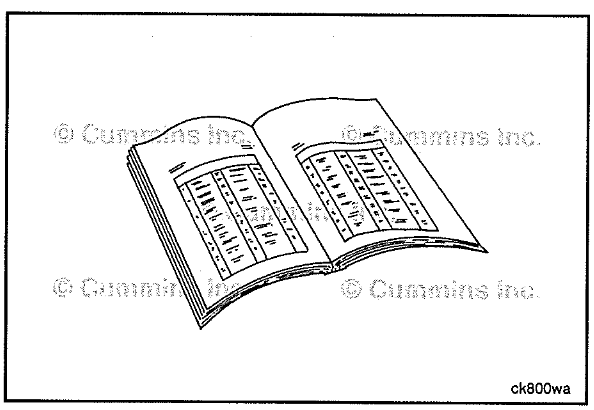
See equipment manufacturer service information.



If necessary, flush the DEF tank using distilled water.

Dry with compressed air.

NOTE: To avoid contamination, make certain that the DEF tank is completely dry before filling the tank with DEF.

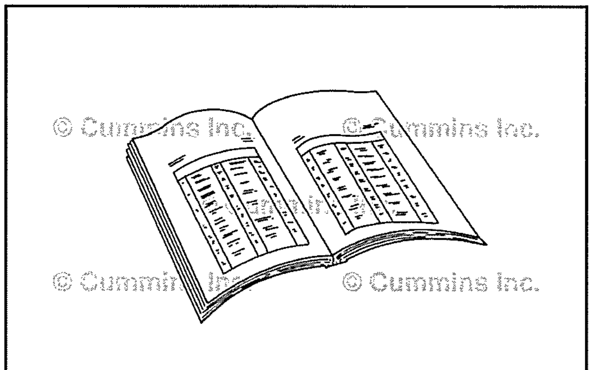


Install

NOTE: If the DEF level and temperature sensor was removed, install the DEF level and temperature sensor on the DEF tank first before installing the DEF tank. See equipment manufacturer service information.

Install the DEF tank. See equipment manufacturer service information.

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 tank with DEF.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

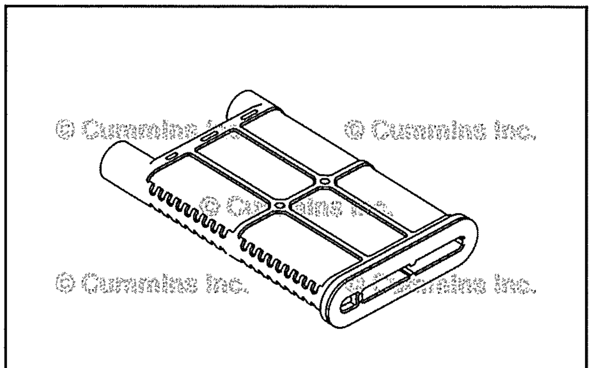
ck800wa

Aftertreatment Diesel Exhaust Fluid Tank Filter (011-083)

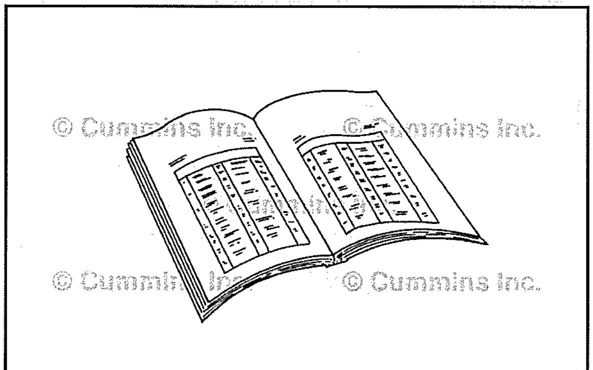
General Information

The diesel exhaust fluid (DEF) tank 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 malfunctions to the aftertreatment DEF dosing unit.

NOTE: The vehicle may be equipped with a different DEF tank filter. The illustration is for reference only.



19903480



ck800wa

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.

⚠CAUTION⚠

Do not pressure wash or steam clean this unit. Pressure washing or steam can damage the unit. Use compressed air to remove any loose debris.

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 5 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 an intervention to occur. The aftertreatment DEF dosing unit will issue an audible pumping noise during the purging process.

- Disconnect the batteries. See equipment manufacturer service information.
- To access the DEF tank filter, remove the DEF tank level and temperature sensor. See equipment manufacturer service information.
- To access the DEF tank filter, remove the DEF tank level and temperature sensor. See equipment manufacturer service information.

Clean and Inspect for Reuse

The DEF tank filter is an OEM supplied component. See equipment manufacturer service information for assemble and disassemble instructions.

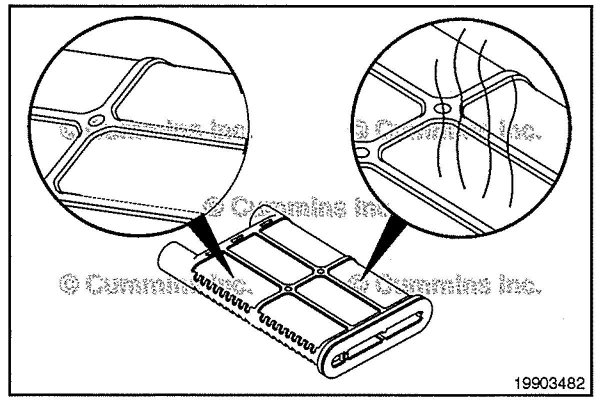
If it is suspected that contaminated DEF has gone through the DEF dosing system, check the DEF tank filter prior to discarding the filter.

Inspect the DEF tank filter for evidence of contaminated DEF. Use visual and aroma characteristics of the filter to determine if contaminated fluid has passed through the dosing system.

Use the following procedure for further information on contaminated DEF. Refer to Procedure 011-056 in Section 11.

Inspect the DEF filter for debris. If debris is evident, also inspect the aftertreatment DEF dosing unit filter. Refer to Procedure 011-060 in Section 11.

Discard the DEF tank filter.

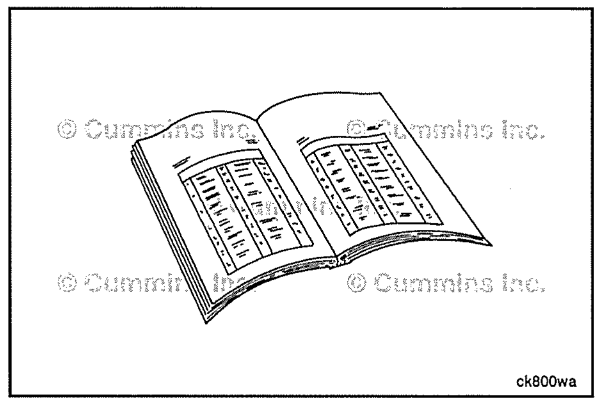

19903482

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.

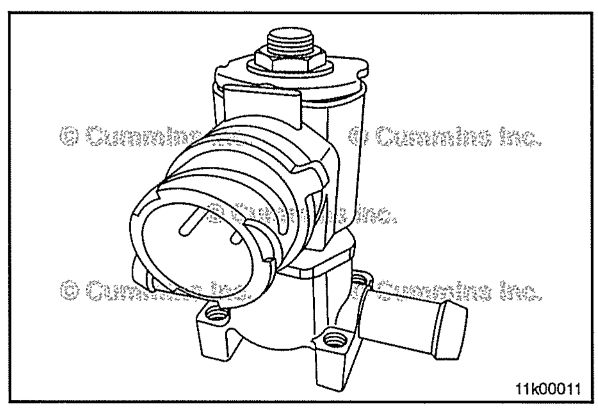
- Install the DEF tank level and temperature sensor. See equipment manufacturer service information.
- Install the DEF tank level and temperature sensor. See equipment manufacturer service information.
- Connect the batteries. See equipment manufacturer service information.

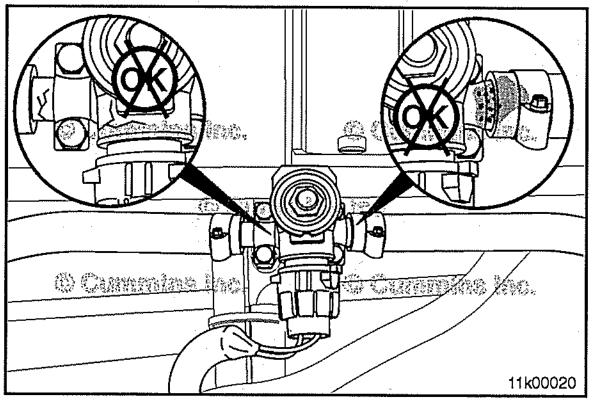

ck800wa

Aftertreatment Diesel Exhaust Fluid Tank Heater Control Valve (011-084)

General Information

The aftertreatment diesel exhaust fluid (DEF) tank heater control valve controls the coolant flow through the DEF tank to thaw the frozen DEF and also maintain the temperature above freezing point.


11k00011



Initial Check

WARNING

The exhaust and exhaust components can remain hot after the engine has been shut down or secured. 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 might come in contact with hot exhaust or exhaust components.

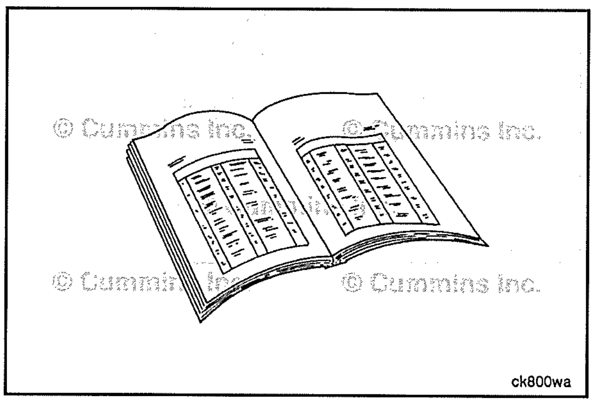
See equipment manufacturer service information.

Inspect the aftertreatment DEF tank control heater valve. Inspect for signs of leaks and/or deposits.

If the aftertreatment DEF tank control heater valve is suspected to be leaking coolant and the source of the coolant leak can **not** be identified, pressurize the cooling system. Refer to Procedure 008-020 in Section 8.

If leaks and/or deposits are identified, see equipment manufacturer service information.

NOTE: The coolant supply/return and diesel exhaust fluid lines are supplied by the OEM. The removal of these lines may vary by OEM.



Preparatory Steps

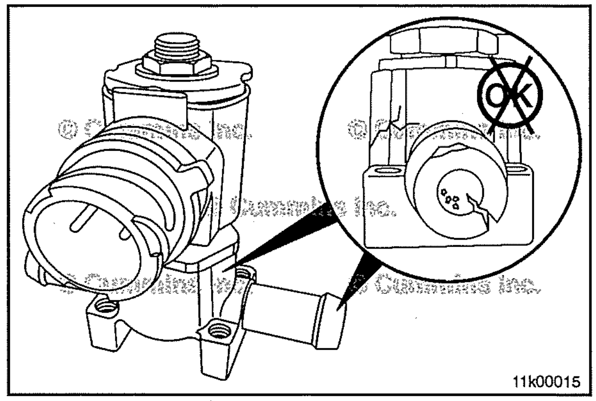
WARNING

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: 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 5 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.

- Disconnect the batteries. See equipment manufacturer service information.

Clean and Inspect for Reuse



Inspect the aftertreatment DEF tank heater control valve for any cracks and damage.

Replace the aftertreatment DEF tank heater control valve if damage is found.

Inspect the electrical connection and pins for damage/ corrosion. Refer to Procedure 019-361 in Section 19.

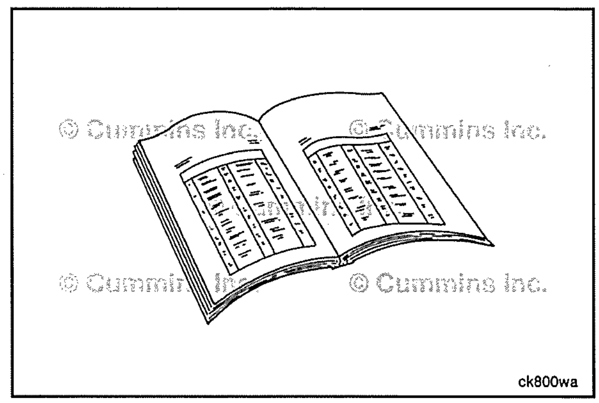
NOTE: If damage/corrosion is found, inspect the electrical connector and pins on the OEM harness. See equipment manufacturer service information.

If leaks/deposits are found at the coolant line connections during the Initial Check, inspect the coolant fittings for cracks and signs of corrosion and/or pitting.

If corrosion is found, the coolant may be contaminated and/or the concentration incorrect. Check the coolant.

Use the following service bulletin for specifications. Refer to Cummins® Coolant Requirements and Maintenance, Bulletin 3666132.

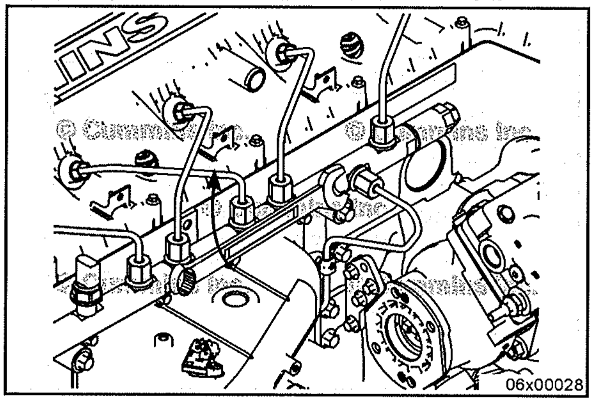
Finishing Steps



⚠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.

- If any coolant was spilled, check the coolant level. Fill as required. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



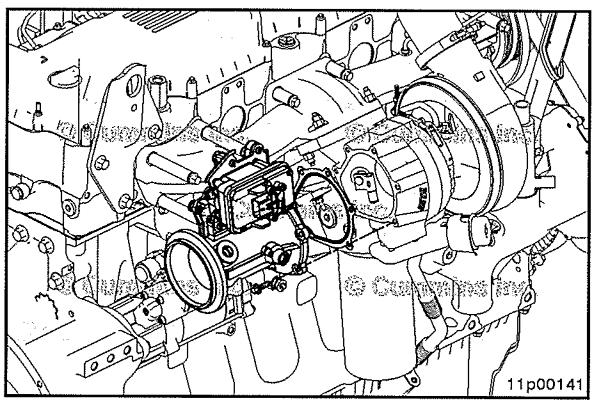
Exhaust Pressure Regulator (011-105)

Preparatory Steps

WARNING

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

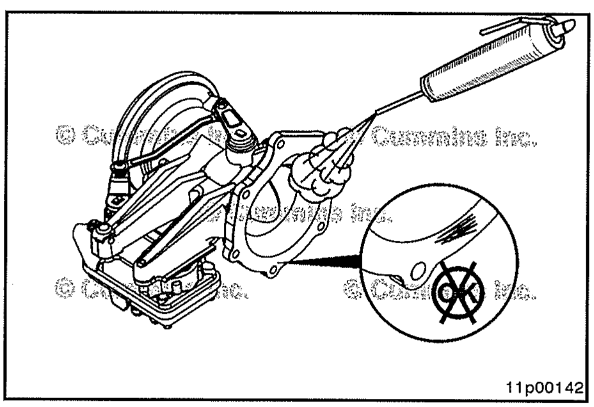
- Disconnect the batteries. See equipment manufacturer service information.
- Disconnect the exhaust pressure regulator electrical connection.
- Remove the exhaust pipe from the turbocharger. See equipment manufacturer service information.
- Remove the coolant supply and drain lines. Refer to Procedure 010-041 in Section 10.
- Remove the aftertreatment intake NOx sensor. Refer to Procedure 019-463 in Section 19.



Remove

Remove the exhaust pressure regulator and gasket from the turbocharger.

Discard the gasket.



Clean and Inspect for Reuse

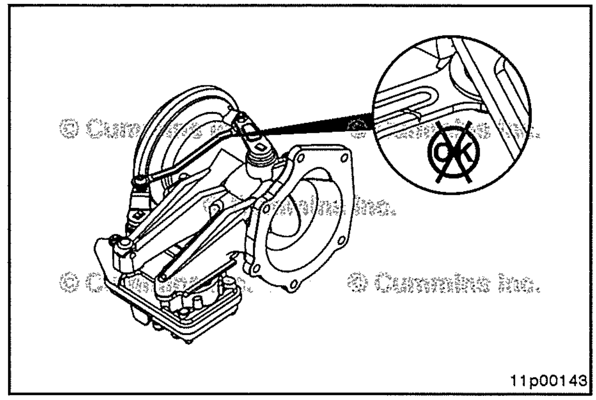
Clean the turbocharger mating surfaces with Scotch-Brite™ 7448 abrasive pad.

After abrasive cleaning, wipe debris from both surfaces with a clean shop towel.

Inspect the mating surface for scratches.

If scratches cannot be removed with the abrasive pad the exhaust pressure regulator **must** be replaced.

Inspect the actuator arm and linkages for damage and wear.

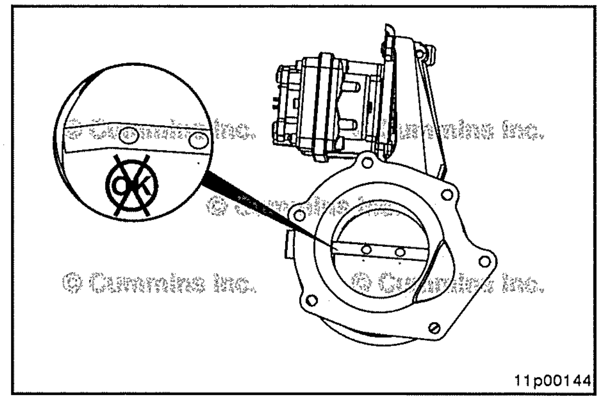


11p00143

Check the exhaust pressure regulator valve for damage.

Manually push the valve closed and inspect the valve. There should be a small even gap between the valve and the housing.

If the valve contacts the housing or the valve is visibly bent the exhaust pressure regulator **must** be replaced.



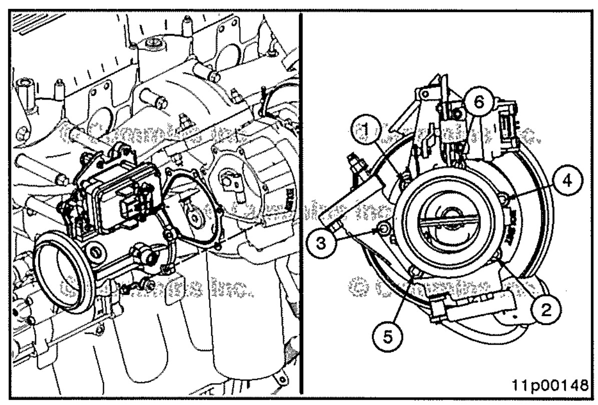
11p00144

Install

Install the exhaust pressure regulator and new gasket. Install the six capscrews hand tight.

Tighten the capscrews in the sequence shown.

Torque Value: 25 N•m [18 ft-lb]



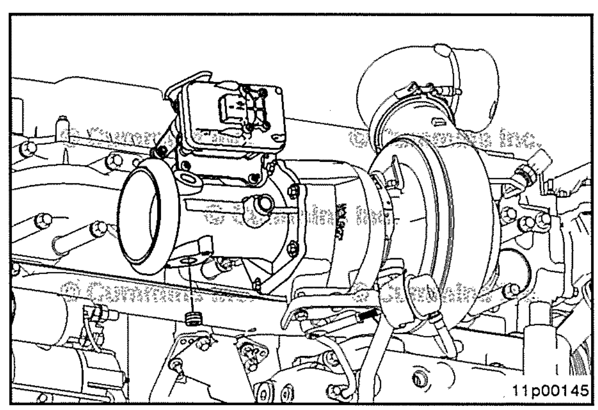
11p00148

NOTE: Depending on the turbocharger configuration the exhaust pressure regulator has two possible NOx sensor mounting locations. The NOx sensor **must** be installed in the top of the exhaust pressure regulator housing. A plug is provided with new exhaust pressure regulators. This plug **must** be installed in the bottom NOx sensor location.

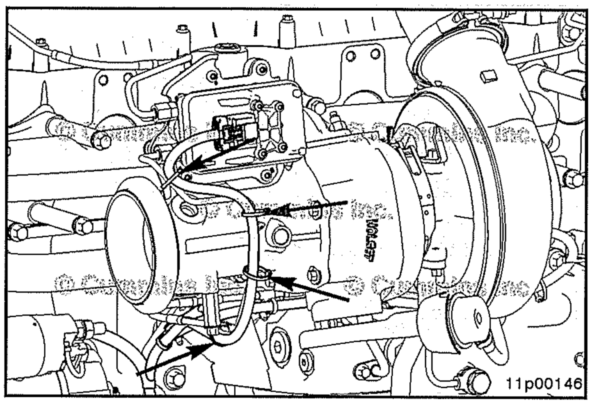
If the exhaust pressure regulator is being replaced install the NOx sensor plug at the **bottom** of the housing.

Install the NOx sensor plug.

Torque Value: 50 N•m [37 ft-lb]



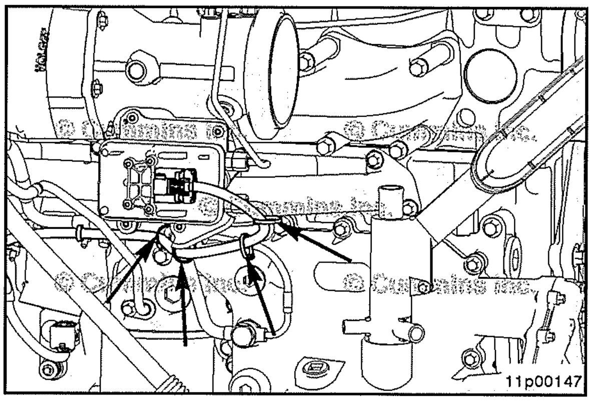
11p00145



NOTE: This stepblock applies to a rear out turbocharger mounting.

Connect the exhaust pressure regulator electrical connection.

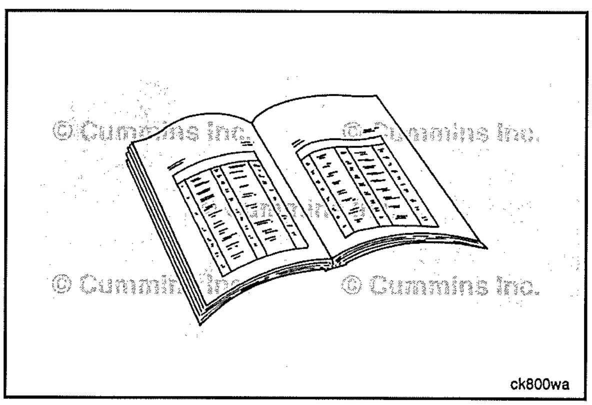
Secure the electrical connection wire harness to the coolant return line as shown.



NOTE: This stepblock applies to a front out turbocharger mounting.

Connect the exhaust pressure regulator electrical connection.

Secure the electrical connection wire harness to the coolant supply line as shown.



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 aftertreatment intake NOx sensor. Refer to Procedure 019-463 in Section 19.
- Install the coolant supply and drain lines.Refer to Procedure 010-041 in Section 10.
- Install the exhaust pipe from the turbocharger. See equipment manufacturer service information.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

Section 12 - Compressed Air System - Group 12

Section Contents

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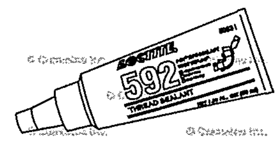
Service Tools

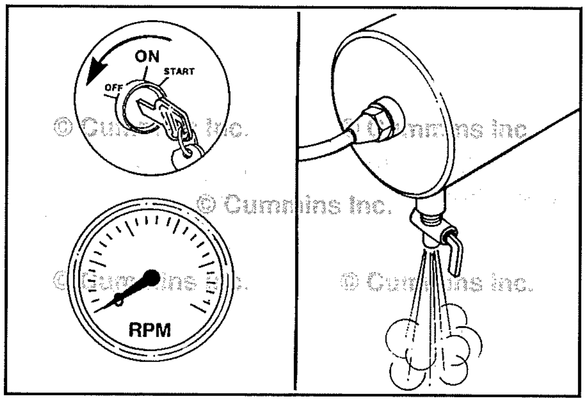
Compressed Air System

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3375066	**Thread Sealant** This product locks and seals threaded fluid fitting. This product resists leakage, vibration loosening, moisture, hydraulic fluids and diesel fuels and other liquids. It also lubricates the threads for easy assembly and disassembly.	 22x00008

Air Compressor Carbon Buildup (012-003)

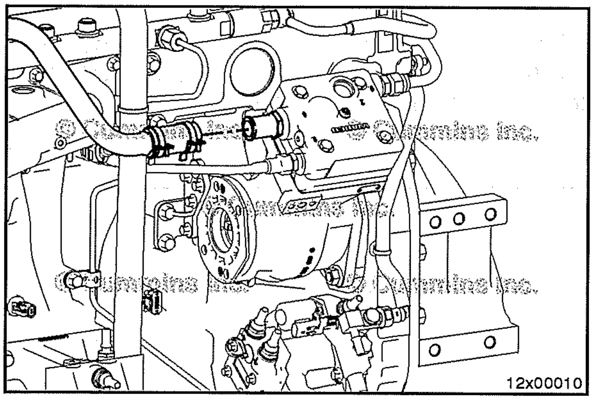
Initial Check



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

Shut the engine OFF.

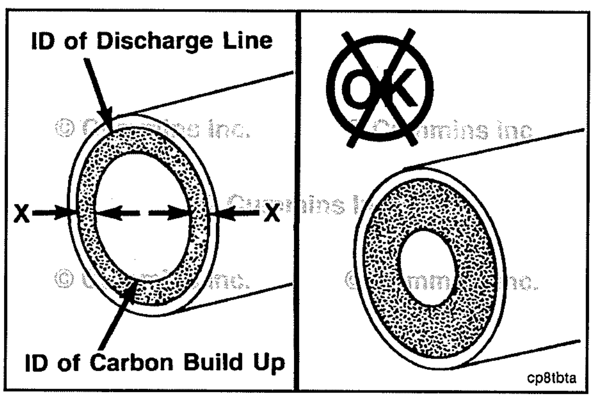
Open the drain cock on the air tanks to release compressed air from the system.



⚠WARNING⚠
Air discharge lines can be very hot. Make sure the lines are cool before touching to reduce the possibility of personal injury.

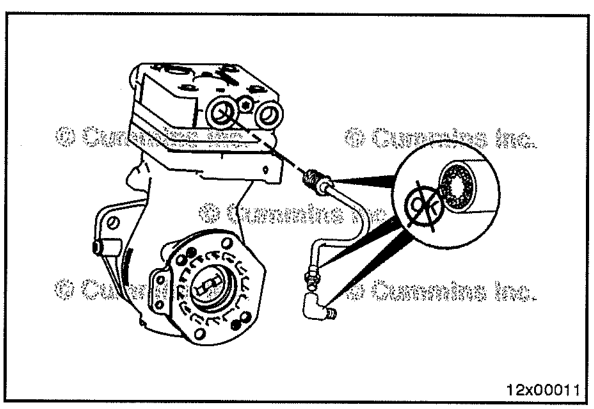
Remove the air compressor inlet tube. Refer to Procedure 012-109 in Section 12.

Remove the outlet connections from the air compressor. Refer to Procedure 012-109 in Section 12.



Measure the total carbon deposit thickness inside the air discharge line as shown.

NOTE: The carbon deposit thickness **must not** exceed 1.6 mm [0.06 in].



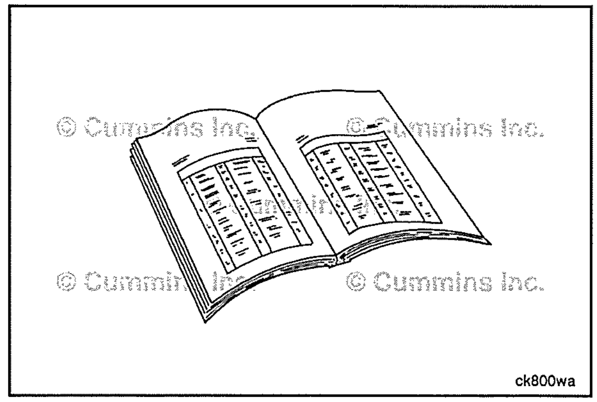
⚠WARNING⚠
The air discharge line must be capable of withstanding extreme heat and pressure to prevent personal injury and property damage. Refer to the manufacturer's specifications.

NOTE: If the total carbon deposit thickness exceeds specification, remove and clean, or replace the air discharge line.

Continue to check for carbon buildup in the air discharge line connections up to the first connection or air tank.

Clean or replace any lines and fittings with carbon deposits thicker than 1.6 mm [0.06 in]. See equipment manufacturer service information for cleaning or replacement instructions.

If carbon buildup is suspected in the air compressor head and valve assembly, see the appropriate troubleshooting symptom tree for repair direction.



ck800wa

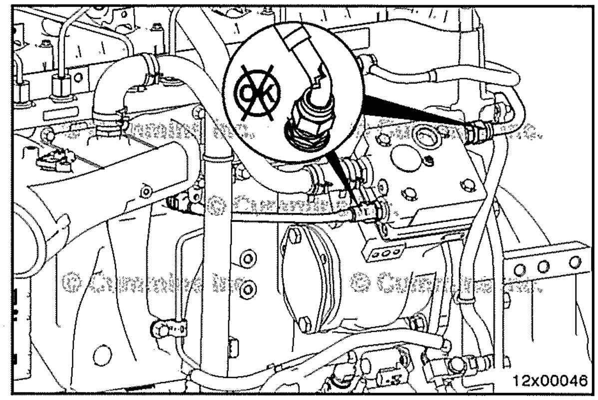
Air Compressor Coolant Lines (012-004)

Initial Check

Inspect the hoses for splits, cracks, hardening, or other damage.

Inspect the metal coolant lines for kinks, corrosion, or cracks.

Replace any damaged components.



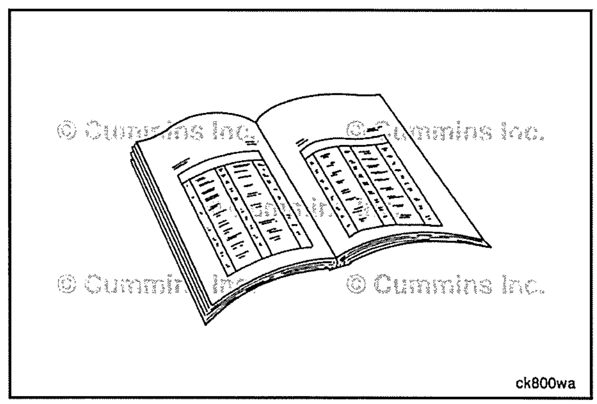
12x00046

Preparatory Steps

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

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

- Drain the cooling system. Refer to Procedure 008-018 in Section 8.
- Use a steam to clean the air compressor. Dry with compressed air.



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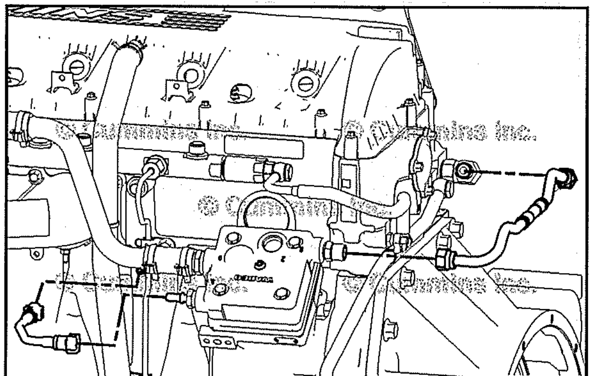


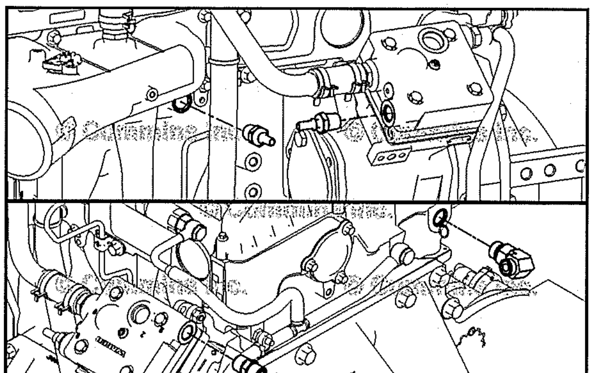
12x00015

Remove

Remove the coolant lines from the fittings.

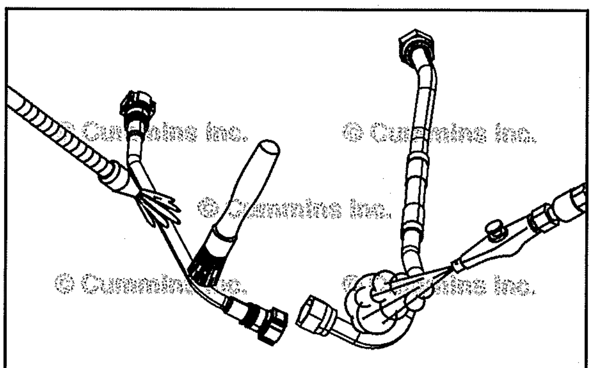
Use a second wrench to hold the face-seal fitting when loosening the coolant return line connections.

The coolant supply line connections are quick release fittings. To release, press both sides of the connectors.



12x00047

Remove the quick disconnect fittings and face-seal fittings, if necessary.



12x00017

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⚠

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

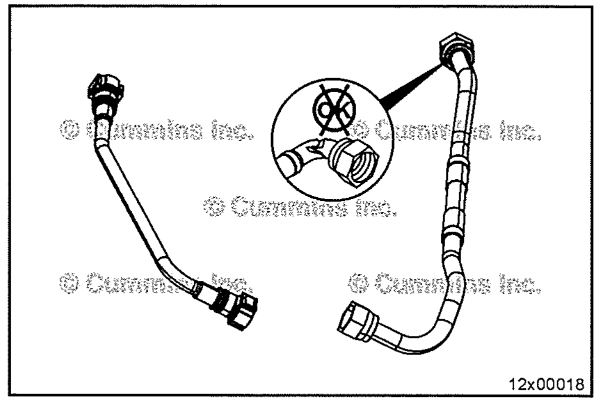
⚠WARNING⚠

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

Clean the air compressor coolant lines with solvent.

Dry with compressed air.

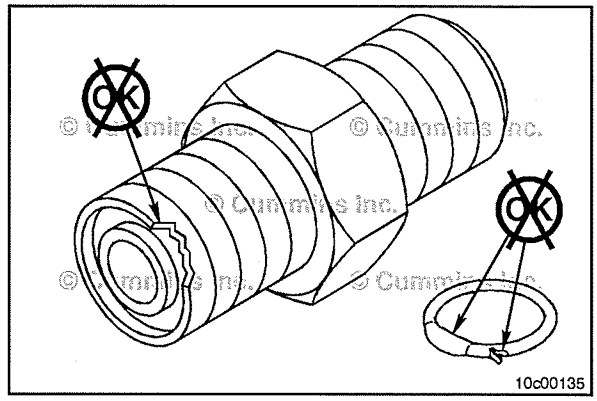
Check the air compressor coolant lines for cracks or other damage. Replace the coolant lines if damage is found.



Check the face of the coolant fittings for damage. Replace if damage is found.

Check to be sure the o-rings are in place and are **not** damaged. A damaged or missing o-ring will result in a coolant leak.

Replace the o-rings if damage is found.



Install

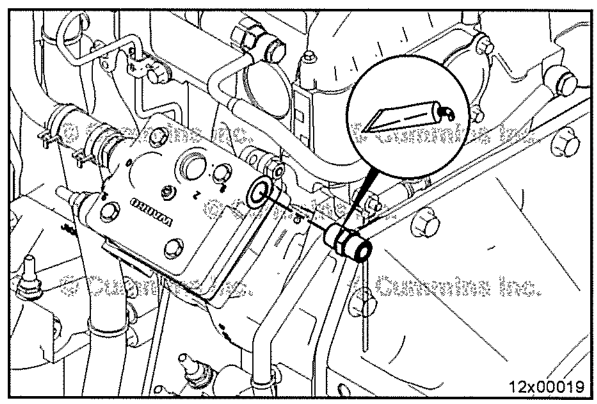
If the o-rings were removed, install new o-rings.

Apply sealant, Part Number 3375066 or equivalent, to the threads of the air compressor head face seal fitting before installation. Do **not** put sealant on the threads of the rocker lever housing face seal fitting.

If removed, install the face seal fittings.

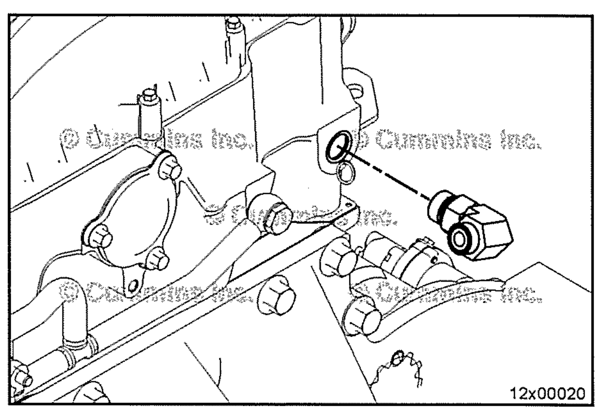
Tighten the fitting into the air compressor head.

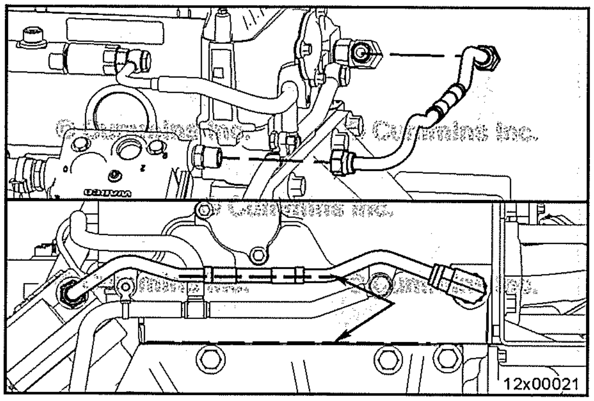
Torque Value: 35 N•m [26 ft-lb]



NOTE: The elbow face seal fitting at the rocker lever housing **must** be installed in the proper orientation to allow for installation of the coolant return line.

Finger tighten the face seal fitting into the rocker lever housing.





NOTE: The elbow face seal fitting at the rocker lever housing **must** be installed in the proper orientation to allow for installation of the coolant return line.

Install the coolant return line to aid in properly orienting the face seal elbow fitting. The coolant return line will mount parallel to the top of the flywheel housing.

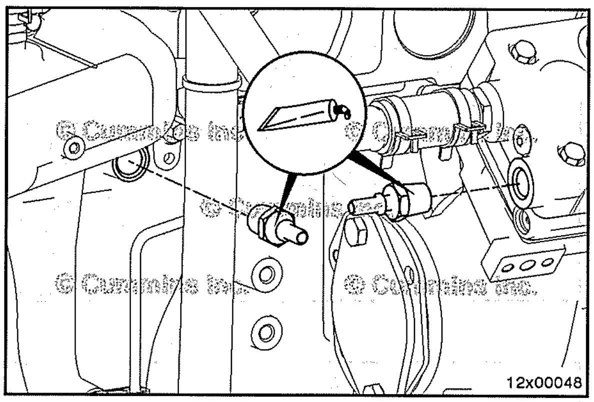
Finger tighten the face seal fittings at the air compressor head and the rocker lever housing.

Holding the coolant return line to prevent kinking, tighten the face seal fittings.

Torque Value: 35 N•m [26 ft-lb]

Tighten the lock nut on the elbow face seal fitting at the rocker lever housing.

Torque Value: 55 N•m [41 ft-lb]



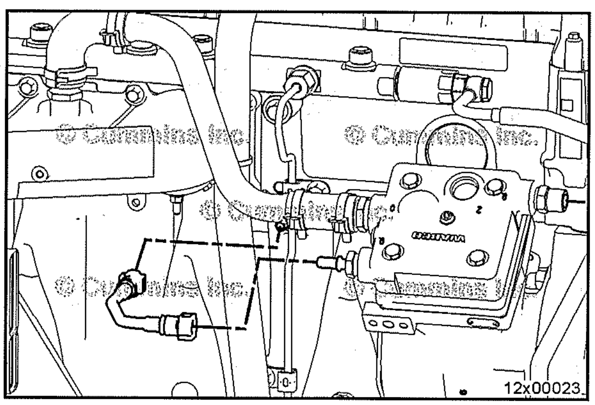
Apply sealant, Part Number 3375066 or equivalent, to the threads of both quick disconnect fittings before installation.

Install and tighten the quick disconnect fitting into the cylinder block.

Torque Value: 35 N•m [26 ft-lb]

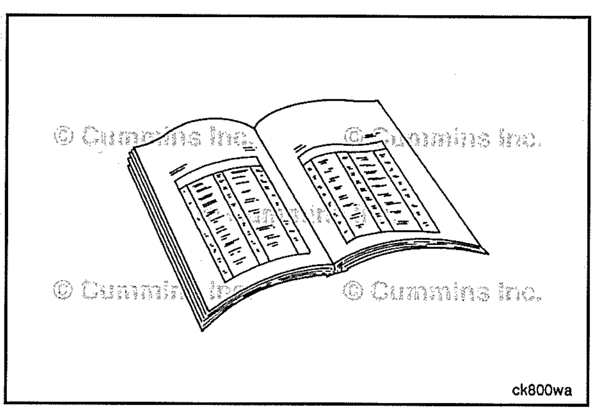
Install and tighten the quick disconnect fitting into the air compressor cylinder head.

Torque Value: 35 N•m [26 ft-lb]



Install the air compressor coolant supply line.

Connect the coolant supply line quick disconnect connections.



Finishing Steps

WARNING

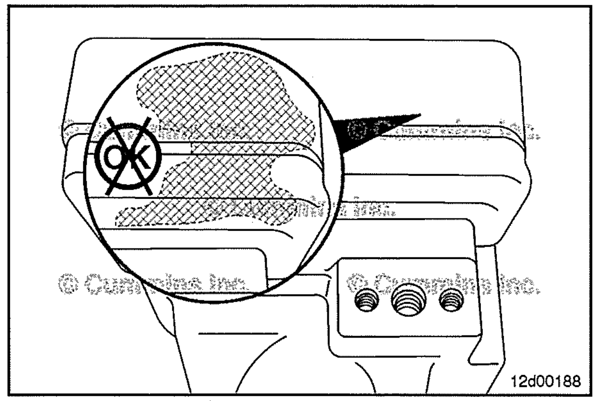
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine to normal operating temperature and check for leaks.

Air Compressor Cylinder Head, Single Cylinder (012-007)

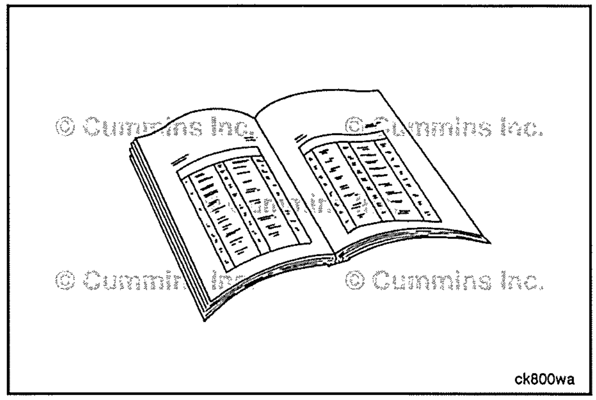
Initial Check

Inspect the cylinder head for signs of a coolant leak. A coolant leak will be identified by an area of engine paint appearing to have been washed away. White crystalline clusters of material are **not** a sign of a coolant leak. If a leak is found, see the appropriate troubleshooting symptom tree for repair direction.



General Information

The air compressor head is **not** serviceable. If there are any issues, see the appropriate troubleshooting symptom tree for repair direction.



Air Compressor Unloader and Valve Assembly (012-013)

Initial Check

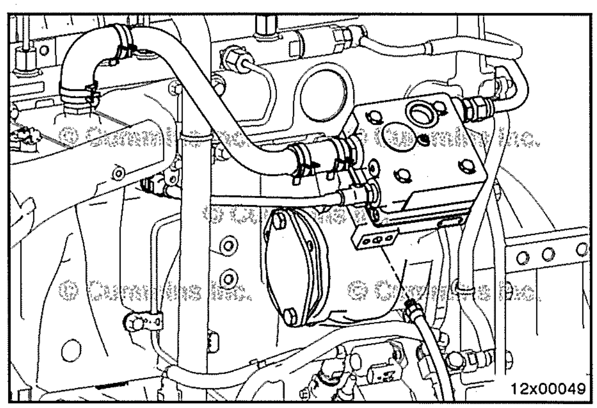
WARNING

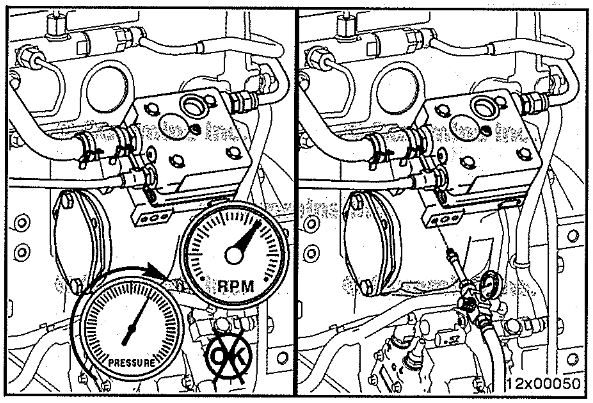
Air pressure must be released from the system before removing the air governor. The governor can be under pressure and cause personal injury.

Remove the air governor signal line from the air compressor. Install a pipe plug into the unloader port on the air compressor.

Operate the engine to activate the air compressor.

If the air system pressure does **not** rise, the unloader valve assembly is malfunctioning. See the appropriate troubleshooting symptom tree for repair direction.

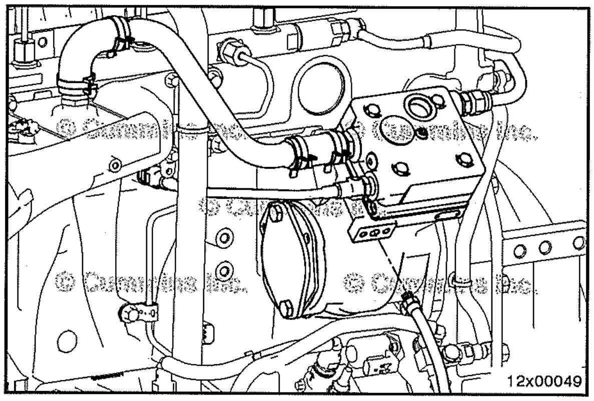




Connect a regulated shop air hose to the fitting in the unloader port.

Operate the engine to activate the air compressor.

When the air system pressure has reached 586 kPa [85 psi], apply 698 kPa [100 psi] of shop air pressure to the unloader port. If the vehicle air system pressure continues rising, the unloader valve assembly is malfunctioning. See the appropriate troubleshooting symptom tree for repair direction.



Remove the regulated shop air hose from the unloader port.

Connect the OEM air governor signal line to the air compressor unloader port.

Operate the engine to activate the air compressor. Verify that the system still builds pressure properly.

If the air system pressure continues to build beyond the governed point, the air governor is malfunctioning. See the appropriate troubleshooting symptom tree for repair direction.

Air Compressor (012-014)

Leak Test

WARNING

The external pressure tank used must meet SAE J10 and FMVSS121 standards, and have a safety pressure relief valve which opens between 1034 to 1207 kPa [150 to 175 psi]. Failure to use the proper pressure vessel and plumbing can result in property damage and serious personal injury.

Air Compressor Diagnostic Test

1 Park the vehicle. Use wheel chocks or an appropriate anti-roll device to stabilize the vehicle.

2 Remove the air discharge hose and air governor signal hose from the air compressor.

3 Plumb the air compressor discharge hose into an external pressure tank. The external pressure tank **must** be equipped with a 1034 kPa [150 psi] pressure gauge and 1034 kPa [150 psi] pressure relief valve. Make sure that the fittings are installed with appropriate thread sealant and do **not** leak.

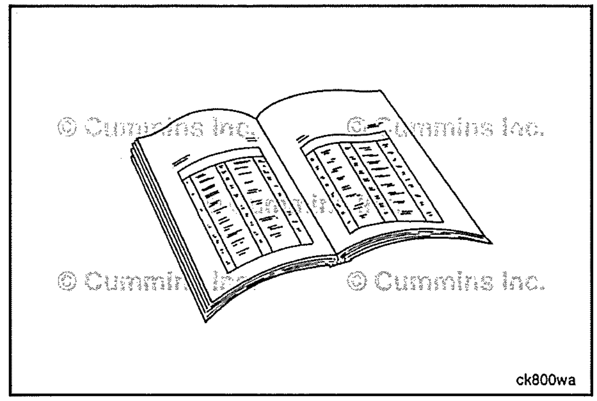
Start the engine and operate at idle engine speed.

NOTE: Once the external pressure tank pressure reaches 862 kPa [125 psi], shut the engine OFF.

Verify that the air compressor will build pressure in the external tank. If air pressure successfully builds, the air compressor functions properly. Inspect the rest of the air system components for leaks and verify proper operation. Reinstall the air discharge hose and air governor signal hose to the compressor.

If air pressure fails to build in the pressure tank, the air compressor has malfunctioned. Refer to Procedure 012-003 in Section 12.

Preparatory Steps



⚠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.

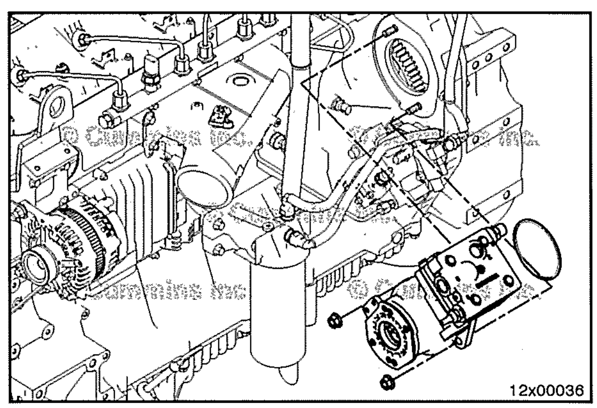
⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

⚠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.

- Use steam to clean the air compressor. Dry with compressed air.
- Remove the air compressor inlet tube. Refer to Procedure 012-109 in Section 12.
- Drain the engine coolant. Refer to Procedure 008-018 in Section 8.
- Remove the air compressor coolant lines. Refer to Procedure 012-004 in Section 12.
- Disconnect the air governor pressure signal line.
- Remove the air discharge line. See equipment manufacturer service information.

Remove

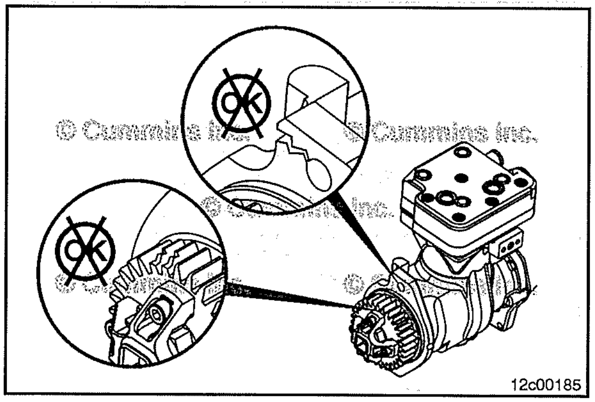


NOTE: When removing the nuts, the studs may also come loose from the housing. Ensure that neither the nuts nor the studs fall down into the hole in the flywheel housing.

Remove the two mounting nuts, starting with the upper nut, and the air compressor.

Discard the gasket.

If necessary, remove the mounting studs. Otherwise, do **not** remove from housing.



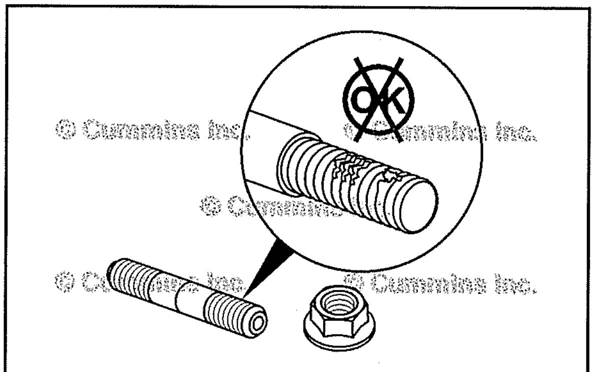
12c00185

Clean and Inspect for Reuse

Inspect the compressor housing for cracks or other damage.

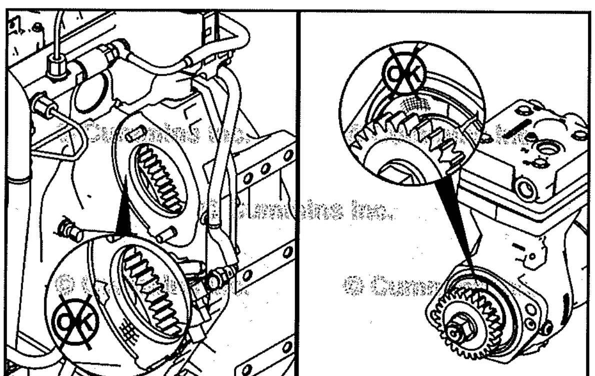
Inspect the compressor drive gear for cracks or other damage.

If there are cracks or other damage to either component, the air compressor assembly **must** be replaced.



12x00037

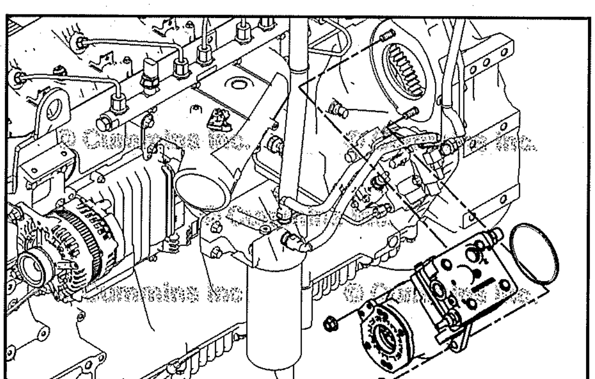
Inspect the mounting studs and mounting nuts for damaged threads or corroded surfaces. If damaged, the component **must** be replaced.



12x00038

Make sure the gasket surfaces of the flywheel housing and the air compressor are clean and **not** damaged.

If damage is found on the gasket surface that will result in a leak path, the damaged component **must** be replaced.


12x00036

Install

If removed, install and tighten the mounting studs.

Torque Value: 12 N•m [106 in-lb]

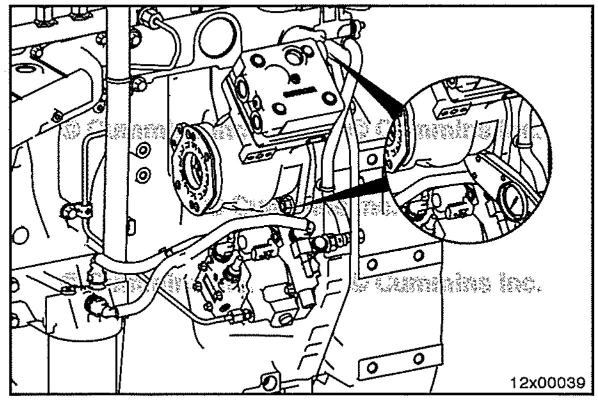
Install the air compressor and the two nuts onto the flywheel housing.

Tighten the nuts.

Torque Value: 80 N•m [59 ft-lb]

Tighten the nuts again.

Torque Value: 80 N•m [59 ft-lb]

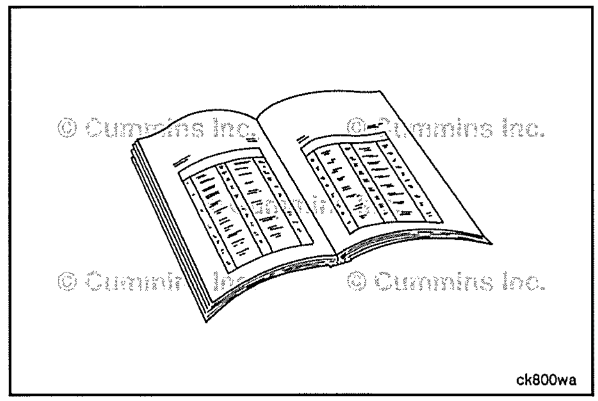


Finishing Steps

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.

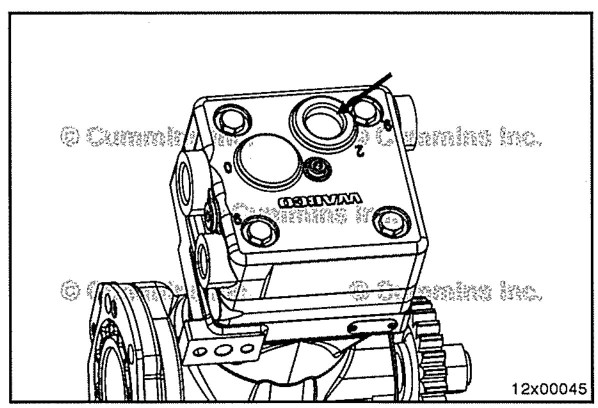
- Install the air discharge line. See equipment manufacturer service information.
- Connect the air governor pressure signal line.
- Install the coolant lines and fittings. Refer to Procedure 012-004 in Section 12.
- Install the air compressor inlet tube. Refer to Procedure 012-109 in Section 12.
- Fill the engine cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine to normal operating temperature and check for leaks.

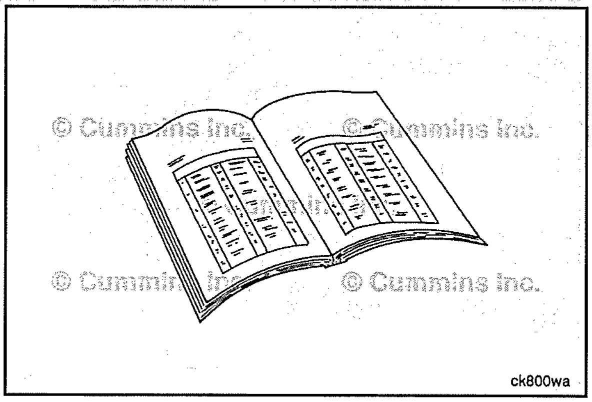


Air Compressor Discharge Lines (012-015)

General Information

The air discharge line is supplied and connected directly to the engine's air compressor by the vehicle OEM.





Preparatory Steps

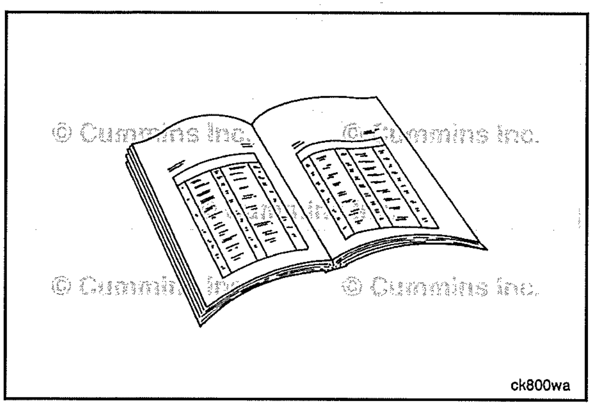
WARNING

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

Air discharge lines can be very hot. Make sure the lines are cool before touching to reduce the possibility of personal injury.

- Disconnect the batteries. See equipment manufacturer service information.
- Drain the vehicle air system. See equipment manufacturer service information.



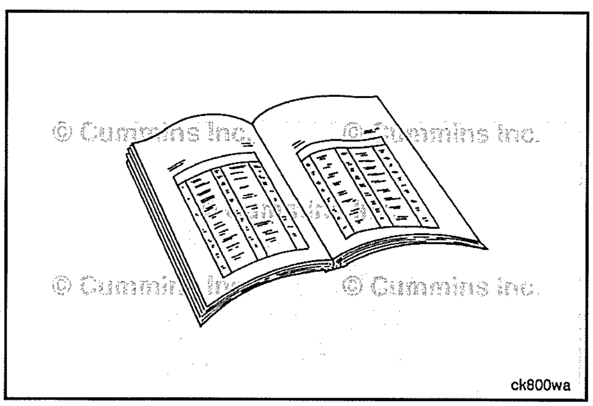
Remove

NOTE: Apply a counter-torque to the air compressor discharge fitting when loosening the discharge line.

See equipment manufacturer service information.

Disconnect the air compressor discharge.

Remove the discharge line.



Clean and Inspect for Reuse

WARNING

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

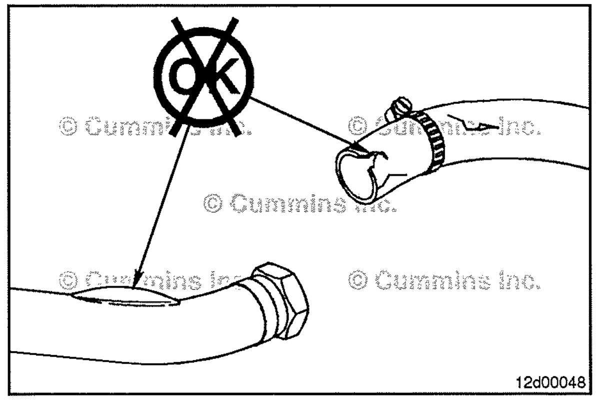
See equipment manufacturer service information.

Clean the air compressor discharge line.

Inspect the air compressor discharge line for any internal restrictions. Replace the component if any restrictions are found.

Inspect the air compressor discharge line for splits, cracks, hardening, or other damage.

Replace the component if any damage is found.



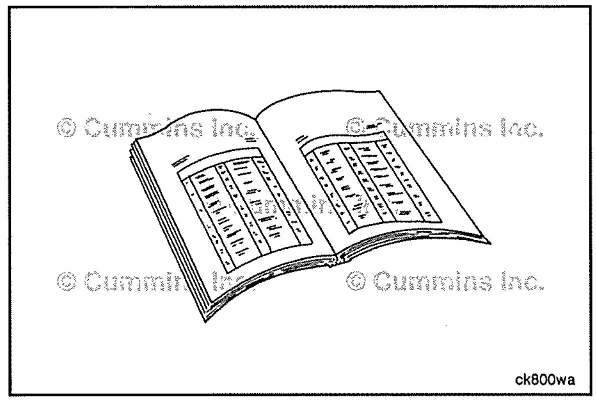
Install

NOTE: Apply a counter-torque to the air compressor discharge fitting when tightening the discharge line.

See equipment manufacturer service information.

Connect the air compressor discharge line.

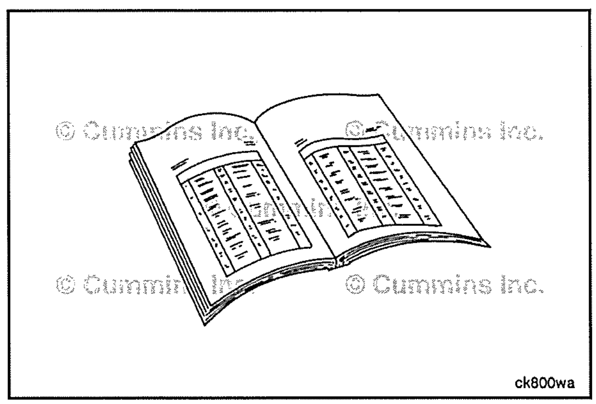
Tighten the air compressor discharge line fittings.



Finishing Steps

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

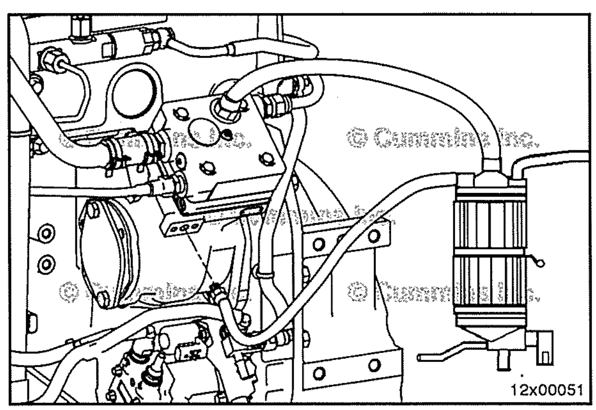
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks.

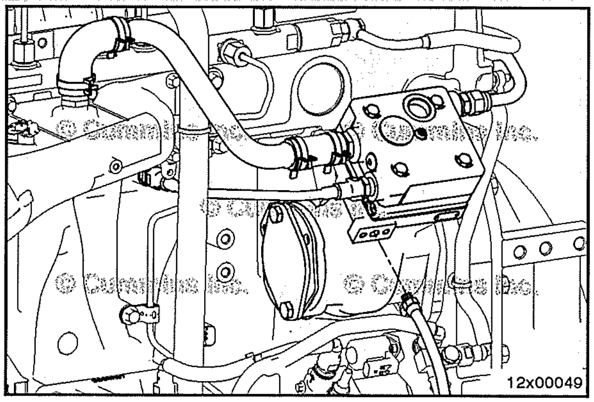


Air Governor (Air Compressor Will Not Pump) (012-017)

Initial Check

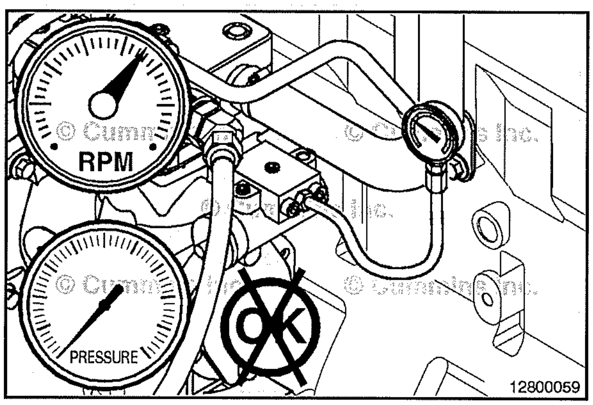
Verify that the air compressor is equipped with an air governor.





Remove

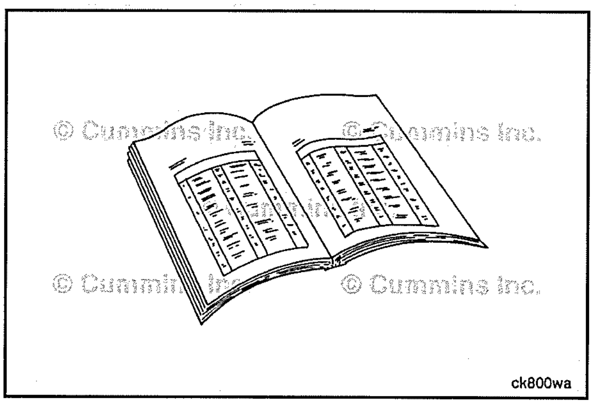
Remove the air governor signal line from the air compressor.



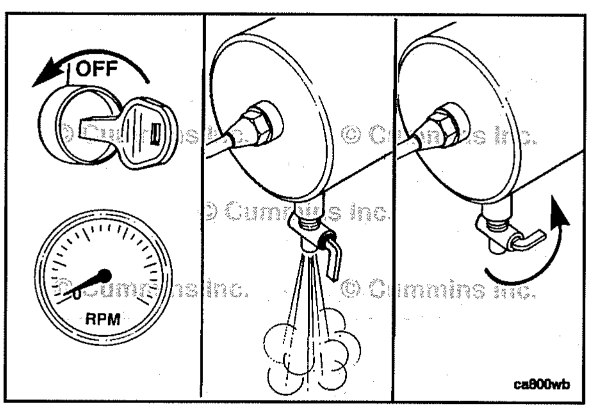
Inspect for Reuse

Operate the engine to activate the air compressor.

If the air compressor is pumping, the air governor is malfunctioning and **must** be replaced. See equipment manufacturer service information.



If the compressor does **not** pump with the governor removed, the unloader valve is malfunctioning. See the appropriate troubleshooting symptom tree for repair direction.



Air Leaks, Compressed Air System (012-019)

Initial 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 cock on the wet tank to release air from the system. Close the drain cock after the pressure is released.

Operate the engine to activate the air compressor.

With the air compressor pumping between 550 to 690 kPa [80 to 100 psi], use a solution of soapy water to check for air leaks in the following areas:

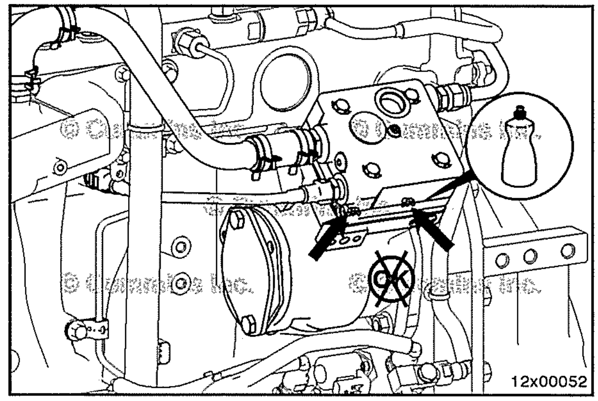
- Air compressor head gasket
- Air compressor cover gasket
- Hose and fitting leaks.

If air leaks are found, verify that the air compressor head and cover bolts are torqued properly. Make sure hoses and fittings are tight. Replace if necessary. If necessary, inspect the air compressor cylinder head gasket, air compressor inlet tube, or air compressor outlet connection.

Air Compressor Cylinder Head, Single Cylinder. Refer to Procedure 012-007 in Section 12.

Air Compressor Inlet Tube. Refer to Procedure 012-109 in Section 12.

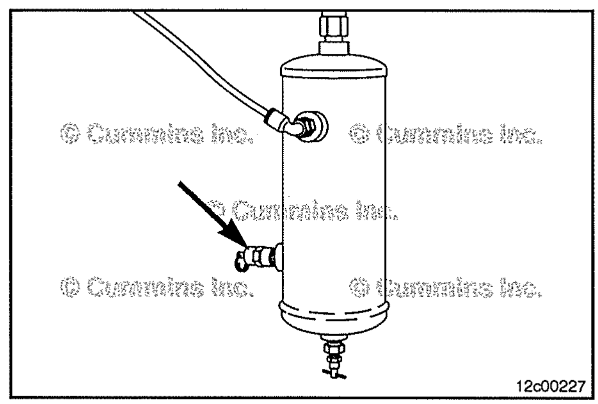
Air Outlet Connection. See equipment manufacture service information.



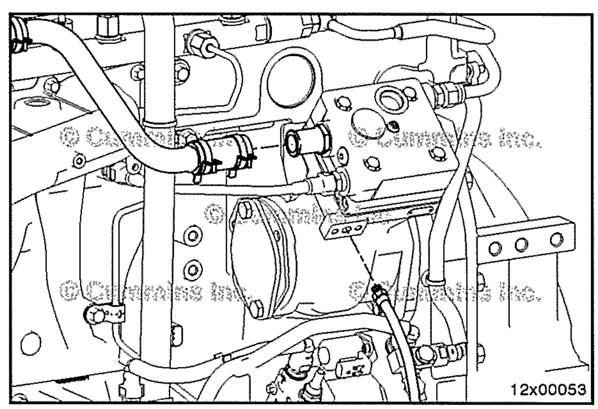
Air Pressure Relief Valve (012-024)

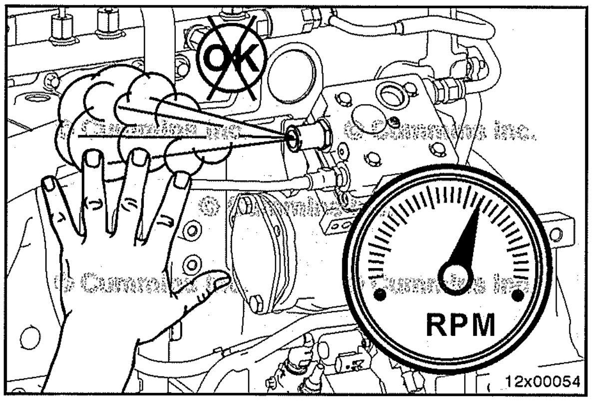
Initial Check

Verify the unit is equipped with an air pressure relief valve.



Remove the air governor signal line from the air compressor. Remove the air compressor inlet tube from the air compressor cylinder head. Refer to Procedure 012-109 in Section 12.



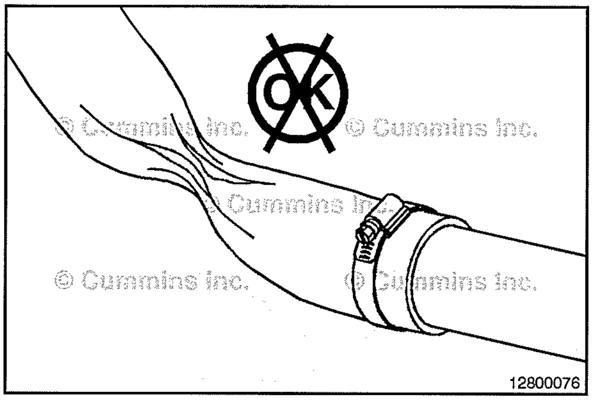


CAUTION

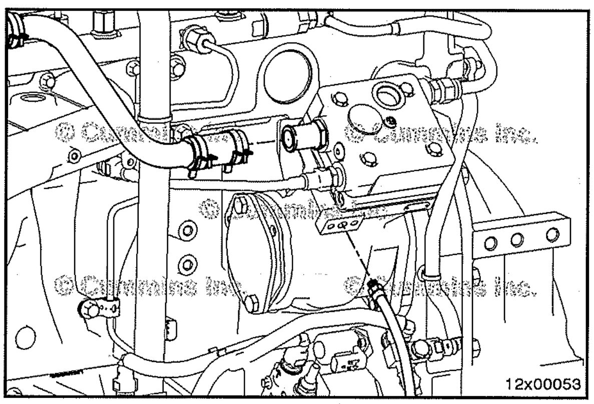
Do not hold hand too close to the intake port of the air compressor. Personal injury can result.

Operate the engine to activate the air compressor.

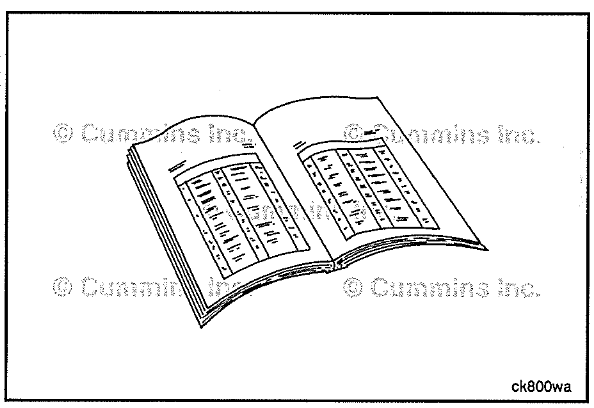
Hold your hand 5 cm [2 in] from the air compressor intake port. If air is coming out of the intake port, the pressure relief valve is malfunctioning and the air compressor cylinder head **must** be replaced. Refer to Procedure 012-007 in Section 12.



If no air is felt from the intake port, check downstream air system components for damage or restrictions.



Install the air compressor inlet tube to the cylinder head. Refer to Procedure 012-109 in Section 12. Install the air governor signal line to the air compressor.



Air Compressor Inlet Tube (012-109)

Preparatory Steps

WARNING

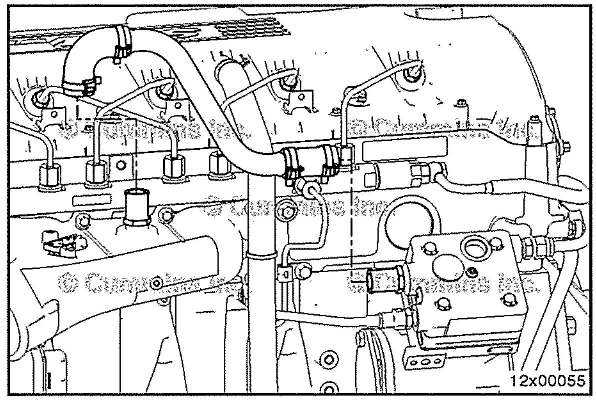
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries. See equipment manufacturer service information.

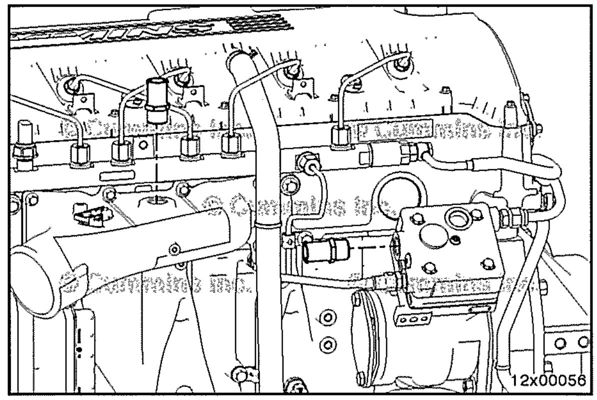
Remove

Remove the hoses and hose clamps from the air intake manifold and air compressor.

Remove the air compressor inlet tube from the engine.



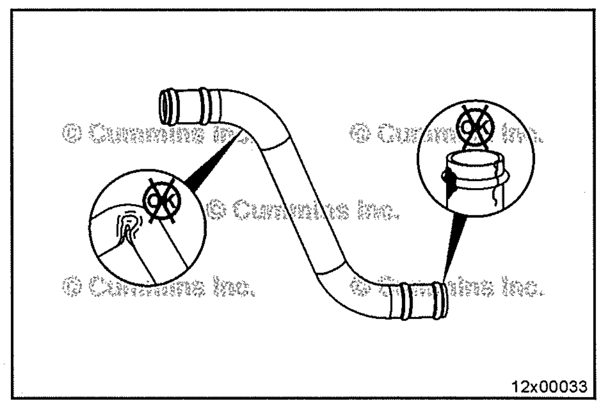
If necessary, remove the fitting from the air compressor head and from the air intake manifold.



Inspect for Reuse

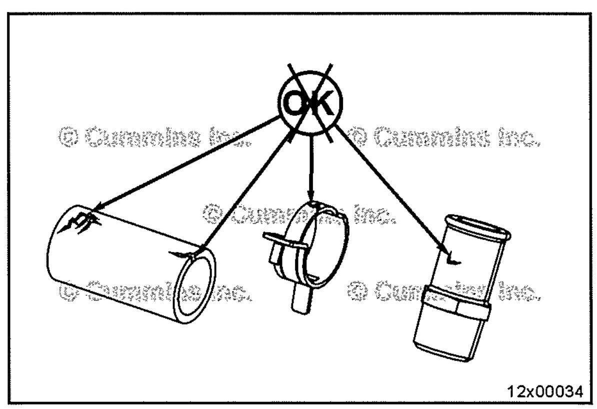
Inspect the air compressor inlet tubes for cracks or other damage.

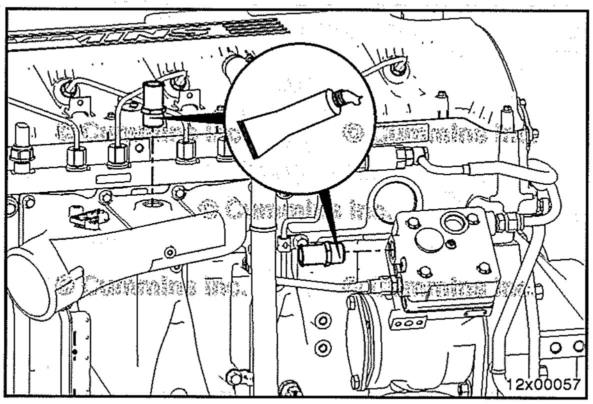
Replace the inlet tubes if cracks or other damage is found.



Inspect the hose clamps, air fittings, and hose clamps for cracks or other damage.

Replace any damaged components if cracks or other damage is found.



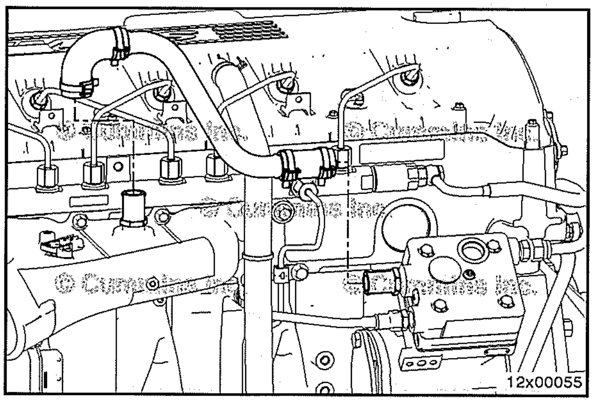


12x00057

Install

If removed, apply Loctite 592, Part Number 3375066, to the threads before installation. Install and tighten the fittings into the air compressor head and the air intake manifold.

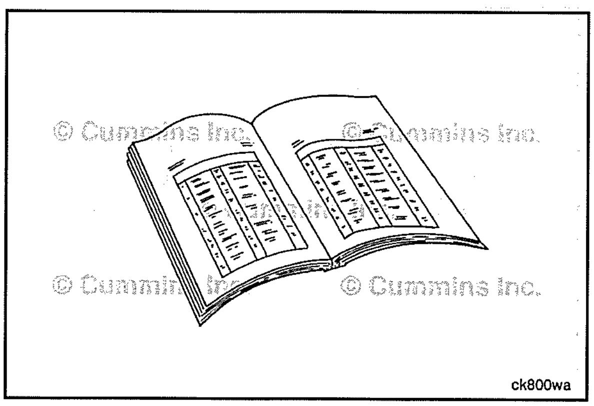
Torque Value: 45 N•m [33 ft-lb]



12x00055

Install the air compressor inlet tube to the engine.

Install the hoses and hose clamps to the air intake manifold and air compressor.



ck800wa

Finishing Steps

⚠WARNING⚠

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine to normal operating temperature and check for leaks.

Section 13 - Electrical Equipment - Group 13

Section Contents

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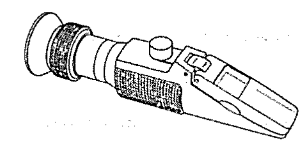
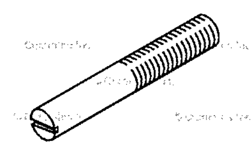
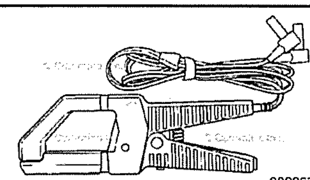
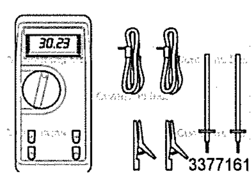
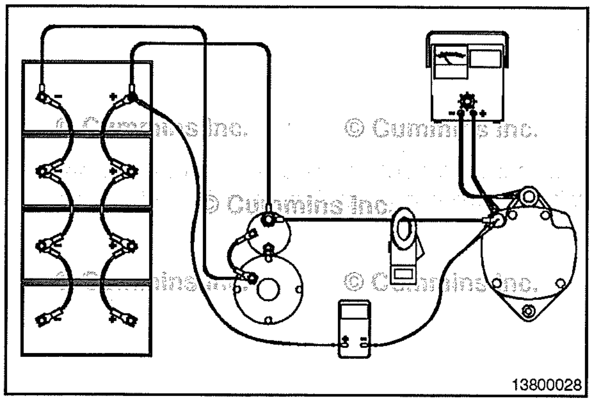
Service Tools

Electrical Equipment

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
CC-2800	**Refractometer** This tool is used to check the charge condition of a conventional battery.	
3163934	**Guide Pin** Used to help align the components during installation.	 22d00114
3164490	**Clamp-On Current Probe** This tool is used to measure AC and DC currents. This unit **must** be used with digital multimeter, Part Number 3400162.	 3823574
3400162	**Digital Multimeter Kit** This tool is used to test various electrical circuits. Includes deluxe multimeter 3164489, pressure adapter 3164491, and immersion probe 3164492.	 3377161
3824510	**QD Contact Cleaner** Used when cleaning electrical connections.	 3824510



Charging System Alternator (013-001)

Initial Check

Alternator Wiring Test

WARNING

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

WARNING

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

Systems that are 24-VDC **must** be connected into a temporary 12-VDC configuration.

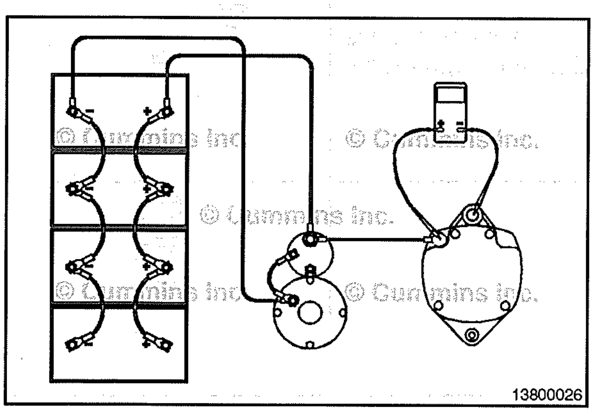
Attach the carbon-pile and clip-on ammeter, Part Number 3164490, as shown.

Adjust the load from the carbon-pile tester to the rated performance of the alternator.

Measure the voltage drop in both the positive and negative circuits.

Add these together and compare the sum to the table below.

System Voltage	Maximum Voltage Drop
12	0.5
24	1.0



Alternator Voltage Output Check

Attach the multimeter, from kit Part Number 3400162, to the alternator as shown in the illustration.

With the batteries in a fully charged condition and all the accessories off, start the engine and run it at high idle.

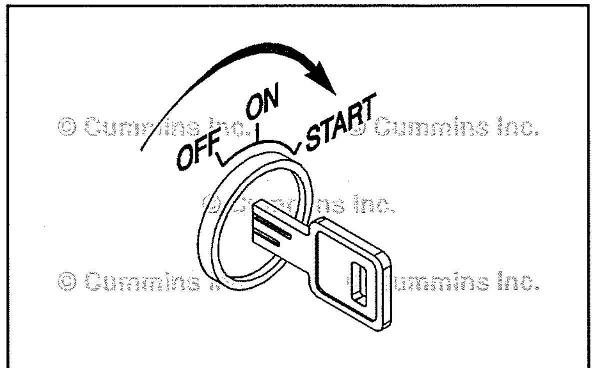
Allow time for the voltage to stabilize before taking any readings.

Measure the alternator output voltage.

System Voltage	Maximum Output Voltage Limit
12	15.5
24	31.0

Repair or replace the alternator or regulator if the voltage limit exceeds the value in the table.

Refer to the manufacturer's specifications for minimum voltage output.



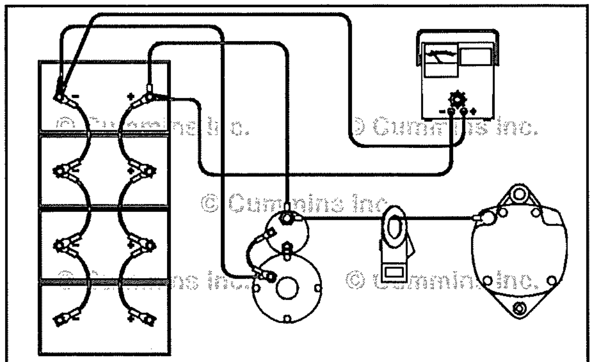
13800029

Alternator Current Output Test

Connect the carbon-pile tester to the batteries in parallel.

If more than one wire is connected to the alternator output terminal, clamp the ammeter around all wires.

Clamp the induction ammeter, Part Number 3164490, around the alternator output wire.


13800027

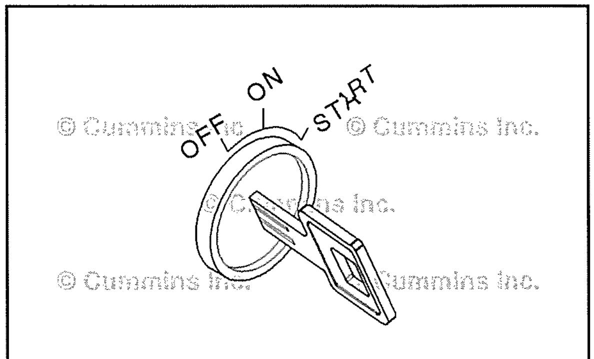
The alternator **must** be turning at approximate rated speed.

Most heavy-duty alternators are rated at 5000 rpm. Check the manufacturer's specifications for the specific alternator being tested.

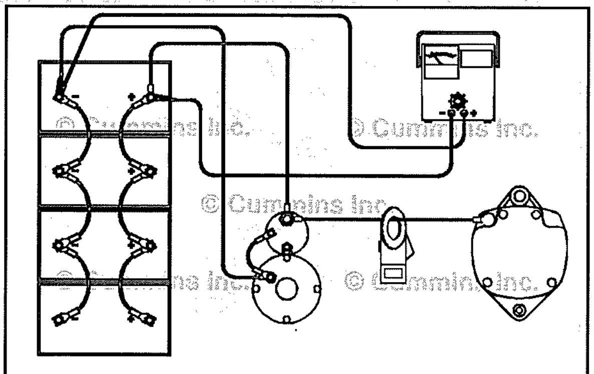
Make sure that all vehicle electrical loads are turned off.

Start the engine and operate at high idle.

Check the speed of the alternator using a digital optical tachometer. A slipping alternator drive belt can result in a low output reading. The alternator output is directly related to alternator speed.



19900325


13800027

Turn the carbon-pile tester on and adjust until the ammeter reaches its highest reading. Record this value.

Turn the carbon-pile tester off and shut the engine OFF.

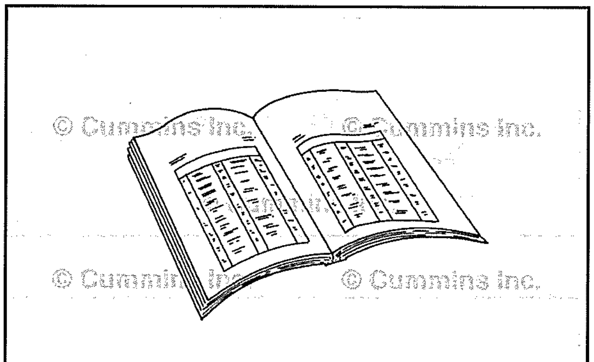
If the reading on the ammeter is 0 (no output), magnetize the rotor with the alternator hooked up normally.

Momentarily connect a jumper lead from the battery positive (+) to the alternator relay (R) or indicator (I) terminal.

This procedure applies to both negative (-) and positive (+) ground systems, and will restore the normal residual magnetism.

Repeat the test. If the output is still 0, replace the alternator.

If the alternator output is **not** within 10 percent of the rated output (stamped on the alternator case), replace the alternator.

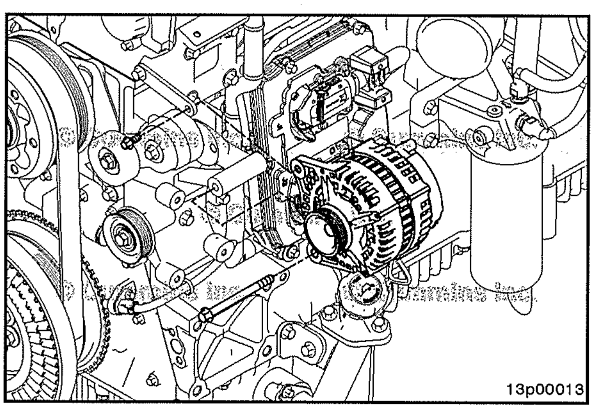

ck800wa

Preparatory Steps

WARNING

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

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the electrical connection from the alternator. Label the connections as they are removed.
- Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.


13p00013

Remove

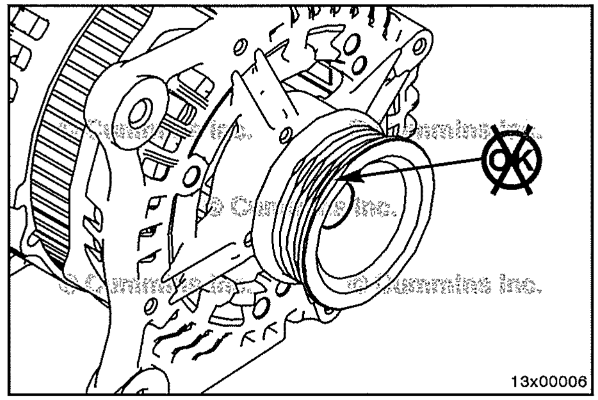
Remove the alternator top ear mounting capscrew (1).

Remove the alternator lower ear mounting capscrew (2) and alternator.

Clean and Inspect for Reuse

Inspect the alternator pulley for cracks or broken grooves.

If damage is found, replace the alternator.



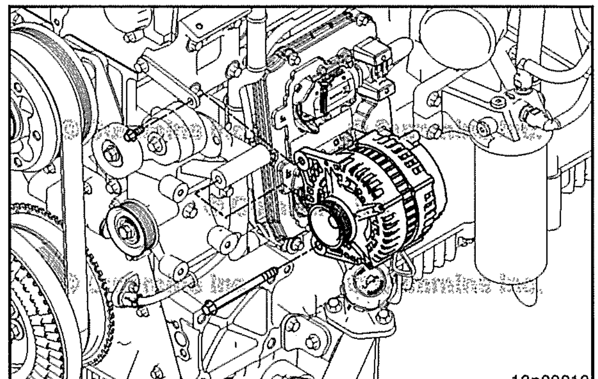
13x00006

Install

Install the alternator, alternator top ear mounting capscrew (1), alternator lower ear mounting capscrew to the mounting bracket (2).

Tighten the mounting capscrews.

Torque Value: 46 N•m [34 ft-lb]



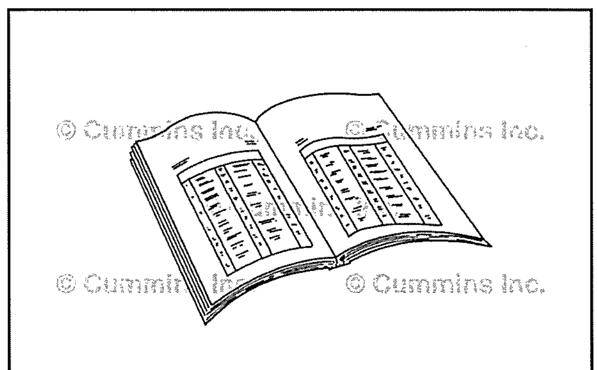
13p00013

Finishing Steps

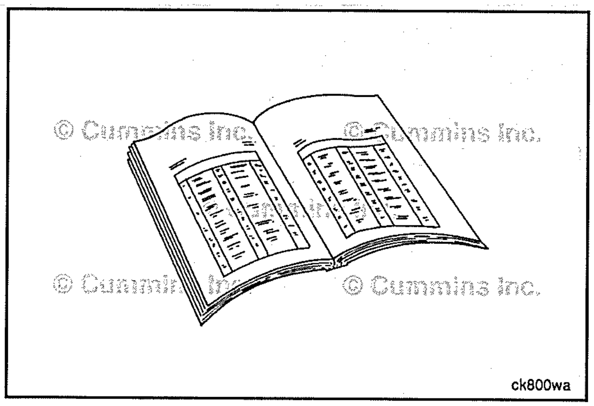
WARNING

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

- Install the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Connect the alternator electrical connections.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for proper operation.



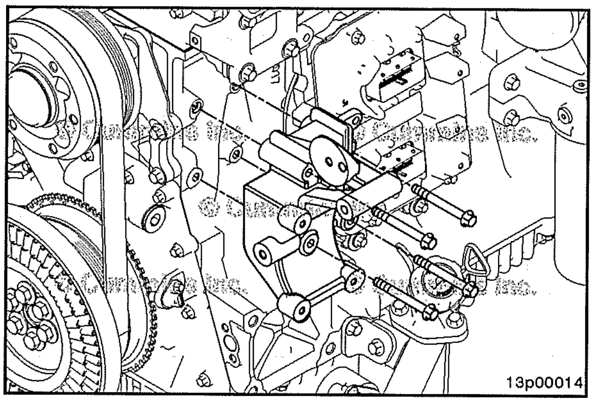
ck800wa



Charging System Alternator Bracket (013-003)

Preparatory Steps

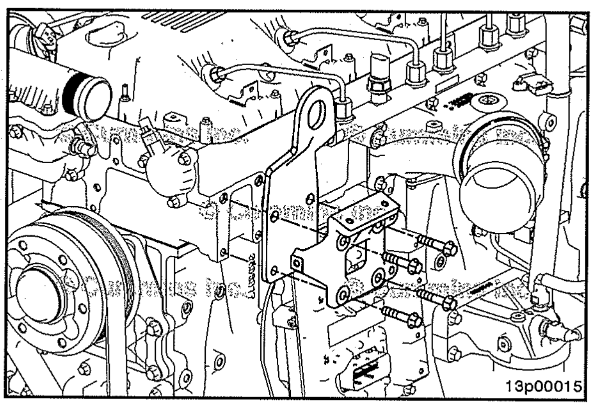
- Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Remove the refrigerant compressor (if equipped). Refer to Procedure 009-051 in Section 9.
- Remove the alternator idler pulley (if equipped). Refer to Procedure 013-039 in Section 13.
- Remove the alternator. Refer to Procedure 013-001 in Section 13.
- Remove the belt tensioner. Refer to Procedure 013-021 in Section 13.



Remove

Remove the four alternator bracket mounting capscrews and remove the alternator mounting bracket.

NOTE: There are two dowel pins which are press fitted into the backside of the bracket at the top two mounting capscrews. Make sure these dowel pins stay in the bracket.



Remove the four accessory bracket mounting capscrews, accessory bracket and front lifting bracket.

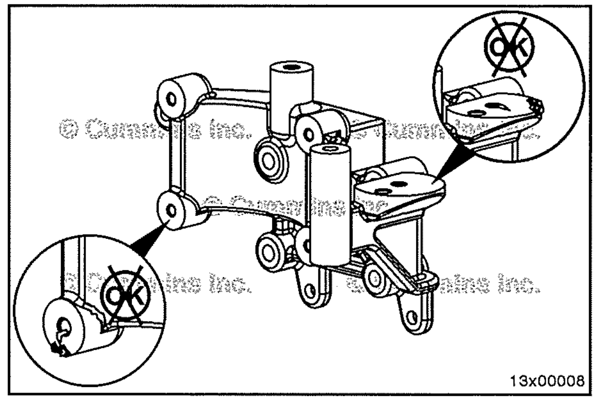
Inspect for Reuse

Inspect the alternator mounting bracket for cracks.

Replace if cracked.

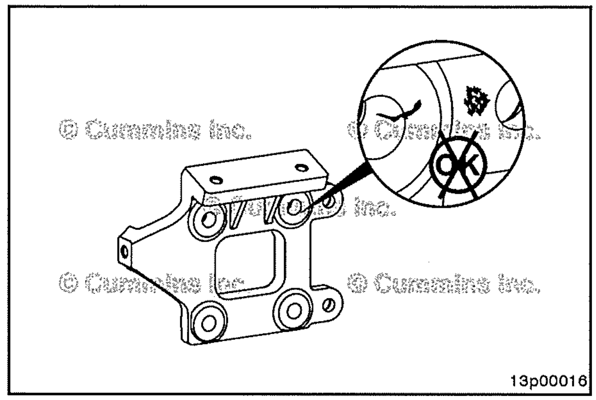
Inspect underneath the alternator and belt tensioner for wear.

If wear is found, replace the alternator bracket.



Inspect the accessory bracket for cracks and wear.

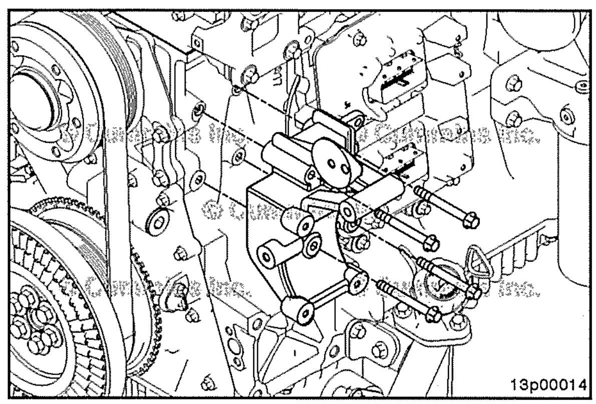
If cracks or wear is found, replace the accessory bracket.



Install

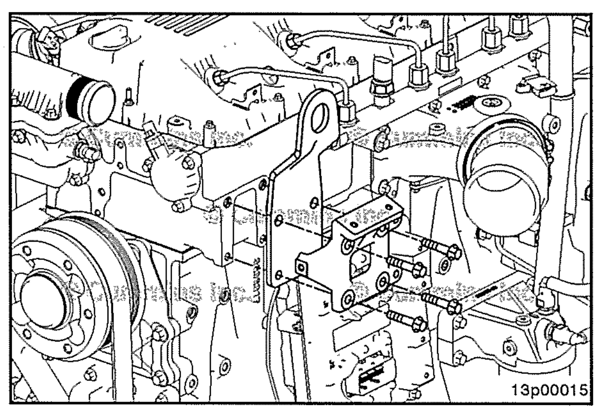
Install the alternator bracket and tighten the four mounting capscrews.

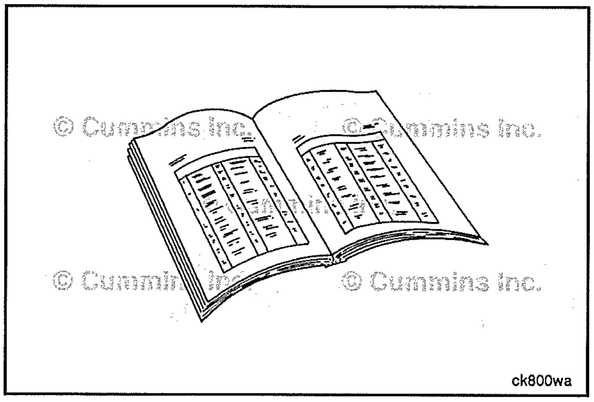
Torque Value: 65 N•m [48 ft-lb]



Install the front lifting bracket and accessory bracket and tighten the four mounting capscrews.

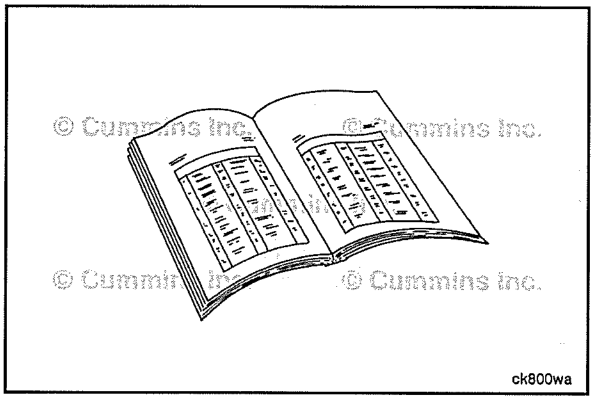
Torque Value: 46 N•m [34 ft-lb]





Finishing Steps

- Install the belt tensioner. Refer to Procedure 013-021 in Section 13.
- Install the alternator. Refer to Procedure 013-001 in Section 13.
- Install the refrigerant compressor (if equipped). Refer to Procedure 009-051 in Section 9.
- Install the alternator idler pulley (if equipped). Refer to Procedure 013-039 in Section 13.
- Install the alternator belt. Refer to Procedure 013-005 in Section 13.
- Operate the engine and check for proper operation.



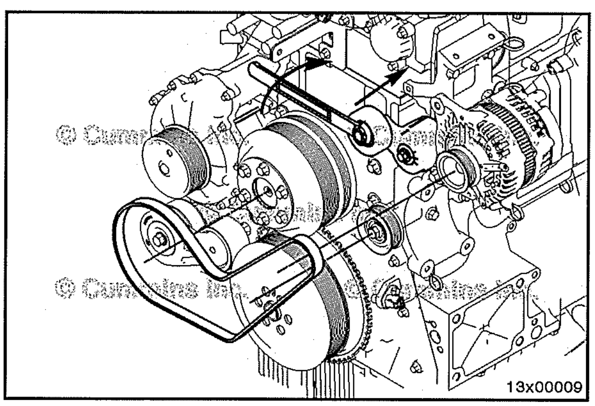
Charging System Alternator Drive Belt (013-005)

Preparatory Steps

⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.
- Make a diagram of the cooling fan belt routing and remove the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.

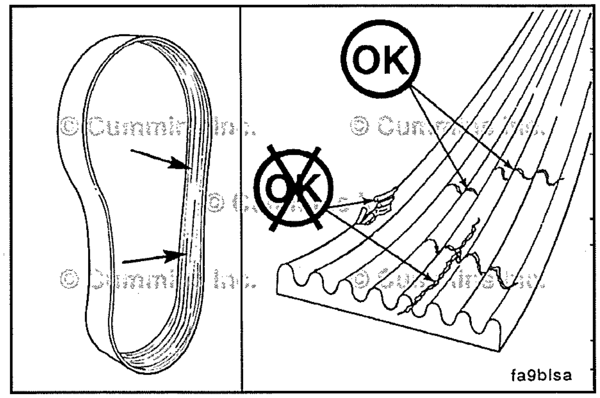


Remove

Use a socket and ratchet to rotate the tensioner pulley away from the belt until belt is loose enough to remove.

Remove the alternator belt while holding the tensioner and ratchet.

Clean and Inspect for Reuse



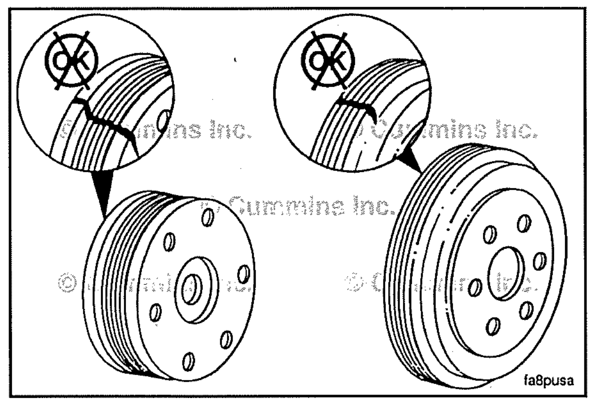
Check the belt for damage. Transverse (across the belt width) cracks are acceptable. Longitudinal (direction of the belt length) cracks that intersect with transverse cracks are **not** acceptable. If the belt is frayed or has any piece of material missing, the belt is unacceptable and needs to be replaced.

Inspect the belt for:

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

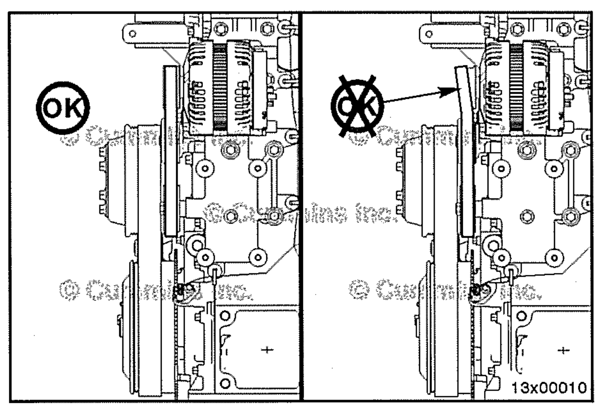
Replace the belt if any damage is found.

NOTE: If a damaged belt spun on a pulley, inspect the pulley for damage. Use the following procedure for pulley inspection. Refer to Procedure 009-051 in Section 9.



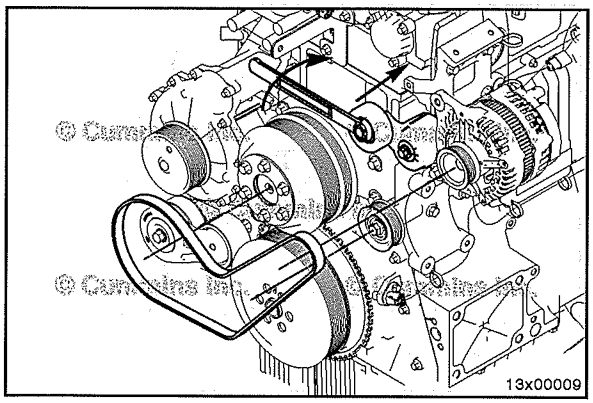
Inspect the idler and drive pulleys for wear or cracks.

Inspect the alternator drive belt tensioner. Refer to Procedure 013-021 in Section 13.



Inspect the pulley alignment.

Pulley misalignment **must not** exceed 4.5 mm for each meter of distance between the pulley centers.



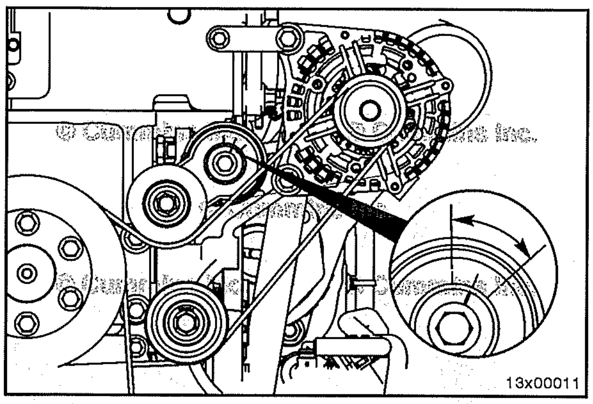
Install

Install a new belt over the pulleys while holding the tensioner back. Be careful **not** to damage the belt while working it over the flanged pulleys.

Do **not** roll a belt over the pulley or pry on it with a tool.

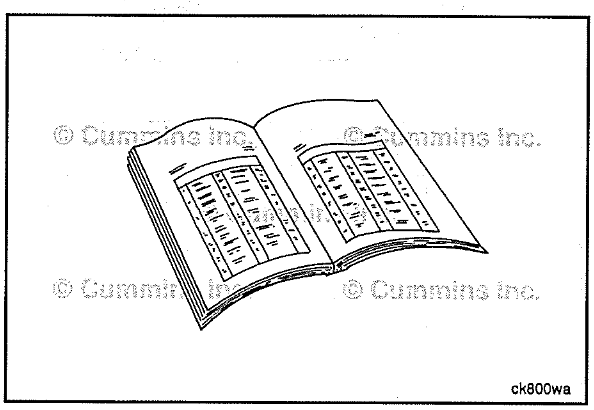
Release the tensioner slowly, and remove the socket and ratchet.

Belt drive systems equipped with an automatic belt tensioner can **not** be adjusted. A belt tension gauge will **not** give an accurate measure of the belt tension. The automatic belt tensioner is designed to maintain the proper belt tension over the life of the belt. **Only** an inspection of the tensioner is required. Refer to Procedure 013-021 in Section 13.



The belt tensioner is designed to operate within the limit of arm movement provided by the internal cast stops when the belt length and geometry are correct. The tensioner contains three external marks to indicate if the tensioner is hitting either of the limits. The middle mark indicates proper tension.

If the tensioner is hitting either of the limits during operation, check the mounting brackets and belt length. Loose brackets, bracket failure, alternator movement, incorrect belt length, or belt failure can cause the tensioner to hit the limits.



Finishing Steps

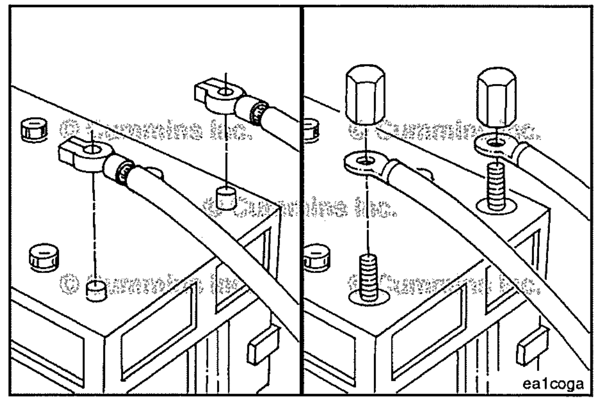
WARNING

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

- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Run engine and check operation.

Batteries (013-007)

General Information

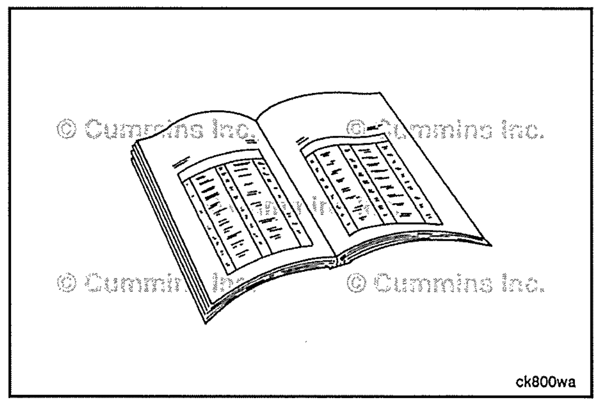


WARNING

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.

There are many types of batteries with varying technology. Common battery types include:

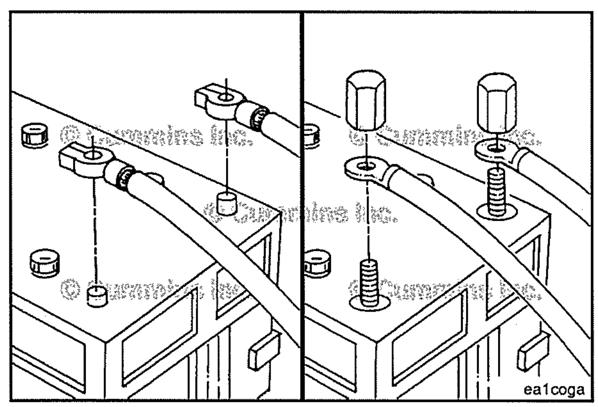
- Standard lead acid (also called flooded or wet cell)
- Starting
- Deep cycle
- Serviceable or maintenance free
- Maintenance free absorbent glass mat (AGM)
- Maintenance free gel cell



Check Original Equipment Manufacturer (OEM) or battery supplier service literature for battery removal and installation, maintenance, inspection, and testing requirements.

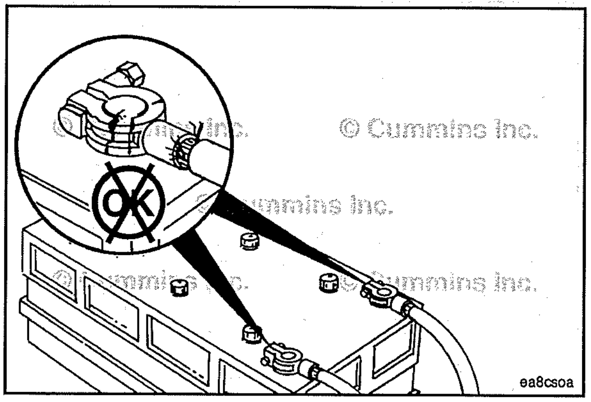
Battery Cables and Connections (013-009)

Initial Check



There are two possible heavy-duty battery connections:

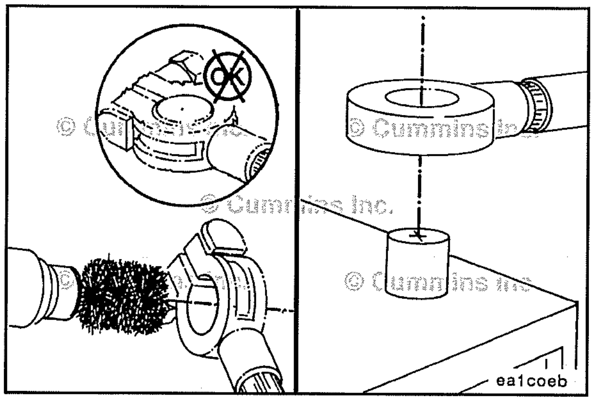
- Battery terminal and clamp (1)
- Threaded battery terminal and nut (2).



⚠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.

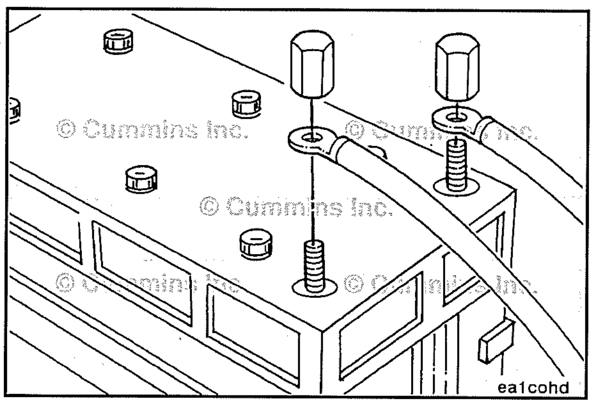
Remove and inspect the battery cables and connections for cracks or corrosion.

Replace broken terminals, connectors, or cables.



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

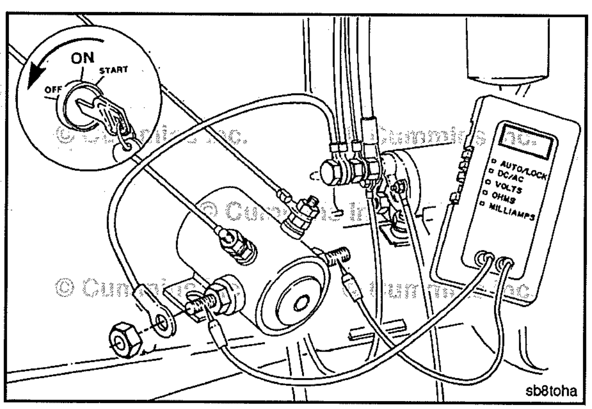
Make sure all debris is removed from the connecting surfaces.



⚠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.



Starter Magnetic Switch (013-017)

Current Check

⚠WARNING⚠
Be sure the keyswitch is in the OFF position to reduce the possibility of electrical shock and personal injury.

Remove the cable connecting the magnetic switch to the starter solenoid from the magnetic switch terminal.

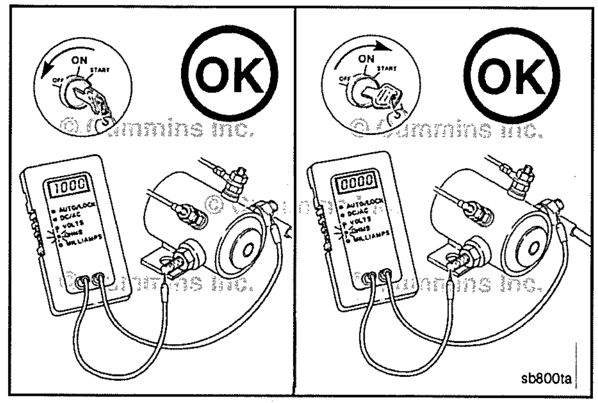
Connect the leads of the Cummins® digital multimeter, Part Number 3377161, to the two large switch terminals.

Set the multimeter to measure resistance (ohms).

With the starter switch OFF, the multimeter **must** indicate resistance at infinity (open circuit).

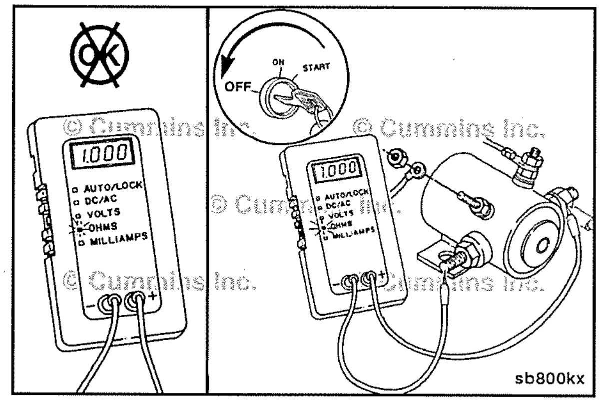
Turn the starter switch to the START position.

The multimeter **must** indicate zero resistance (closed circuit).

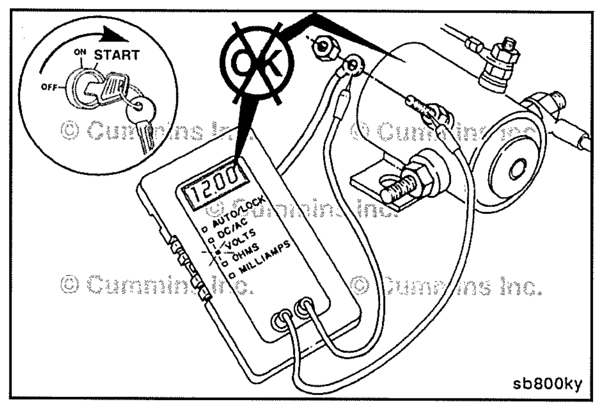


If the multimeter indicates resistance at infinity with the starter switch in the START position:

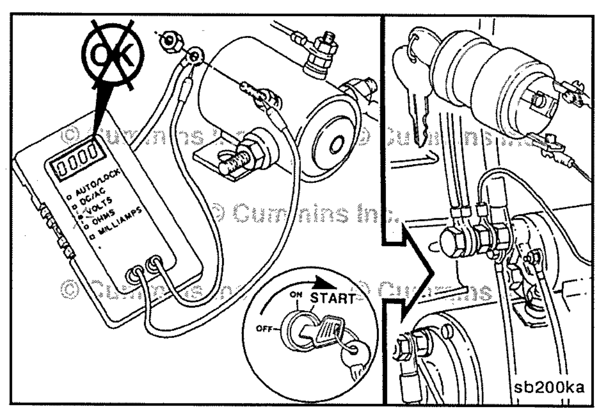
- Turn the starter switch OFF.
- Remove the ground wire connected to one of the small magnetic switch terminals.

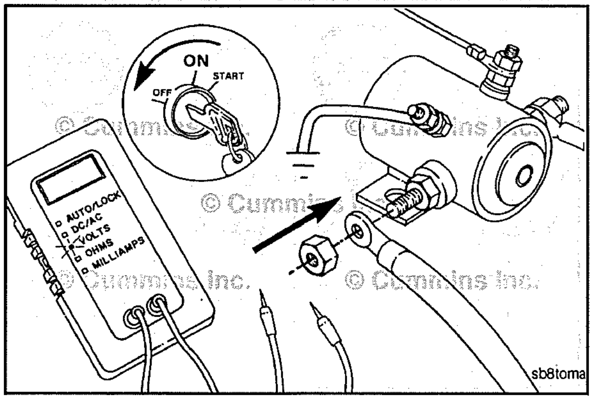


- Set the multimeter scale to indicate volts, 24-VDC or more.
- Connect the positive lead of the multimeter to the magnetic switch ground terminal and the other lead to the ground wire.
- Turn the starter switch to the START position.
- The multimeter **must** indicate vehicle electrical system voltage.

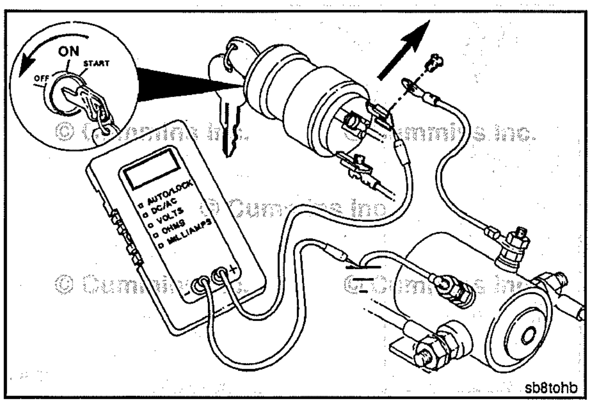


- If the multimeter does **not** indicate voltage, Refer to Procedure 013-018 in Section 13.





- Turn the starter switch to the OFF position.
- Remove the multimeter leads.
- Connect the starter solenoid cable to the magnetic switch terminal and the ground wire to its corresponding terminal on the magnetic switch.



Starter Switch (013-018)

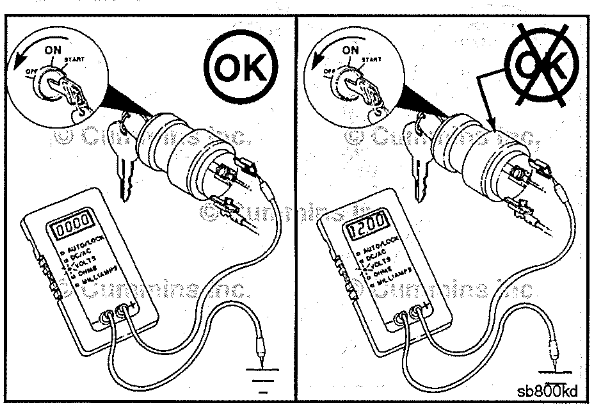
Voltage Check

WARNING

Be sure the keyswitch is in the OFF position to reduce the possibility of electrical shock and personal injury.

Remove the wire connecting the starter switch to the magnetic switch from the starter switch terminal.

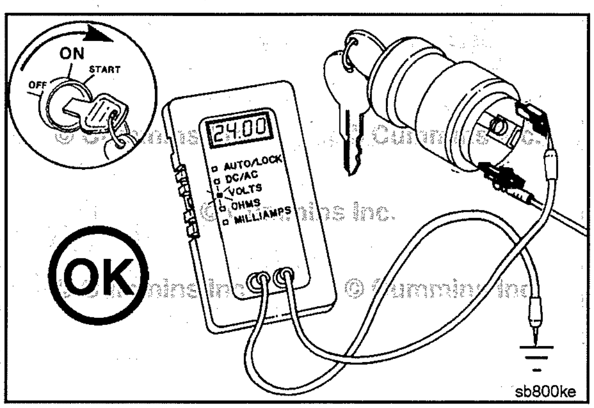
Connect the positive lead of Cummins® digital multimeter, Part Number 3377161, to the starter switch terminal and the negative lead to the chassis or an engine ground location.



- Set the multimeter to indicate DC volts.

With the starter switch in the OFF position, there **must not** be a voltage reading.

If the meter indicates voltage, the starter switch is malfunctioning and **must** be replaced.

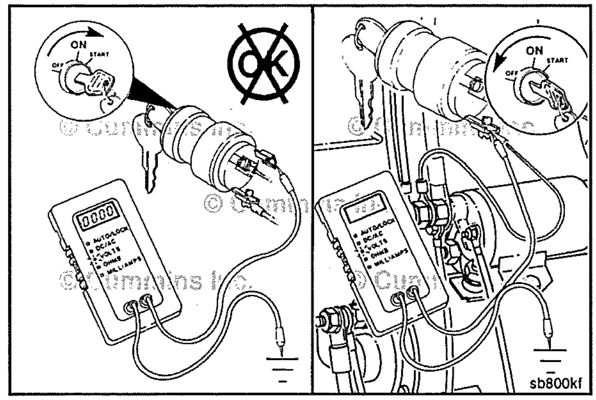


Turn the starter switch to the START position.

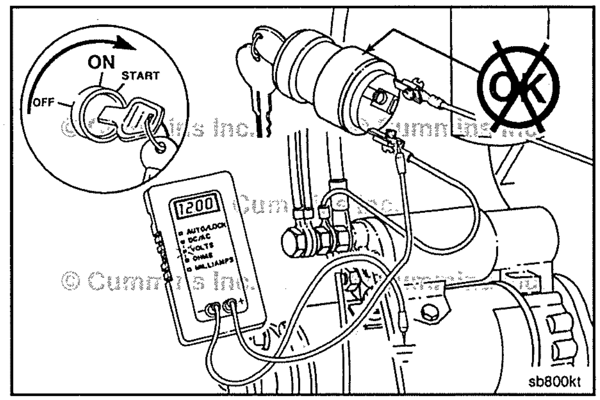
The multimeter **must** indicate voltage in order for this check to be normal.

If there is **not** voltage:

- Turn the starter switch to the OFF position.
- Check the cable from the positive (+) voltage terminal of the starter solenoid to the starter switch for breaks.
- Check for loose or corroded connections.



If the cable is good and the connections are clean and tight, the starter switch is malfunctioning and **must** be replaced.



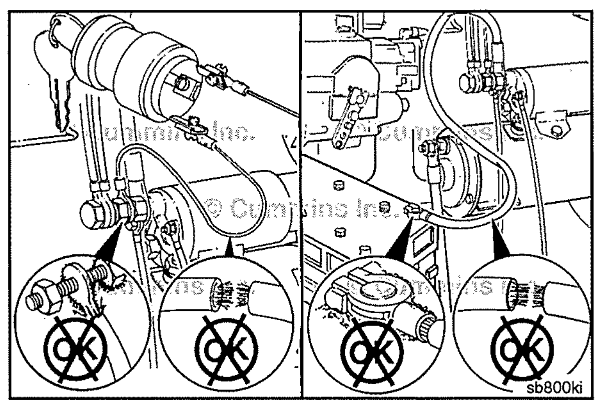
Starter Solenoid (013-019)

Voltage Check

Use digital multimeter, Part Number 3400162, with the switch set to indicate DC volts.

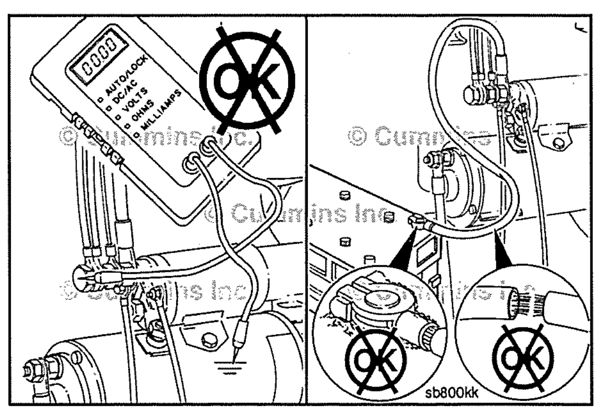
Connect the multimeter positive (+) lead to the starter solenoid positive (+) cable terminal and the negative (-) lead to the chassis or engine ground location.

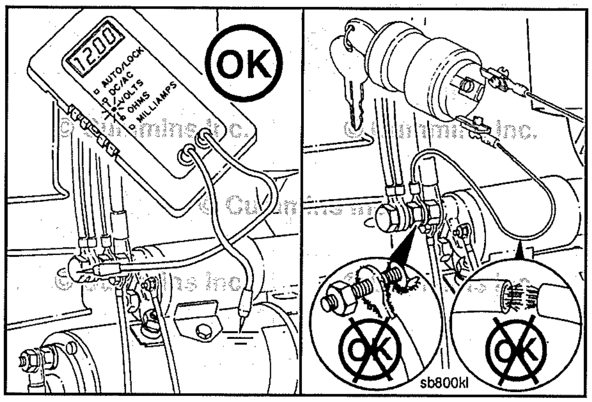
The multimeter **must** indicate voltage with the starter switch OFF to be normal.



If the multimeter does **not** indicate voltage,

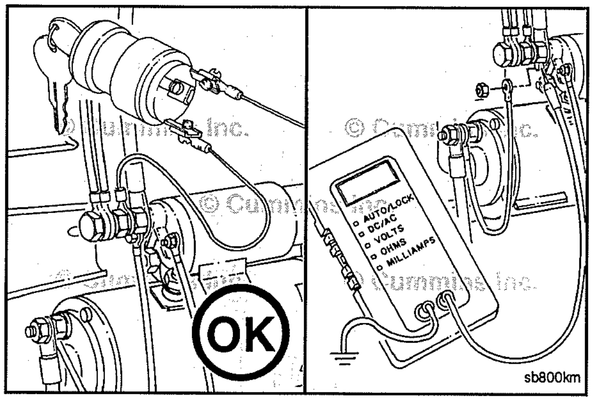
- Check the cable connecting the starter solenoid and battery for breaks or cracks.
- Check for loose or corroded connections.





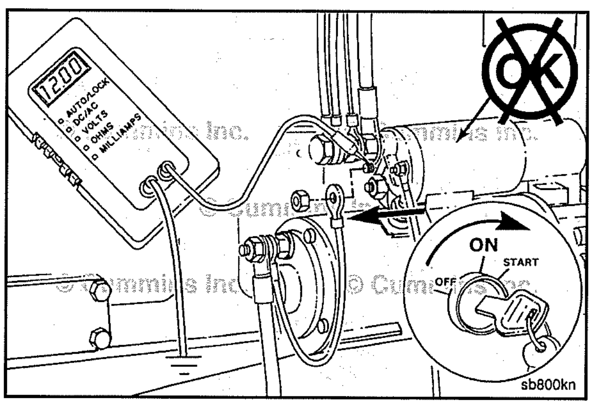
If the multimeter indicates voltage but the starter will **not** operate,

- Check the wire connecting the starter solenoid to the starter switch for breaks or cracks.
- Check for loose or corroded connections.



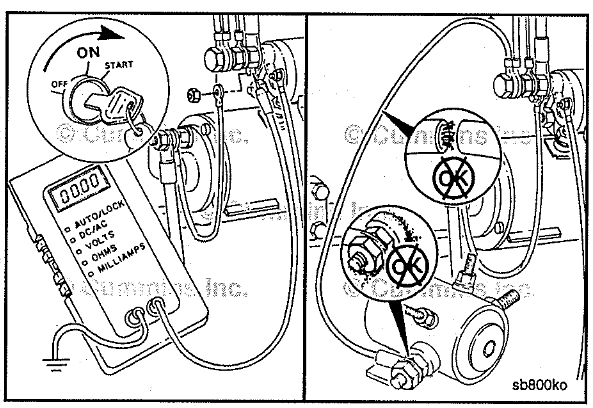
If the wire connecting the starter solenoid and starter switch is **not** loose or damaged and the starter will **not** operate:

- Remove the cable connecting the starter and starter solenoid from the solenoid terminal.
- Connect the multimeter positive (+) lead to the solenoid positive (+) terminal and the negative (-) lead to the chassis or an engine ground location.



- Turn the starter switch to the START position.

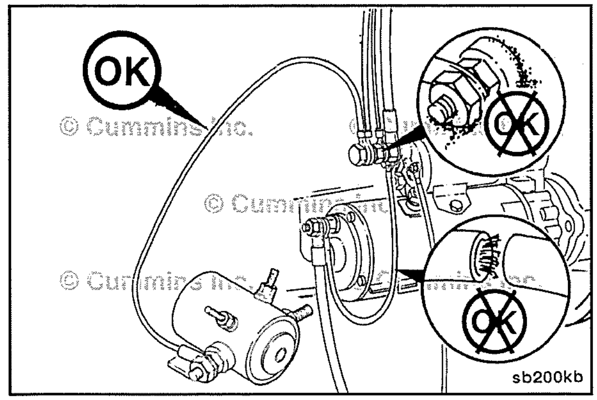
If the multimeter indicates voltage, the starter solenoid is malfunctioning and **must** be replaced.



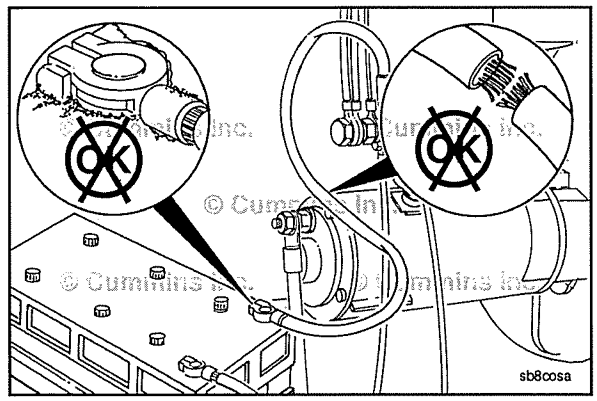
If the multimeter does **not** indicate voltage, check the wire connecting the starter solenoid to the magnetic switch for breaks and loose or corroded connections.

If the wire connecting the starter solenoid to the magnetic switch is **not** loose or damaged and the starter will **not** operate:

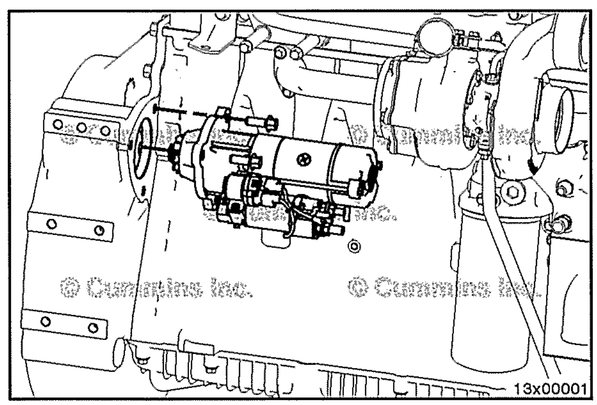
- Check the cable connecting the starter solenoid to the starting motor for breaks and loose or corroded connections.



- Check the cable connecting the starting motor to the battery for breaks and loose or corroded connections.

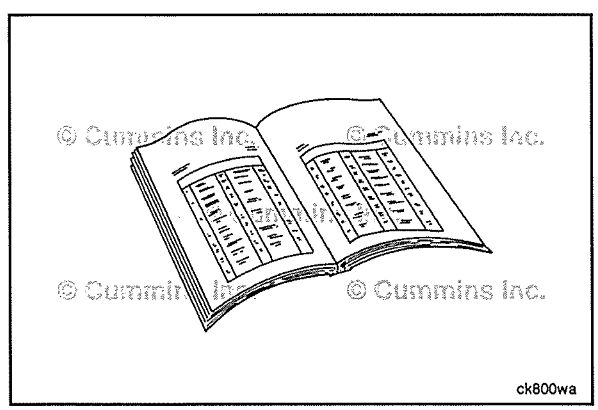


If the cables are **not** loose or damaged, the starting motor is defective and **must** be replaced. Refer to Procedure 013-020 in Section 13.



Starting Motor (013-020)

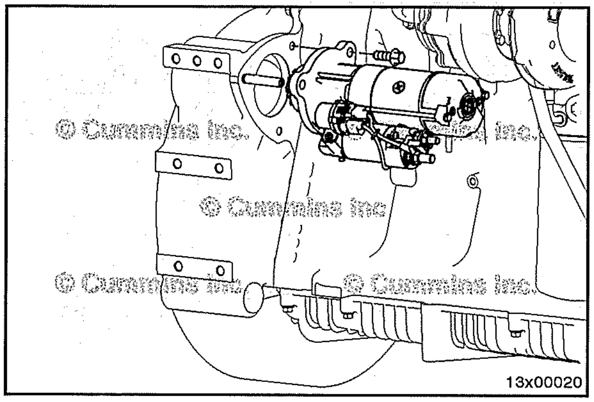
Preparatory Steps



⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.
- Tag and remove the electrical connections from the starting motor.

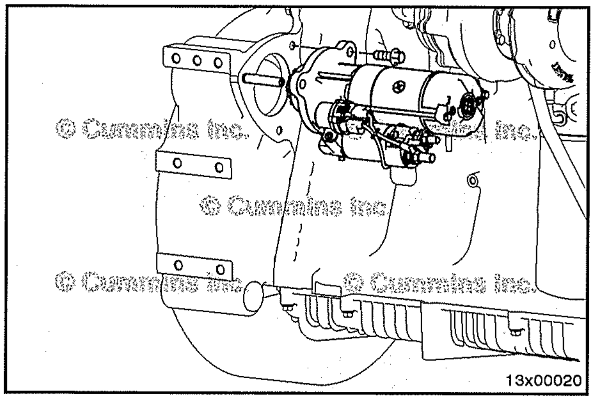


Remove

Remove the ground strap (if used).

Remove one capscrew and install guide pin 3163934.

Remove remaining two capscrews and starting motor.



Install

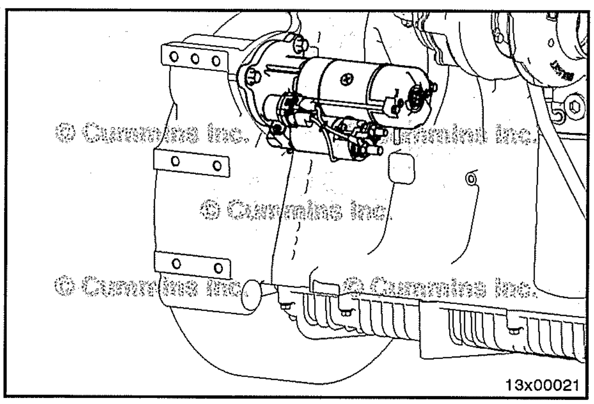
CAUTION

Make sure to use the same thickness of starting motor spacer (if used) as the one removed to install the starting motor, to reduce the possibility of engine or starting motor damage.

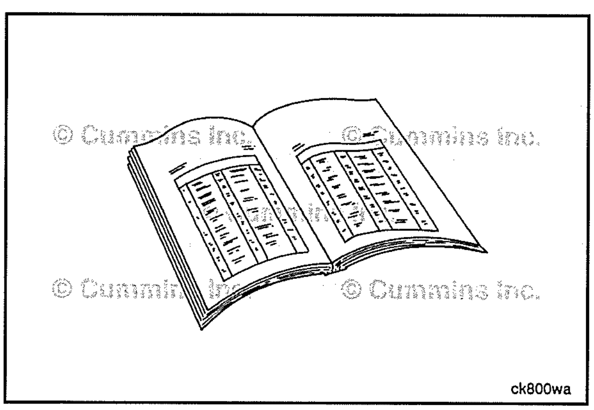
Using guide pin Part Number 3163934, install the starting motor and the three M12 grade 9.8 mounting capscrews.

Tighten the capscrews.

Torque Value: 80 N•m [59 ft-lb]



Install and tighten the electrical connections to the starting motor, including the ground strap (if used).



Finishing Steps

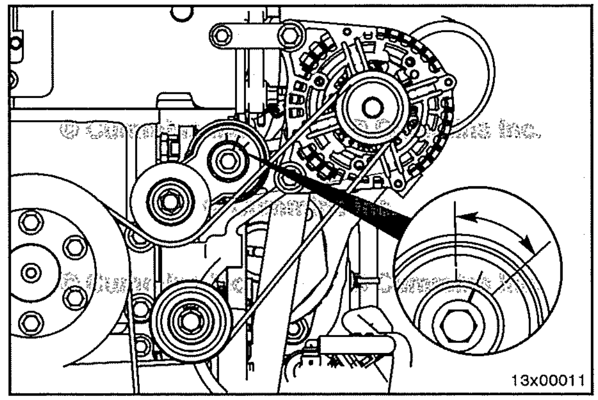
WARNING

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 and tighten the battery electrical connections. See equipment manufacturer service information.
- Operate the engine and check for proper operation.

Charging System Alternator Automatic Belt Tensioner (013-021)

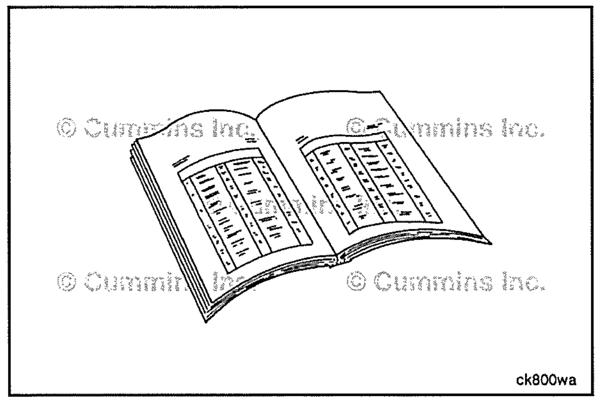
Initial Check



The tensioner has marks on the front to indicate tension. The middle of the three marks indicates proper tension.

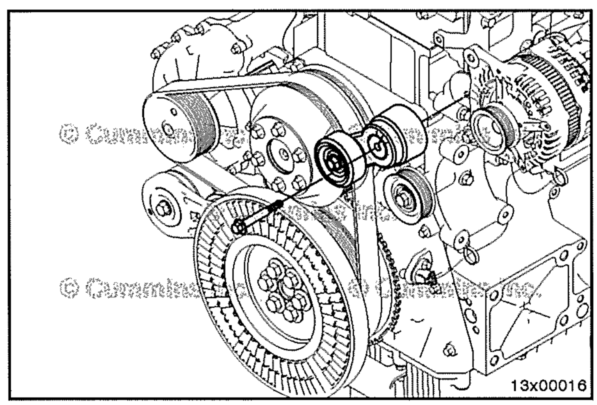
If the tensioner marks indicate improper tension, check the mounting brackets and the belt length. Loose brackets, bracket failure, alternator movement, incorrect belt length, or belt failure can cause the tensioner to give improper tension.

Preparatory Steps



- Remove the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the alternator drive belt. Refer to Procedure 013-005 in Section 13.

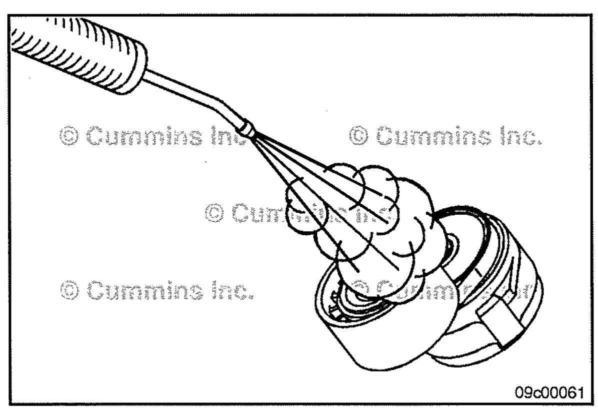
Remove



While tensioner is still on the engine, pivot the tensioner through the full range of motion. Tensioner **must** move with resistance from internal spring, if **not** replace tensioner.

Remove the mounting capscrew and the belt tensioner from the bracket.

Clean and Inspect for Reuse



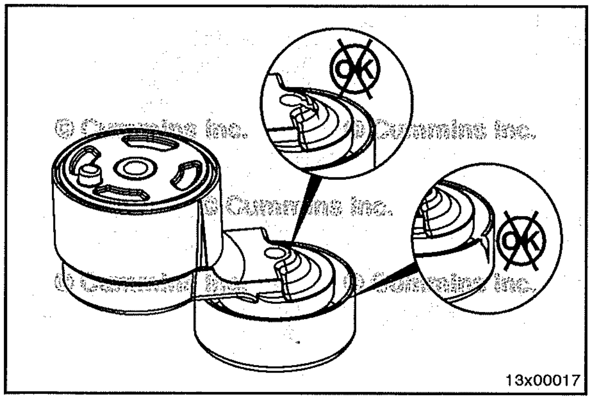
WARNING

The belt tensioner is spring loaded. Do not attempt to disassemble the tensioner. Personal injury can result.

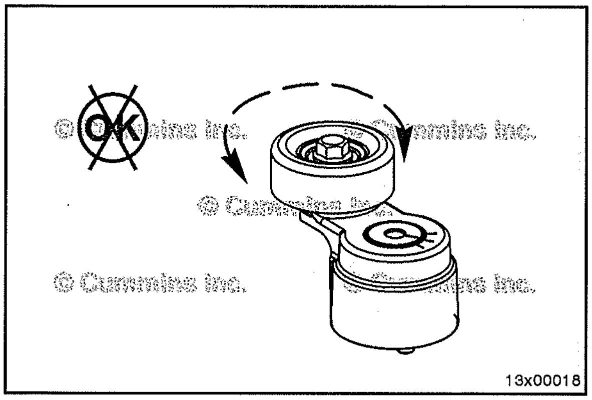
WARNING

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

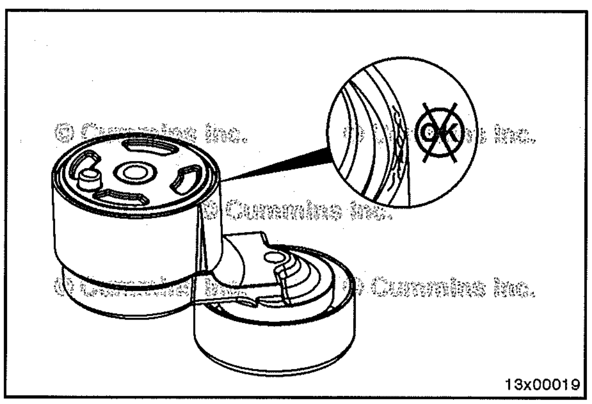
Check the tensioner for dirt buildup. If tensioner has dirt buildup, remove and use safety solvent to clean belt tensioner.



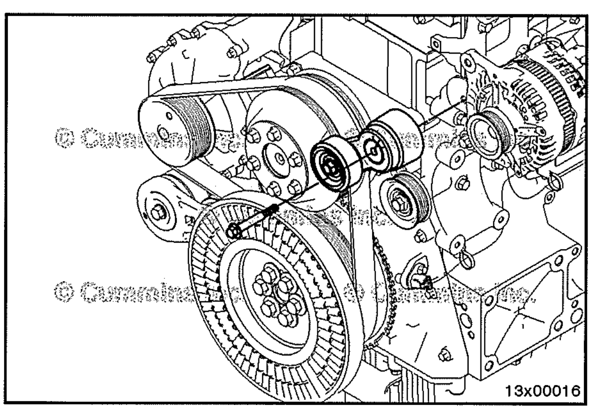
Check the belt tensioner pulley and body for cracks. If cracks are found, replace the tensioner.



Spin the tensioner pulley. The pulley **must** spin freely. If pulley does **not** spin freely, replace the belt tensioner.



Inspect the belt tensioner for evidence of the tensioner pivoting arm contacting the stationary circular base of the tensioner or the alternator bracket. If so, the pivot bushing is excessive worn. Replace the belt tensioner.



Install

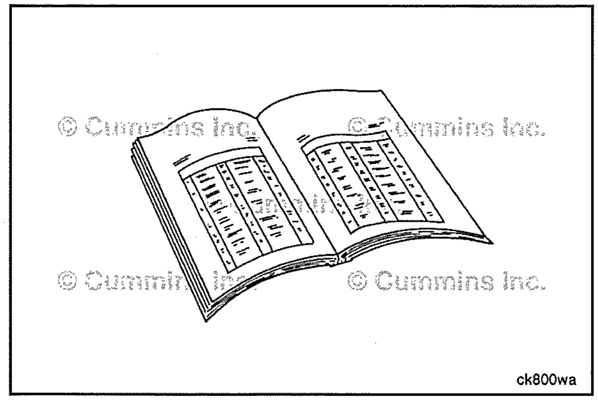
Install the belt tensioner. The tensioner has a pin for alignment with the alternator bracket.

Install and tighten capscrew.

Torque Value: 46 N•m [34 ft-lb]

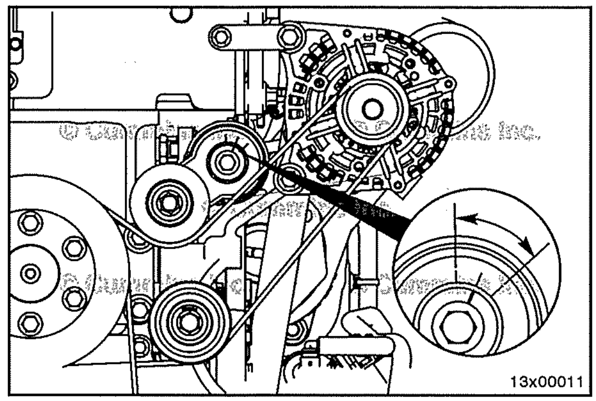
Finishing Steps

- Install the alternator drive belt. Refer to Procedure 013-005 in Section 13.
- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.


ck800wa

The tensioner has marks on the front to indicate tension. The middle of the three marks indicates proper tension.

If the tensioner marks indicate improper tension, check the mounting brackets and the belt length. Loose brackets, bracket failure, alternator movement, incorrect belt length, or belt failure can cause the tensioner to give improper tension.

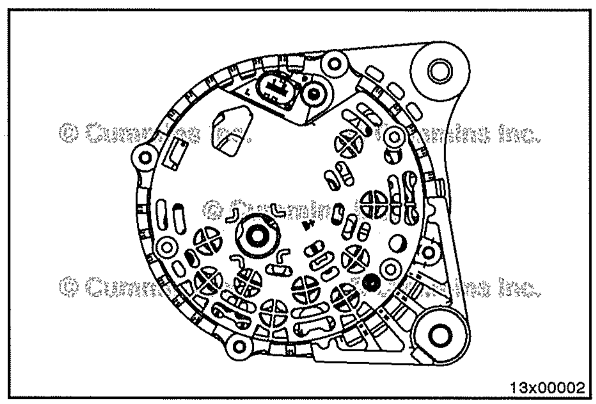

13x00011

Charging System Indicator (013-023)

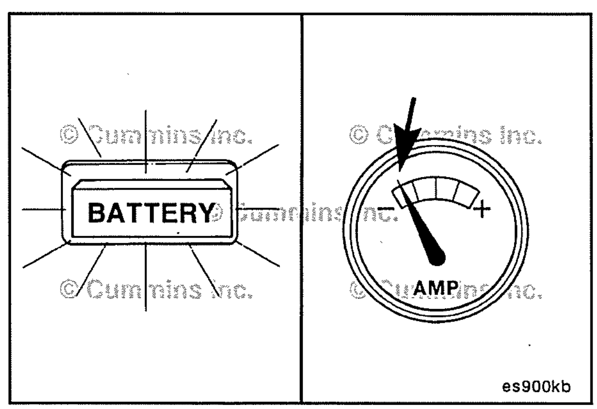
Initial Check

NOTE: Be positive that the correct terminals are used on the alternator.

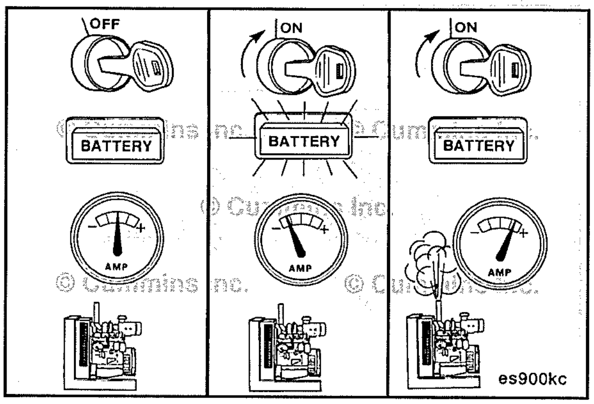
See the alternator manufacturer's instructions.


13x00002

Trouble with the charging system can be indicated by the indicator lamp or ammeter.

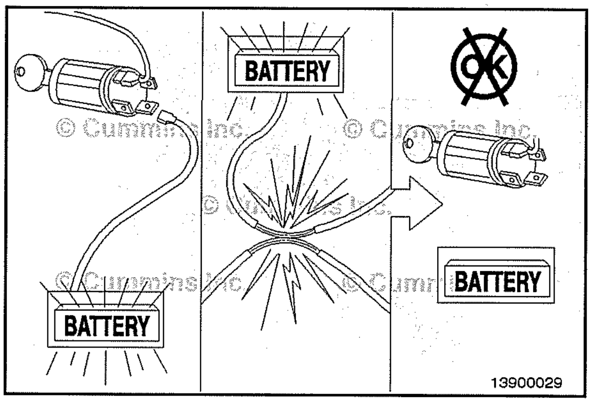


es900kb



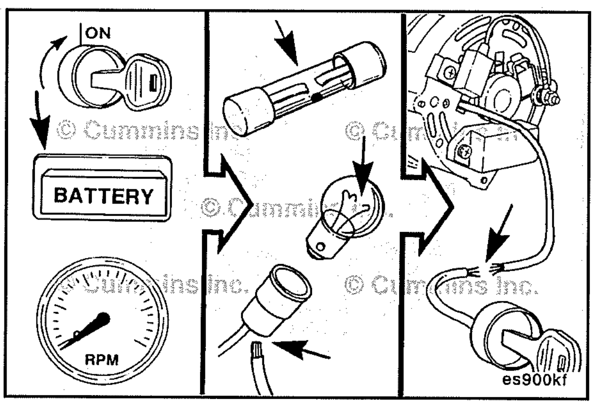
Check the indicator lamp for normal operation as shown below.

Stopped	Off	Off	0
Stopped	On	On	(-)
Running	On	Off	(+)



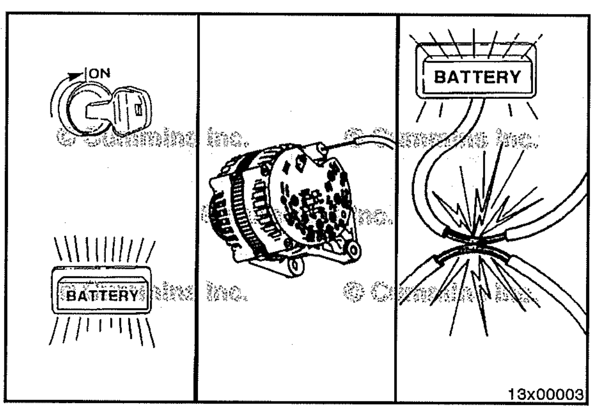
If the lamp is on when the switch is in the OFF position and the engine is **not** running, disconnect the lamp lead at the keyswitch.

- If the lamp stays on, there is a short to a positive (+) wire.
- If the lamp goes out, there is a short in the switch.



If the lamp is off when the switch is in the ON position and the engine is **not** running, there can be an open circuit.

Check for a blown fuse, a burned out bulb, defective bulb socket, or an open circuit in number 1 or "D+" lead between alternator and keyswitch.



If the lamp is on when the switch is on and the engine is running, disconnect the lead to the alternator.

- If the lamp stays on, there is a short to ground in the lamp circuit. Refer to Procedure 013-001 in Section 13.
- If the lamp goes out, inspect the alternator. Refer to Procedure 013-001 in Section 13.

Key Switch (013-030)

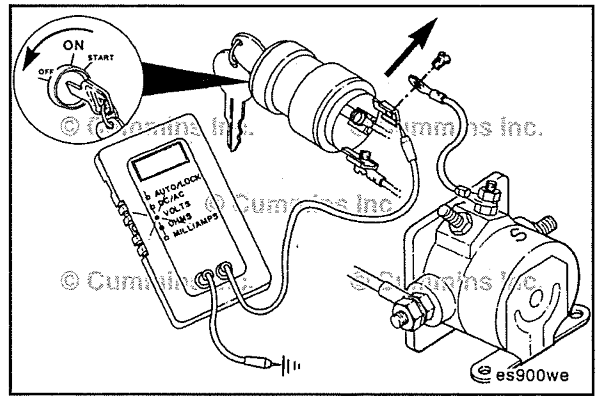
Voltage Check

⚠WARNING⚠

Be sure the keyswitch is in the OFF position to reduce the possibility of electrical shock and personal injury.

Remove the wire connecting the keyswitch to the magnetic switch from the keyswitch terminal.

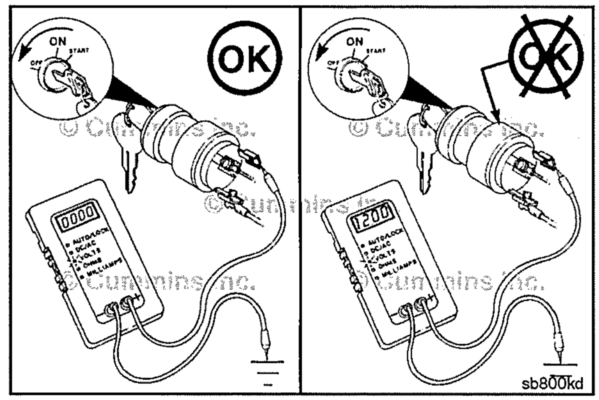
Connect the positive (+) lead of digital multimeter, Part Number 3400162, to the keyswitch terminal and the negative (-) lead to the chassis or engine ground location.



Set the multimeter to indicate DC volts.

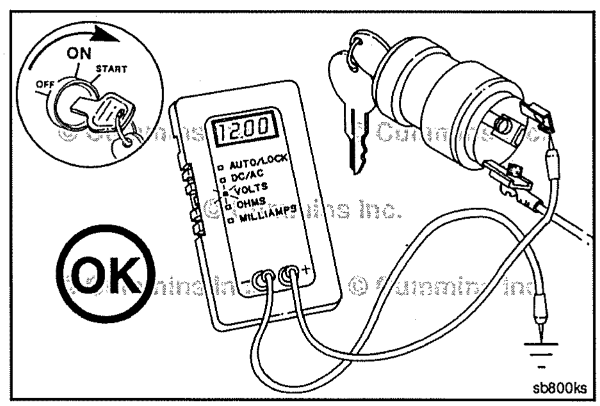
With the keyswitch in the OFF position, the digital multimeter **must** indicate 0 volt.

If the meter indicates voltage, the keyswitch is malfunction and **must** be replaced.



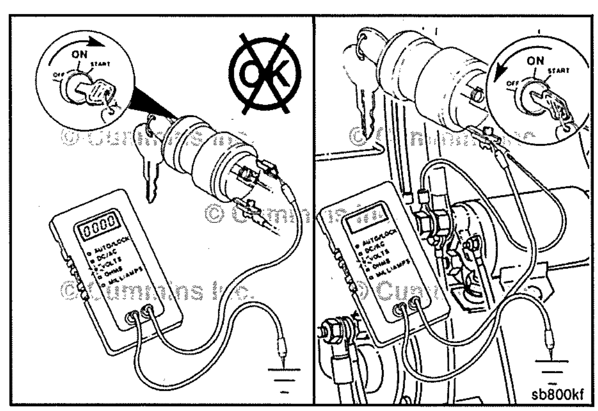
Turn the keyswitch to the START position.

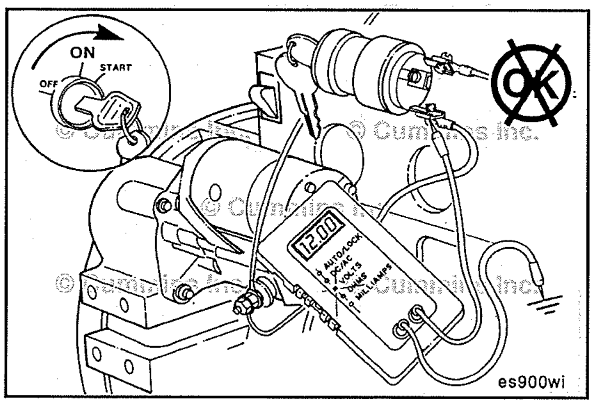
The multimeter **must** indicate system voltage.



If there is no voltage:

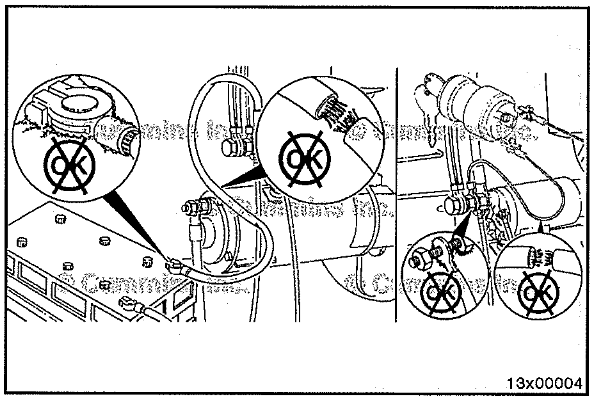
- Turn the key switch to the OFF position.
- Check for supply voltage to the keyswitch by connecting the multimeter positive (+) lead to the key switch terminal having a wire connecting the keyswitch to the starter motor solenoid. Leave the multimeter (-) lead connected to the chassis or engine ground.





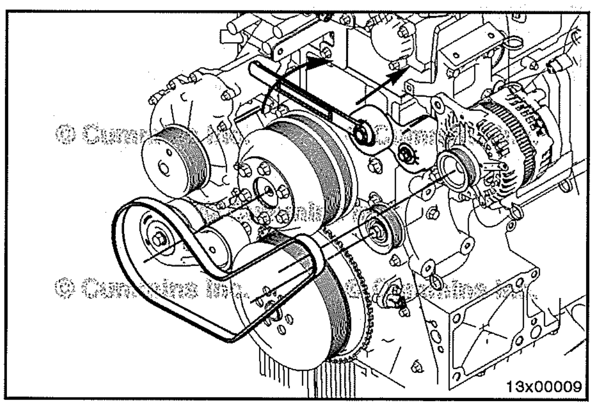
Turn the keyswitch to the START position.

If the meter indicates system voltage at the key switch input terminal, the key switch is defective and **must** be replaced. See equipment manufacturer service information for replacement.



If the meter indicates no voltage, the switch is **not** malfunctioning.

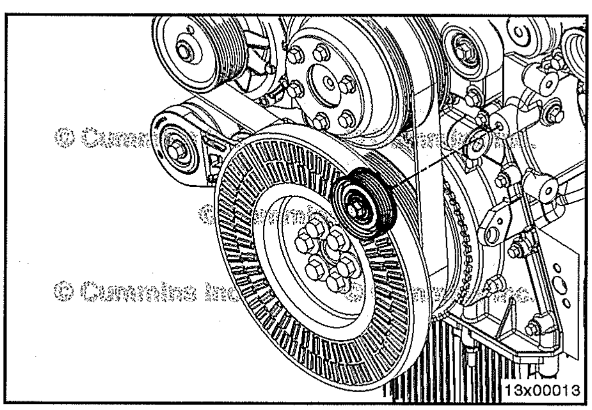
Check the wiring from the keyswitch to the starter motor solenoid, and from the starter motor solenoid to the battery, for broken or damaged wires and loose or corroded connections.



Charging System Alternator Idler Pulley (013-039)

Preparatory Steps

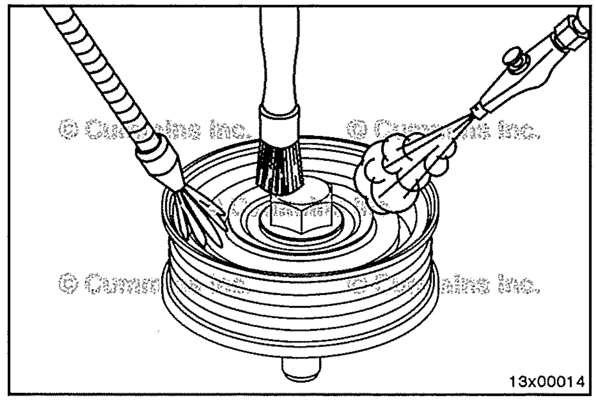
Make a diagram of the alternator belt routing. Remove the alternator belt. Refer to Procedure 013-005 in Section 13.



Remove

Loosen the mounting capscrew and remove the idler pulley assembly.

Clean

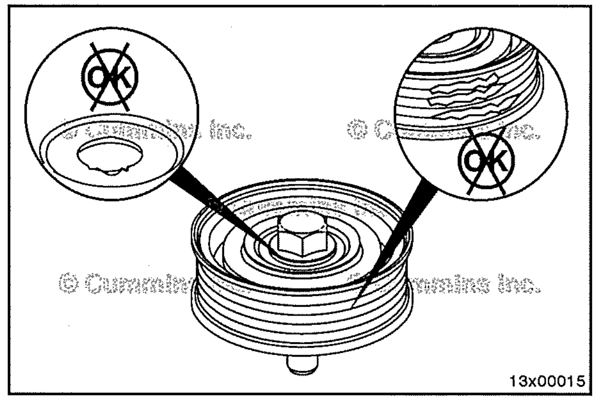


⚠WARNING⚠
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

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

Clean the pulley assembly with solvent and dry with compressed air.

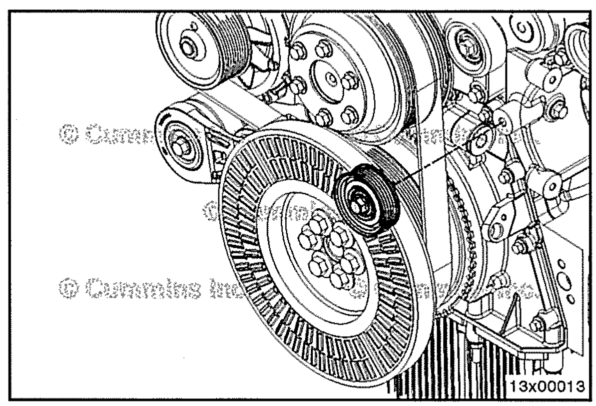
Inspect for Reuse



Inspect the idler pulley assembly for belt groove damage. The pulley should rotate freely.

Replace the pulley if damage is found.

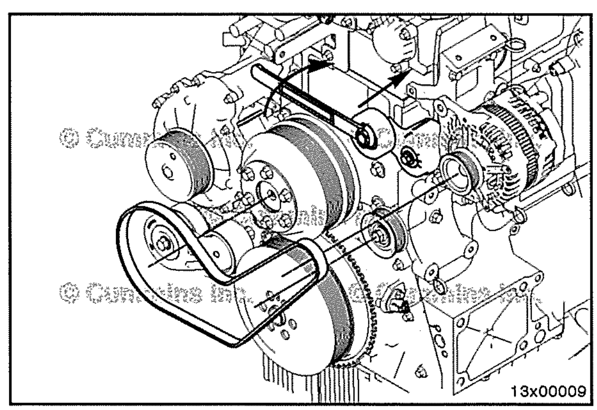
Install



Install the idler pulley assembly and tighten mounting capscrew.

Torque Value: 46 N•m [34 ft-lb]

Finishing Steps



Install the alternator belt. Refer to Procedure 013-005 in Section 13.

Operate engine and check for proper operation.

Notes

Section 14 - Engine Testing - Group 14

Section Contents

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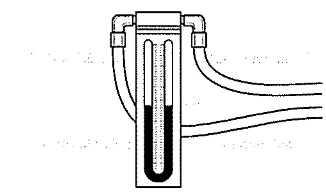
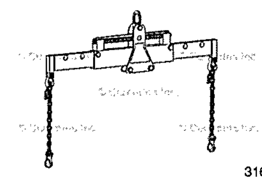
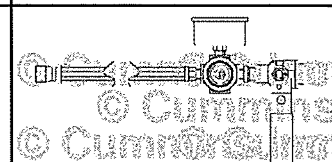
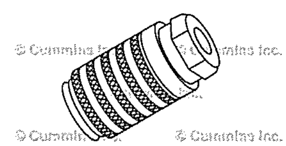
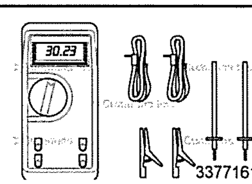
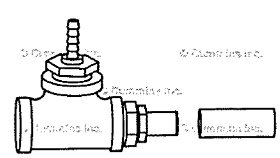
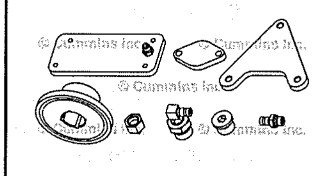
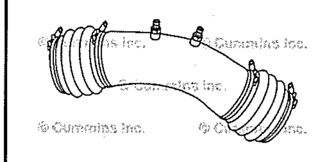
Service Tools

Engine Testing

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-1111-3	**Manometer** Used to measure fuel drain line restriction.	 eg100ja
3162871	**Engine Lifting Fixture** Used to remove and install the engine. Maximum capacity 2722 kg [6000 lb].	 3162871
3164231	**Air Pressure Regulator Kit** Used to regulate air pressure.	 22c00403
3376920	**Female Quick Connect 1/4 NPT** Compuchek™ coupling (1/4 inch pipe thread).	 22x00028
3400162	**Digital Multimeter Kit** Includes deluxe multimeter 3164489, pressure adapter 3164491, and immersion probe 3164492.	 3377161
3822571	**Blowby Tool** Used to check engine crankcase blowby.	 eg8toge

Tool No.	Tool Description	Tool Illustration
5298873	**Lubrication Oil Cooler Pressure Test Kit** Used to seal and pressurize the lube oil cooler to test for leaks. Requires regulated pressure supply, Part Number 3164231, or equivalent (purchased separately). Contains Quick Disconnect Connector, Part Number 5298882.	
5298903	**Testing Boot Kit** This kit is used to provide testing ports in the charge air cooler piping. It contains two testing boots, Part Number 5298904.	

Dynamometer Worksheet (014-001)

Worksheet

Date:	Repair Order No.:	Operator:
ESN:	CPL:	ECM Code:
Complaint:		

Parameter	Code Specifications	Actual Reading
Intake Air Restriction (in H_2O)[1,2]		
Exhaust Restriction (in Hg)[1,2]		
Fuel Inlet Restriction (in Hg)[1,2]		
Fuel Drain Line Restriction (in Hg)[1,2]		
Engine Blowby (in H_2O)[2]		

Engine Set up for Dyno with INSITE™ Electronic Service Tool? (Circle one) Yes / No									
Oil Level (Circle one) Low / High / OK					**Fuel Quality (Circle one) OK / Not OK**				
Road Speed Limit									
Engine Speed									
Horsepower or Torque									
EGR Valve Position (if equipped)									
Turbocharger Control Valve Command									
Fuel Rate (lb/hr)[3]									
Rail Fuel Pressure (psi)									
Fuel Temperature									
Intake Manifold Air Temperature									
Intake Manifold Pressure (in Hg)									
Coolant Temperature									
Coolant Pressure (psi)									
Engine Oil Pressure (psi)									

1 Record at advertised horsepower rpm and full load.

2 Use the following procedure: Specifications - Engine Testing. Refer to Procedure 018-023 in Section V.

3 Be sure that the fuel rate is corrected for temperature, see table below.

Fuel Temperature	Correction for Flow Rate
Less than 7°C [45°F]	Flow meter is **not** accurate
7 to 13°C [45 to 55° F]	Subtract 2 percent from flow rate reading
13 to 20°C [55 to 68°F]	Subtract 1 percent from flow rate reading
20 to 29°C [68 to 84°F]	No Correction
29 to 42°C [84 to 108°F]	Add 1 percent to flow rate reading
42 to 56°C [108 to 133°F]	Add 2 percent to flow rate reading
56°C [133°F] above	Flowmeter **not** accurate

Pressure Conversions
1 in H_2O = 0.074 in Hg = 0.036 psi
1 in Hg = 13.600 in H_2O = 0.491 psi
1 psi = 2.036 in Hg = 27.680 in H_2O

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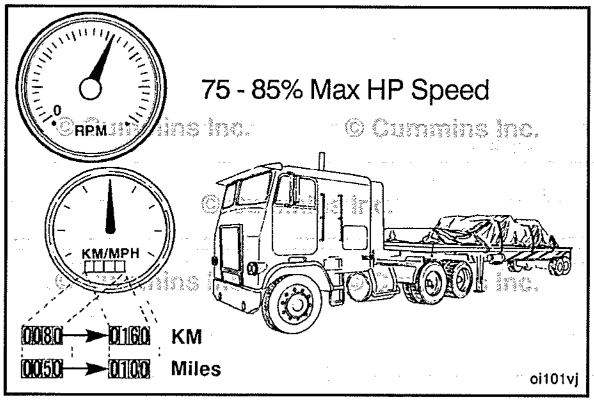


Engine Run-in (Without Dynamometer) (014-004)

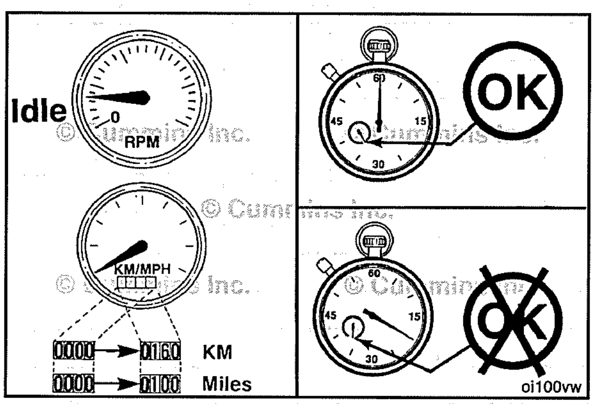
Run-In Instructions

On-Highway Applications

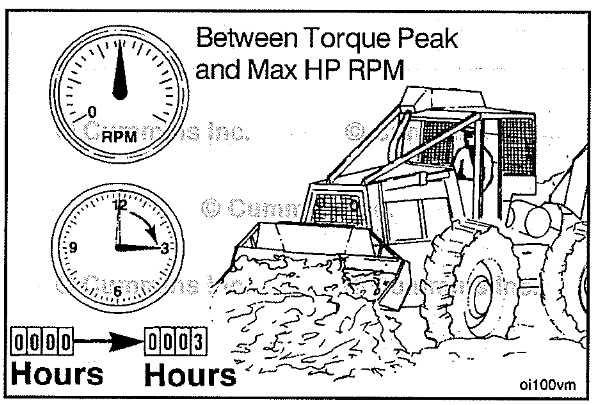
CAUTION

Refer to Procedure 018-023 in Section V before operating the engine to avoid internal component damage.

Operate the vehicle pulling the heaviest available trailer allowed for the first 80 to 160 Km [50 to 100 mi] after rebuild. Operate the vehicle in the highest gear possible within the normal operating rpm range of the engine. It will be necessary to operate the engine at or near full throttle at 75 to 85 percent of maximum horsepower rpm indicated on the dataplate.



Do not idle the engine for more than 5 minutes at any one time during the first 160 Km [100 mi] of operation.



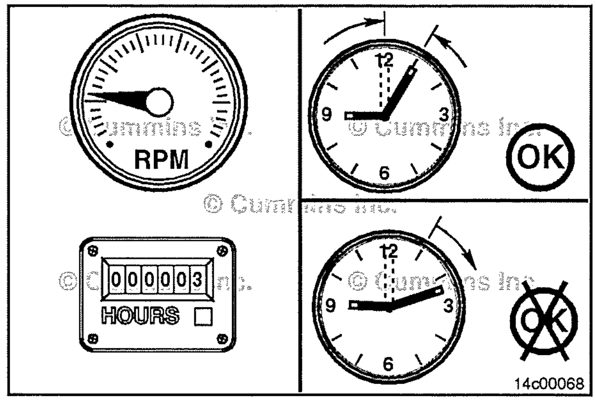
Off-Highway Applications

CAUTION

Refer to Procedure 018-023 in Section V before operating the engine to avoid internal component damage.

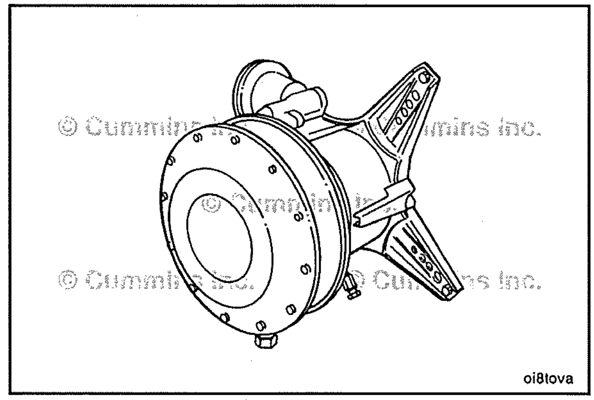
Operate the engine under the highest load possible at full throttle within the normal operating rpm range of the engine for the first 3 hours of operation after rebuild.

Do **not** idle the engine for more than 5 minutes at any one time during the first 3 hours of operation after a rebuild.



Engine Testing (Engine Dynamometer) (014-005)

Setup

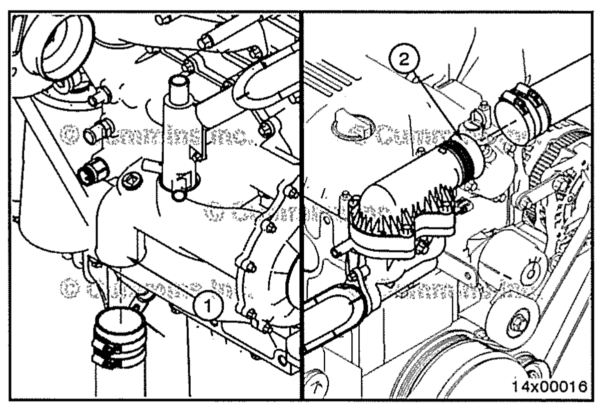


Use engine lifting fixture, Part Number 3162871, to remove the engine from the chassis. Refer to Procedure 000-001 in Section 0.

Install the engine to the test stand.

Align and connect the dynamometer. See equipment manufacturer service information for aligning and testing the engine.

Make sure the dynamometer capacity is sufficient to permit testing at 100 percent of the engine's rated horsepower. If the capacity is **not** enough, the testing procedure **must** be modified to the restrictions of the dynamometer.

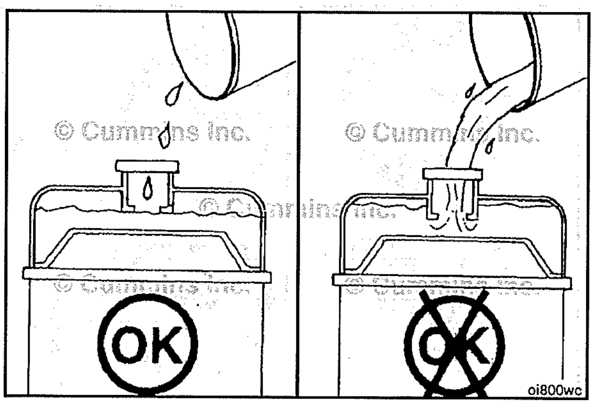


Connect the coolant supply to the coolant inlet connection (1).

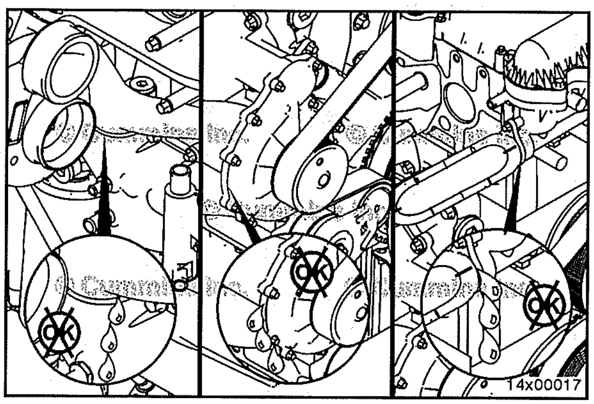
Connect the coolant return to the coolant outlet connection (2).

Install the drain plugs; close all the coolant draincocks.

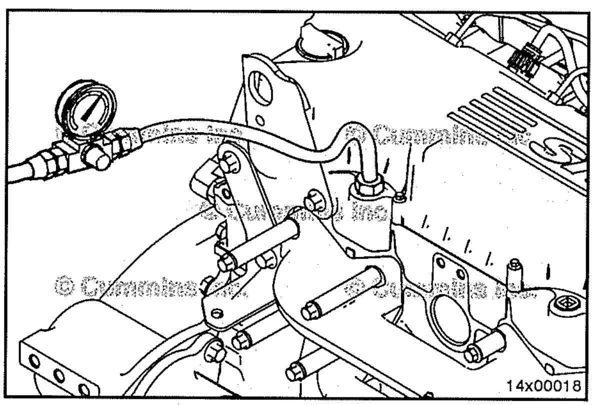
Make sure all the clamps and fittings are tight.



Fill the cooling system with coolant to the bottom of the fill neck in the radiator fill (or expansion) tank. Refer to Procedure 008-018 in Section 8.

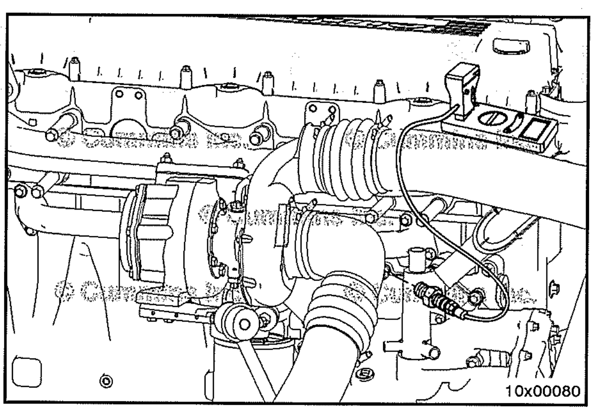


Inspect the engine for coolant leaks at connections, fittings, plates, and plugs. Repair as needed. Refer to Procedure 008-020 in Section 8 if any leaks are found.



Measure the coolant pressure at an OEM coolant port on the cylinder head.

Refer to Procedure 008-020 in Section 8.



⚠CAUTION⚠

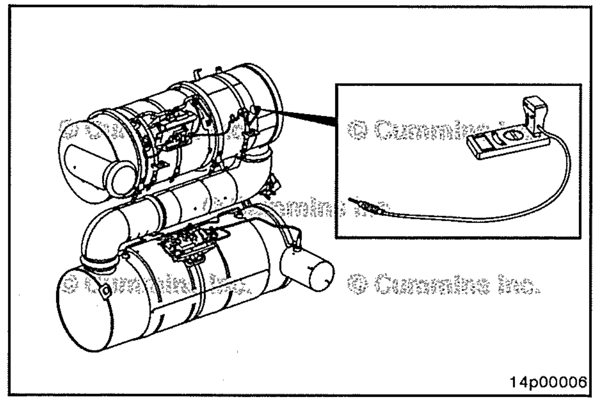
Do not attempt to install pipe thread fittings in plastic or rubber intake piping. Damage to the components can occur.

Air Inlet Restriction

Refer to Procedure 010-031 in Section 10.

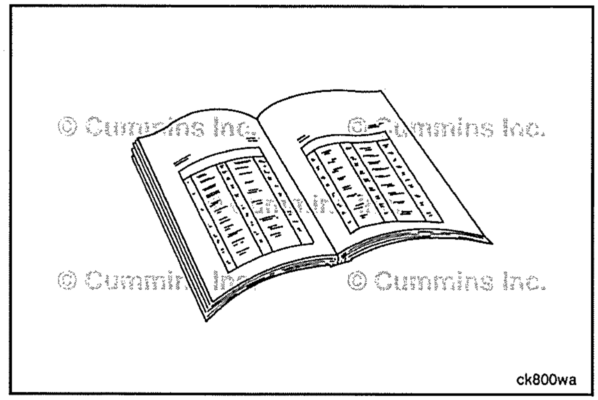
Exhaust Restriction

Refer to Procedure 011-009 in Section 11.

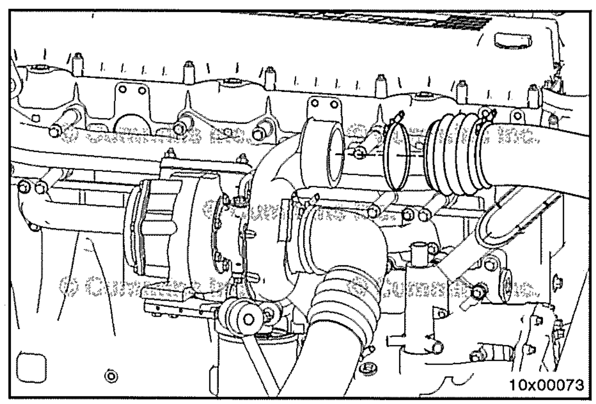


To measure Turbocharger Boost, the following service tools are required:

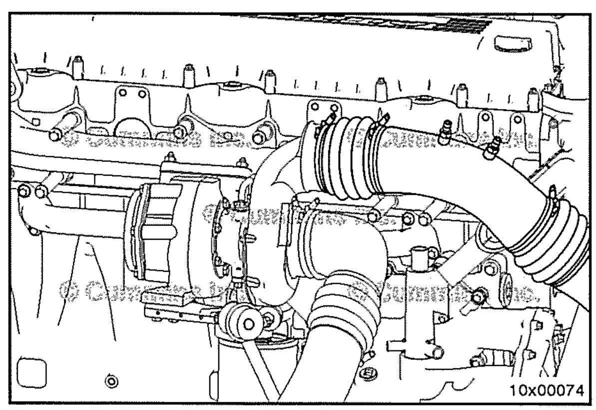
QTY	Part Number	Description
1	3376920	Female Quick Connect
1	3164491	Electronic pressure adapter for multimeter (From kit Part Number 3400162)
1	3164489	Electronic digital multimeter (From kit Part Number 3400162)
1	5298903	Testing Boot Kit

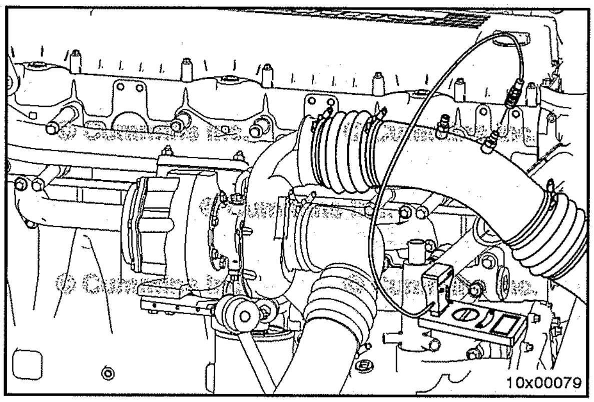


Remove the rubber boot from the turbocharger compressor outlet. See equipment manufacturer service information.



Install testing boot, Part Number 5298903, onto the turbocharger compressor outlet.





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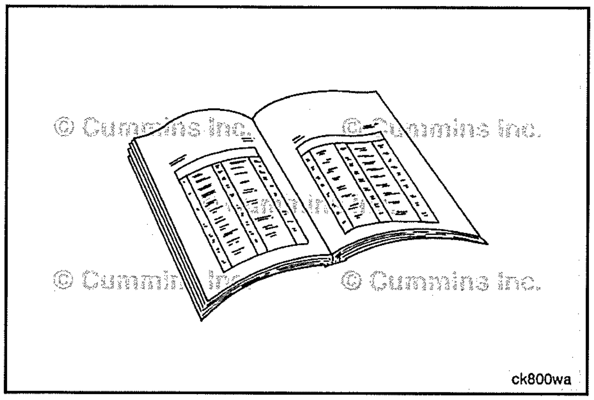
Install the pressure adaptor, Part Number 3164491, onto multimeter, Part Number 3164489.

Install the female quick connect, Part Number 3376920, onto the pressure adaptor.

Install the female quick connect coupling onto the quick connect fitting installed on the testing boot.

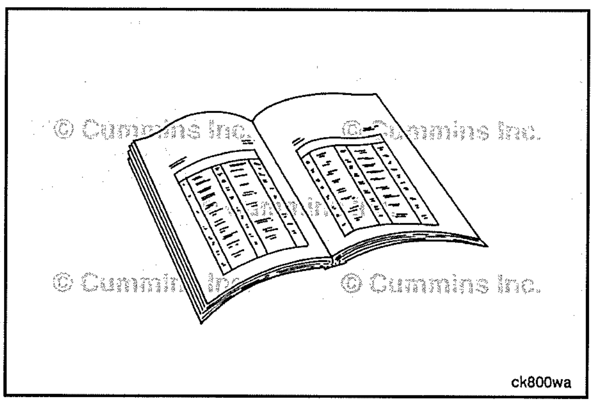
Rout the pressure adaptor wiring so it can be viewed in the cab of the vehicle.

NOTE: The pressure wiring **must** be routed away from any heat sources or moving parts to ensure it does **not** get damaged during testing.



ck800wa

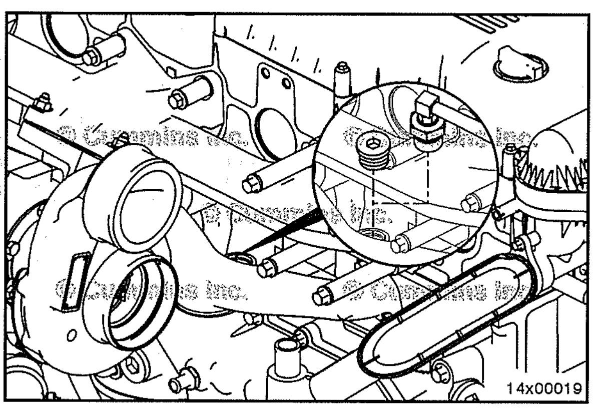
Refer to Procedure 010-057 in Section 10 to measure intake manifold pressure.



ck800wa

Blowby

Refer to Procedure 014-010 in Section 14.



14x00019

⚠CAUTION⚠

The lubricating oil system must be primed before operating the engine after it has been rebuilt to avoid internal damage.

Priming the lubricating system.

Remove the oil plugs from the lubricating oil cooler module at the filter inlet.

Install an M27 Compucheck fittng, Part Number 5298882, from kit 5298873.

Torque Value: 68 N•m [50 ft-lb]

To prime the system, use external pressure, connect the supply to the fitting in the lubricating oil cooler module.

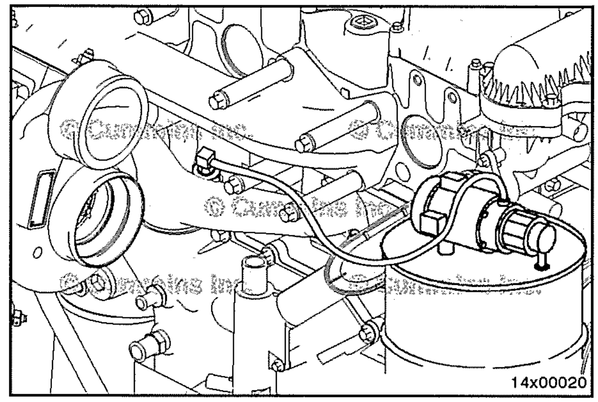
Use a pump capable of supplying 210 kPa [30 psi] of continuous pressure. Connect the pump to the port on the main oil rifle as shown.

Use clean engine oil to prime the system until the oil pressure registers on the gauge.

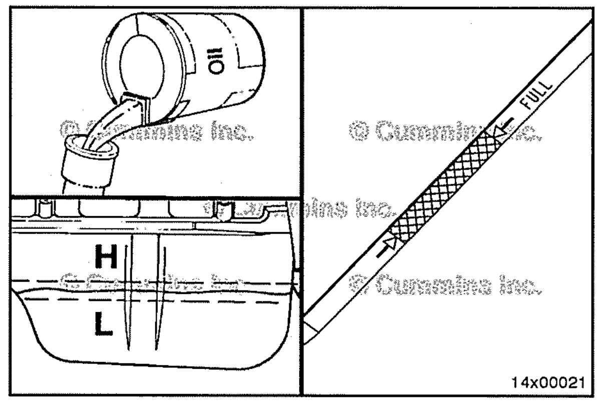
Remove the oil supply tube and fitting, and install the plug.

Tighten the plug.

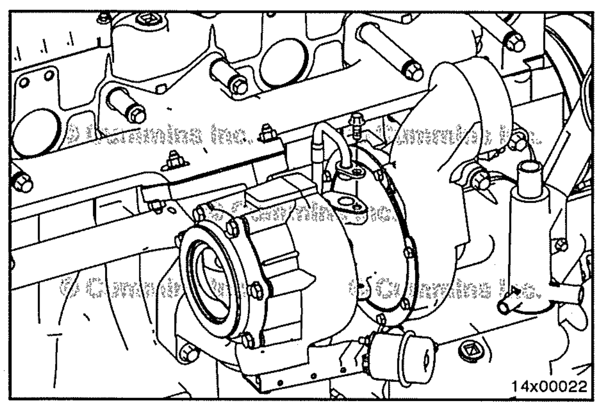
Torque Value: 68 N•m [50 ft-lb]



Fill the engine with clean engine oil. Make sure the lubricating oil has had time to drain to the oil pan and fill the engine to the high mark as measured on the dipstick.



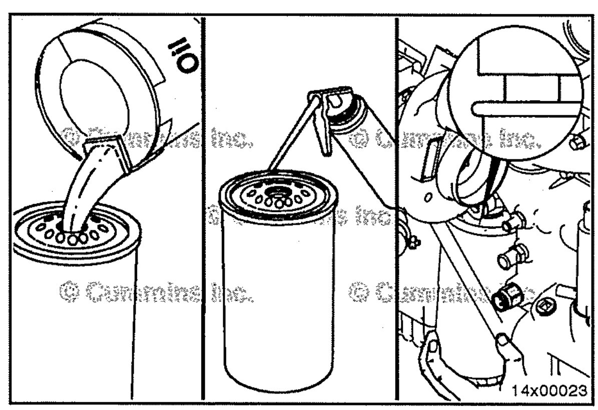
If an external pressure pump is **not** available, prime the lubricating system according to the following procedure.

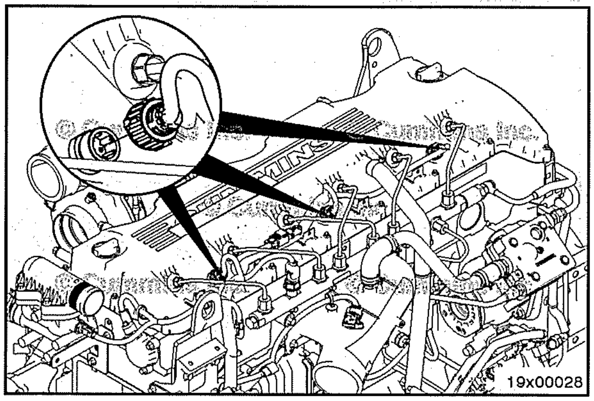


⚠CAUTION⚠

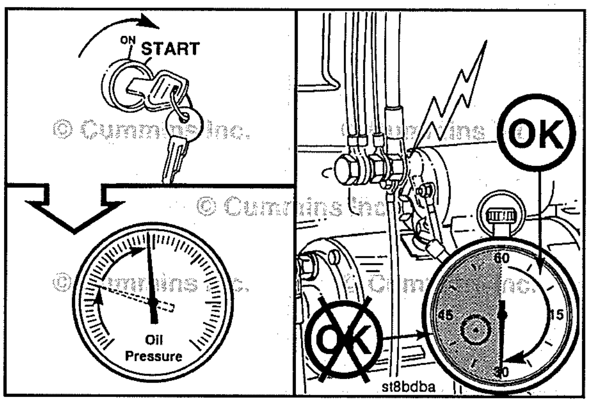
Mechanical overtightening can distort the threads or damage the filter element seal.

- Fill the lubricating oil filters with clean engine oil.
- Screw the filters onto the filter head until the gasket contacts the filter head surface.
- Tighten the filter as specified by the manufacturer.





To disable the engine for cranking, disconnect all of the injector pass-through connectors.



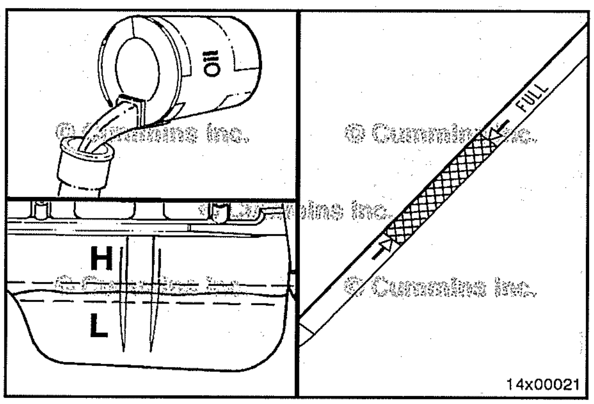
⚠CAUTION⚠

Do not crank the starter motor for periods longer than 30 seconds. Excessive heat will damage the starter motor.

- Crank the engine until the oil pressure gauge indicates system pressure.

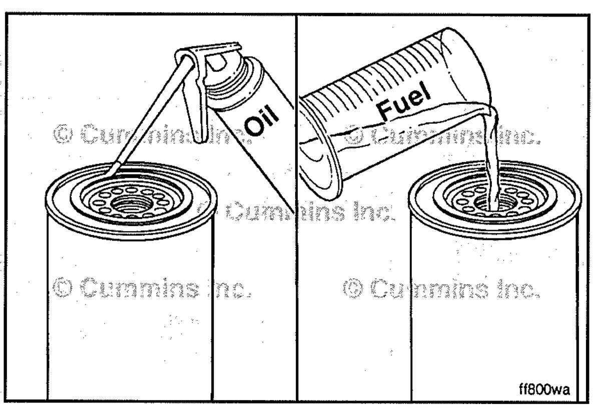
NOTE: Allow 2 minutes between the 30-second cranking periods so the starter motor can cool.

NOTE: If pressure is **not** indicated, find and correct the problem before continuing.



Allow the oil to drain into the oil pan, and measure the oil level with the dipstick.

Add oil, as necessary, to bring the level to the high level mark on the dipstick.

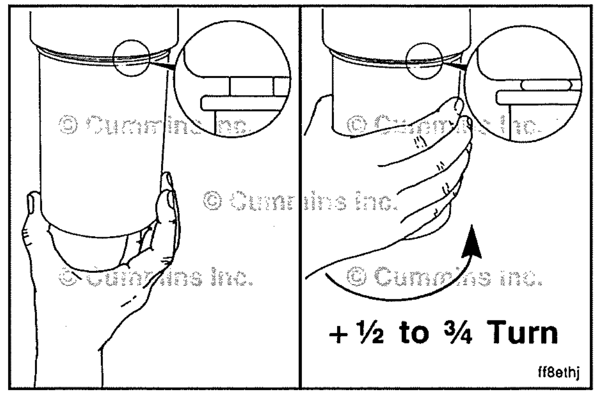


Lubricate the gasket on the fuel filter with clean engine oil.

Fill the fuel filter with clean fuel.

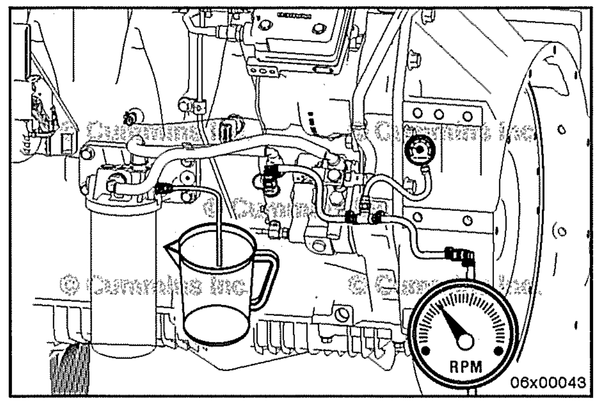
Screw the fuel filter onto the fuel filter head until the gasket contacts the fuel filter head surface.

Tighten the filter as specified by the manufacturer.



Measure fuel filter restriction. Refer to Procedure 006-020 in Section 6.

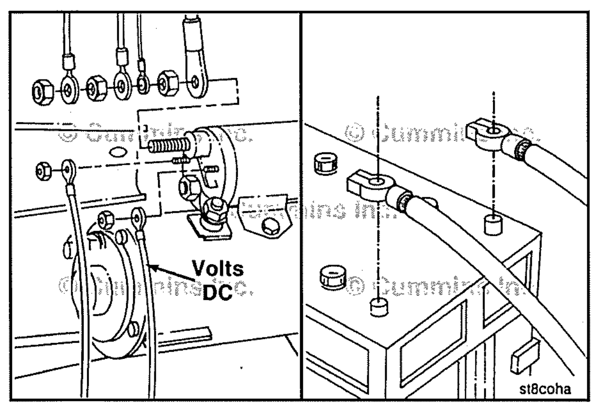
Fuel Filter Restriction Pressure Gauge Capacity		
kPa		psi
1379	MIN	200



Inspect the voltage rating on the starter motor before installing the electrical wiring.

Attach electrical wires to the starter motor and the batteries, if used, negative (-) cable last.

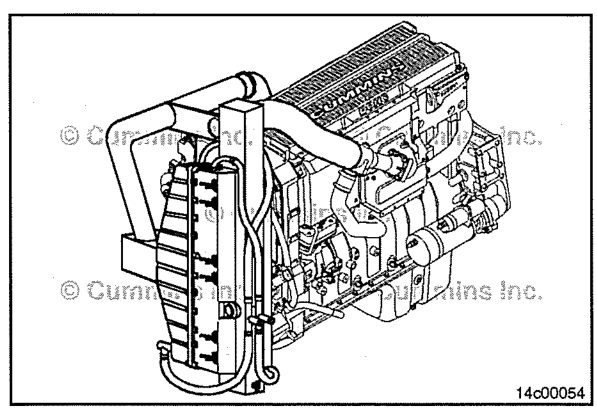
NOTE: If another method of starting the engine is used, follow the manufacturer's instructions to make the necessary connections.

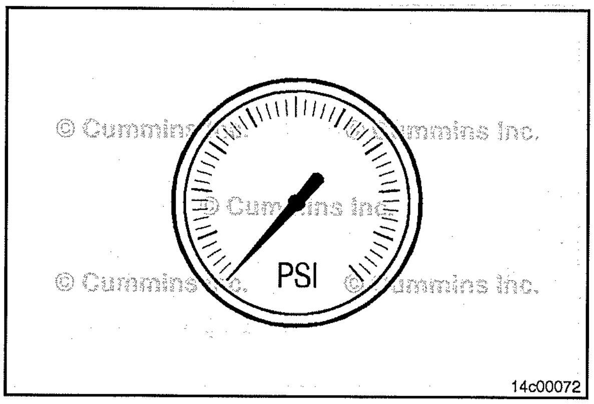


Engine Run-in (Engine Dynamometer) (014-006)

Run-In Instructions

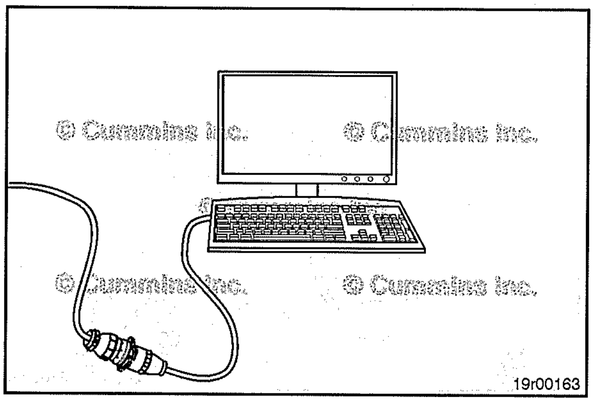
Follow the general operating procedures and safety precautions when performing the engine run-in. Refer to Procedure 014-005 in Section 14.





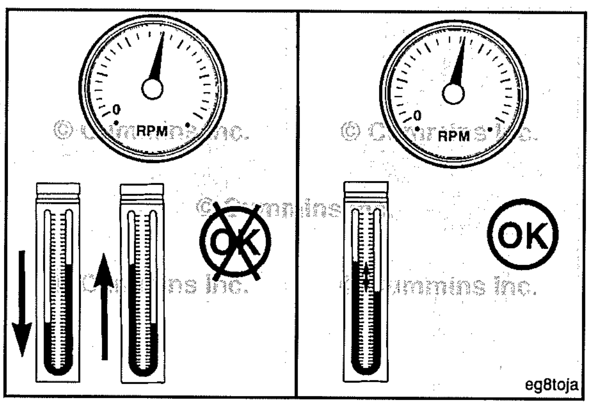
Use the Dynamometer Worksheet to record all of the engine performance parameters. Refer to Procedure 014-001 in Section 14.

Cummins Inc. recommends monitoring block coolant pressure during run-in to aid in early indication of a cooling system problem.



NOTE: INSITE™ electronic service tool **must** be used to confirm that the engine control module (ECM) code on the ECM dataplate is the same as the one installed in the ECM. There is an associated fuel pump code with all ECM codes.

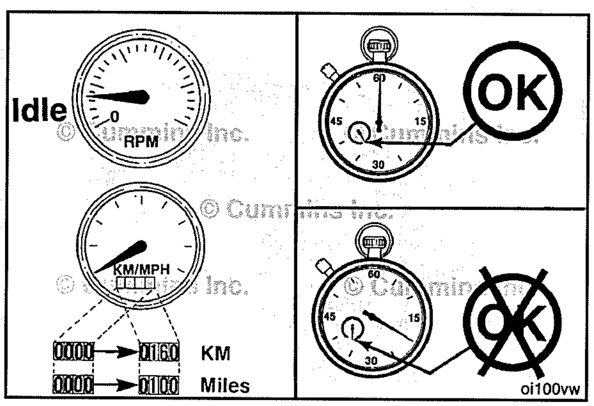
Use INSITE™ electronic service tool to obtain the ECM code and the fuel pump code from the ECM dataplate.



During the test, if a sudden increase in blowby occurs or if blowby exceeds the maximum allowable limit during any run-in, return to the previous step of the test and continue the run-in. If blowby does **not** reach an acceptable level during the next step, discontinue the run-in and determine the cause.

Do **not** proceed to the next step until the blowby becomes stable within specifications.

Refer to Procedure 014-010 in Section 14.



Do **not** idle the engine for more than 5 minutes at any one time during the first 3 hours or 160 km [100 mi] of operation.

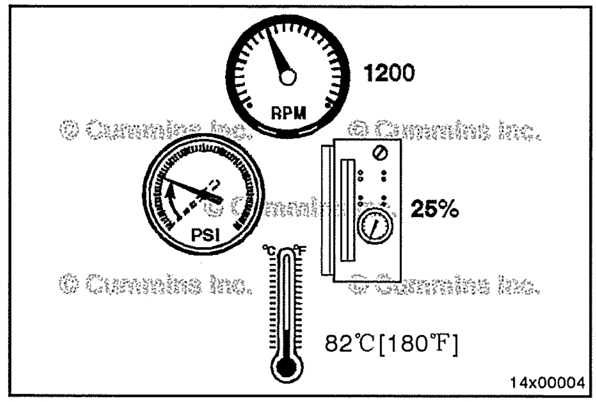
Adjust the engine speed to 1200 rpm. Apply a test load sufficient to develop 25 percent of advertised horsepower of the engine.

Operate the engine at this speed and load level until the coolant temperature is 82°C [180°F].

Check for leaks. Fix all leaks.

Check all gauges and record the data.

Do **not** proceed to the next step until the blowby becomes stable within specifications.

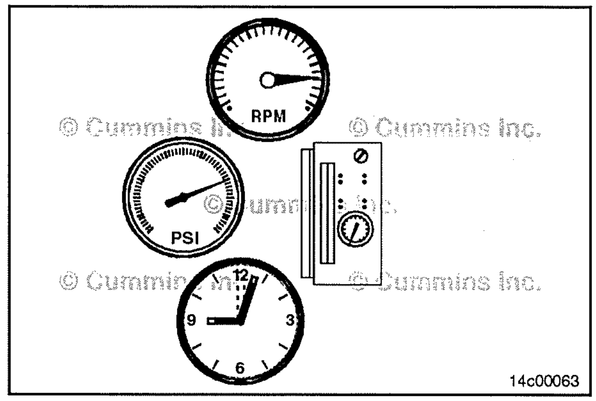


Open the throttle to obtain the engine speed at which advertised horsepower is developed, and adjust the dynamometer load to achieve 75 percent of advertised horsepower on the engine.

Operate the engine at this speed and load level for 3 minutes.

Check all gauges and record the data.

Do **not** proceed to the next step until the blowby becomes stable within specifications.

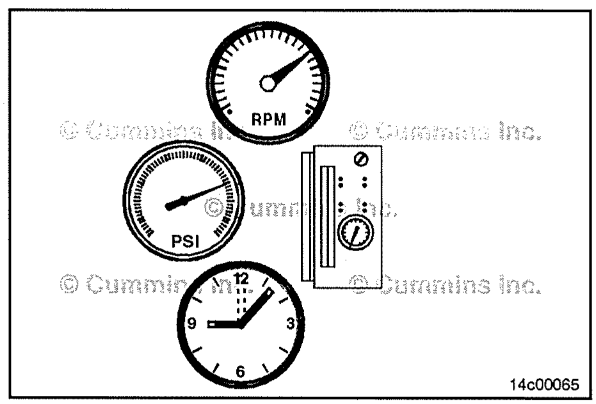


Maintain the engine speed at which advertised horsepower is developed. Move the throttle lever to its fully opened position, and increase the dynamometer load until 100 percent advertised horsepower of the engine is developed.

Operate the engine at this speed and load level for 5 minutes.

Check all gauges and record the data.

Do **not** proceed to the next step until the blowby becomes stable within specifications.

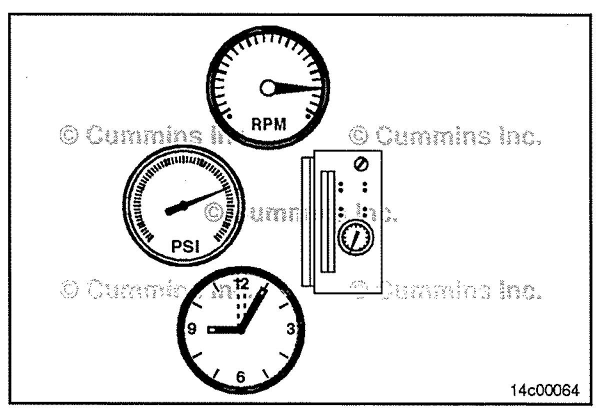


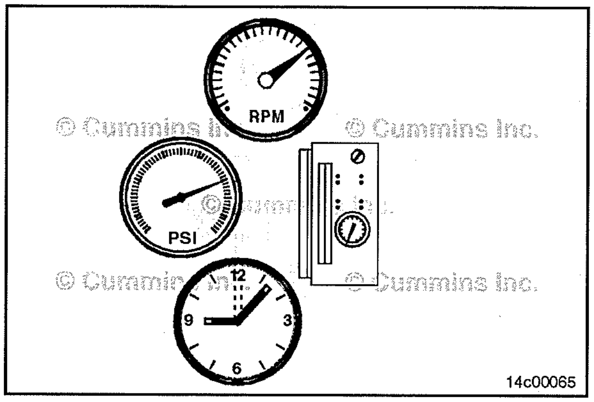
While keeping the throttle fully open, slowly reduce the engine speed to peak torque.

Operate the engine at this speed and load level for 7 minutes.

Check all gauges and record the data.

Do **not** proceed to the next step until the blowby becomes stable within specifications.





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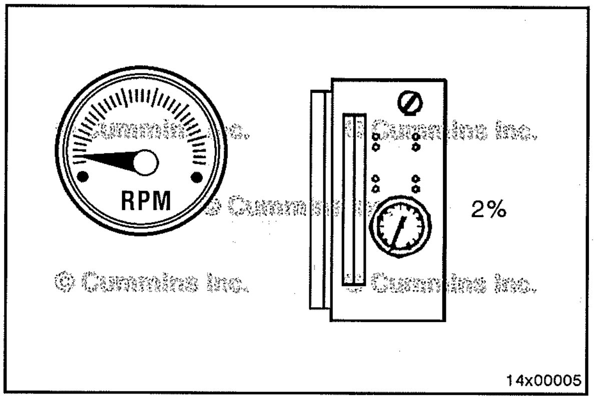
Reduce the dynamometer load until the engine speed increases to the engine speed at which advertised horsepower is developed.

Operate the engine at this speed and load level for 5 minutes.

Check all gauges and record the data.

Do **not** proceed to the next step until the blowby becomes stable within specifications.



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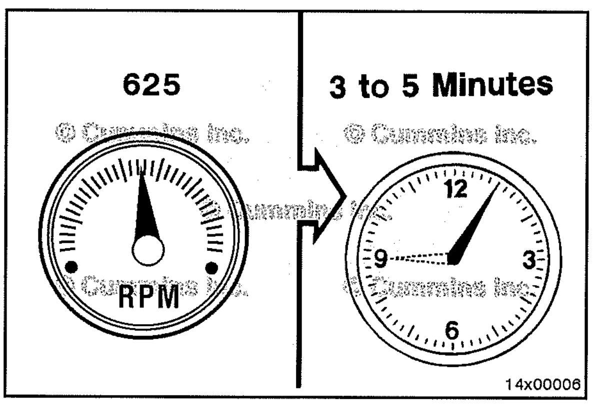
Slowly decrease the dynamometer load on the engine with a ramp of 50 rpm per second and throttle at 2% to avoid internal damage.



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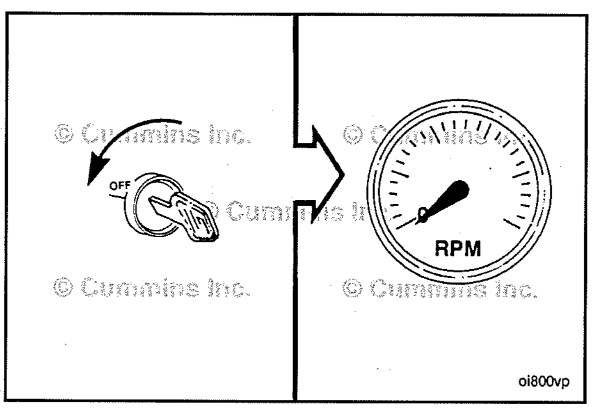
⚠CAUTION⚠

Do not shut off the engine immediately after the run-in is completed. Allow the engine to cool by operating it at 625 rpm for a minimum of 3 to 5 minutes to avoid internal damage. This allows the turbocharger and other components to cool.



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Shut the engine off.

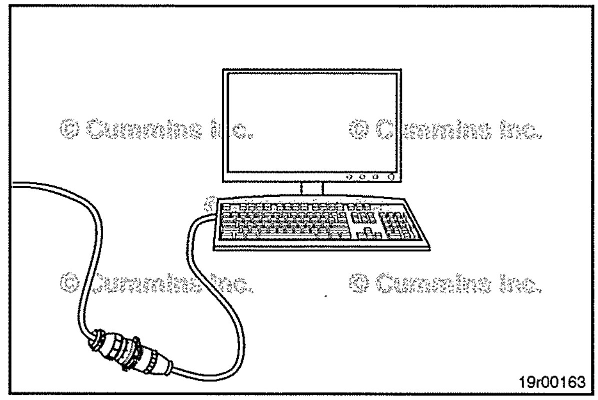
Make sure all instrumentation is removed before removing the engine from the engine dynamometer.

Engine Testing (In Chassis) (014-008)

Setup

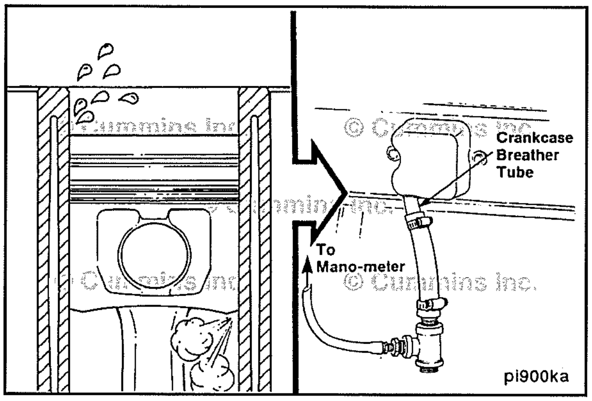
The Setup for Dynamometer function is used to prepare the engine control module (ECM) for an advanced diagnostic test run on the chassis dynamometer. For purposes of this test, the maximum engine speed without vehicle speed sensor (VSS), the maximum vehicle speed in top gear, and the maximum vehicle speed in lower gear are set to their maximum values. The idle shutdown feature is disabled and the fan is locked in the ON mode. All of these values are automatically reset to their previous values when the engine keyswitch is turned to the OFF position.

These maximum allowable parameters and other features can be found in INSITE™. Reference the INSITE™ electronic service tool Help File for detailed setup for dynamometer instructions.



- Maximum Engine Speed without VSS: for testing purposes, this speed is temporarily set to the maximum value allowed.
- Maximum Vehicle Speed in Top Gear: for testing purposes, this speed is temporarily set to the maximum value allowed.
- Maximum Vehicle Speed in Lower Gear: for testing purposes, this speed is temporarily set to the maximum value allowed.
- Gear-Down Protection: This feature is temporarily disabled for testing purposes, if enabled.
- Fan Clutch: On.
- Idle Shutdown: This feature is temporarily disabled for testing purposes, if enabled.

Some SAE J1939 electronic subsystems **must** be disabled. The user has the ability to enable or disable the SAE J1939 data link with the service tool.



Crankcase Blowby, Measure (014-010)

General Information

NOTE: Some illustrations in this procedure do **not** show actual engine configurations. The procedure, however, is the same.

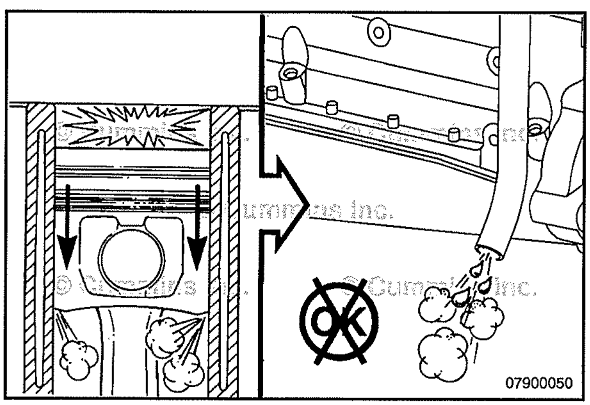
Excessive crankcase pressure and/or blowby can indicate an engine or engine related component malfunction that allows combustion gasses or air to enter the crankcase. This results in the buildup of higher than normal crankcase pressure, which results in increased levels of blowby.

This procedure describes how to measure crankcase pressure/blowby and how to determine which component is malfunctioning.

Blowby is typically measured for the following situations:

- Verifying engine break-in after an engine rebuild
- Troubleshooting for excessive lubricating oil out of the crankcase breather tube, commonly referred to as oil carryover (for open crankcase ventilation systems)
- Troubleshooting oil in the air intake system (for closed crankcase ventilation systems)
- Troubleshooting high crankcase pressure (for engines equipped with a crankcase pressure sensor)
- Troubleshooting possible internal engine damage (worn piston rings, valve stem seals or guides, turbocharger, air compressor, etc.).

This procedure provides general guidelines for measuring blowby relative to the above situations.

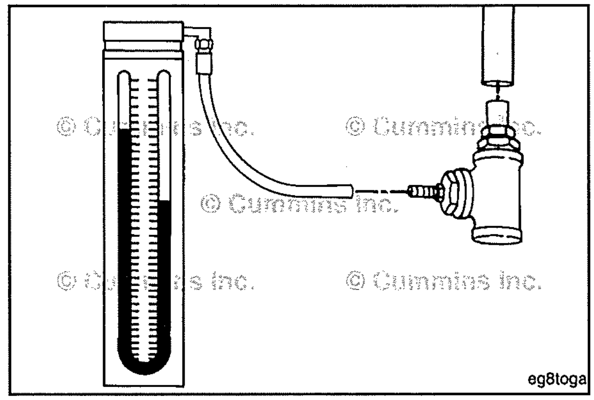


When measuring blowby, if there is an excessive amount of oil coming out of the breather tube, the quantity of oil can affect the blowby measurement.

The blowby measurement is affected by the oil collecting on the orifice of the blowby measurement service tool. This reduces the size of the orifice, which results in higher than actual blowby measurements.

If this occurs, it will be necessary to:

- Find a different location on the engine to measure crankcase pressure (oil fill, oil fill cap, unused turbocharger drain location, etc.).
- Clean any oil residue from the breather and dry thoroughly before measuring blowby.
- Determine if there is an issue causing the breather to be flooded with oil, for example:
- Incorrect oil level
- Vehicle operation (excessive angularity, excessive engine side to side movement)
- Internal engine components are deflecting oil toward the breather cavity (piston cooling nozzles, accessory oil drains, etc.).
- Determine if another breather option is available for the engine being serviced.



The tools used to measure blowby are similar in design. The difference between the tools is in the size of the orifice. Different size orifices are available to more accurately measure blowby and to accommodate the wide variety of engine configurations and ratings. This is due to the fact that engine blowby is dependent on the volume of intake airflow.

For example:

- If measuring blowby on two identically configured and size engines, but the horsepower rating and rated speed are different, the maximum blowby value measured will be different.

The engine with the higher horsepower rating and rated speed will have a higher volume of intake airflow, which will result in higher blowby. This means that if the smaller orifice blowby tool was used on the engine with a higher horsepower rating and rated speed, the measurement can exceed the limits of the pressure measuring tool.

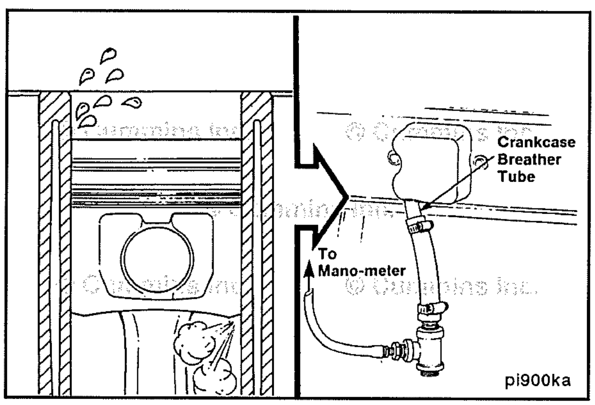
Blowby Tool Part Number	Orifice Size
3822571	8.99 mm [0.354 in]

To measure the crankcase blowby pressure, connect a water manometer, Part Number ST1111-3 or equivalent, pressure gauge, or transducer to the blowby measurement service tool.

NOTE: Water manometer, Part Number ST1111-3, can measure a maximum of 944 mm [37 in] of water.

The following chart shows the relationship of measured pressure to flow rate for a 8.99 mm [0.354 in] orifice.

Blowby Conversion Table with 8.99 mm [0.354 in] Orifice and Blowby	
mm H_2O [in H_2O]	Liter [cfm] per Minute
25.4 [1]	69.7 [2.5]
50.8 [2]	98.7 [3.5]
76.2 [3]	121.9 [4.3]
101.6 [4]	139.7 [4.9]
127 [5]	156.2 [5.5]
152.4 [6]	171.1 [6.0]
177.8 [7]	184.8 [6.5]
203.2 [8]	197.6 [7.0]
228.6 [9]	209.6 [7.4]
254 [10]	221.0 [7.8]
279.4 [11]	231.8 [8.2]
304.8 [12]	242.1 [[8.6]
330.2 [13]	252.0 [8.9]
355.6 [14]	261.6 [9.2]
381 [15]	270.7 [9.6]
406.4 [16]	279.6 [9.9]
431.8 [17]	288.3 [10.2]
457.2 [18]	296.6 [10.5]
482.6 [19]	304.8 [10.8]
508 [20]	312.7 [11.0]
533.4 [21]	320.4 [11.3]
558.8 [22]	328.0 [11.6]
584.2 [23]	335.4 [11.8]
609.6 [24]	342.6 [12.1]



NOTE: If internal engine damage is suspected to be the cause of the excessive blowby condition, other steps can be taken to confirm this.

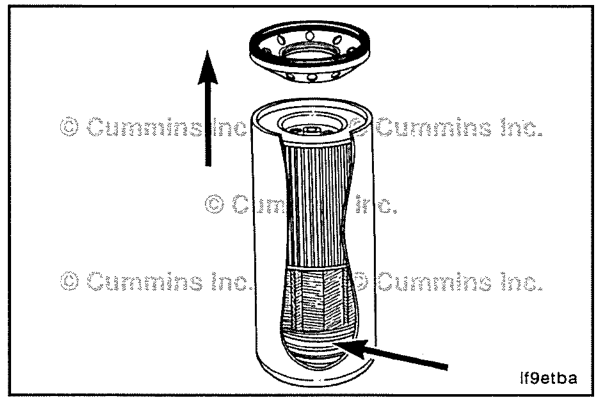
Measuring blowby **must only** be considered when confirming engine break-in after a rebuild, or if another symptom is present. These symptoms can include:

- Excessive carryover (oil out of the crankcase breather tube)
- High crankcase pressure (for engines equipped with a crankcase pressure sensor)
- Low power
- Oil consumption
- Exhaust smoke.

If no other symptom is present, blowby measurements need **not** be taken.

If internal engine damage is suspected to be the cause of the excessive blowby condition, other steps can be taken to confirm this. The steps include:

- Confirm engine maintenance practices.
- Cut the oil filter open and check for debris.
- Take an oil sample and inspect for contamination. Refer to Procedure 007-083 in Section 7.

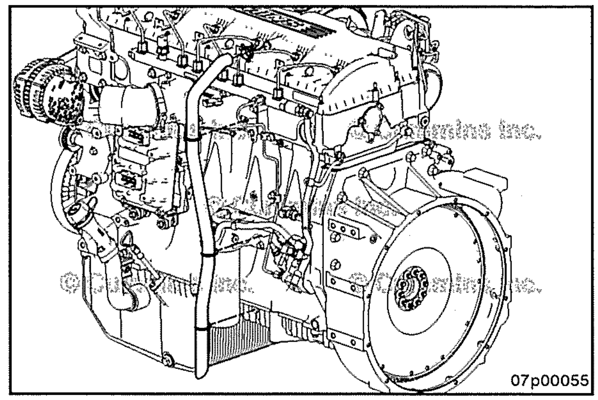


Initial Check

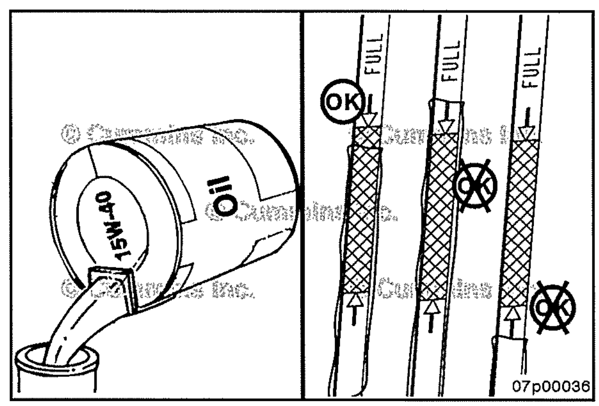
NOTE: The location and type of crankcase breathers vary by engine configuration (front gear train or rear gear train) and/or engine application.

Prior to measuring blowby pressure, check the crankcase breather tube for obstructions. Use the following procedure for crankcase breather tube removal and installation instructions. Refer to Procedure 003-018 in Section 3.

If troubleshooting a complaint of excessive oil out of the breather tube, it can be necessary to remove the breather components to clean and remove any lubricating oil buildup before performing any blowby measurements.



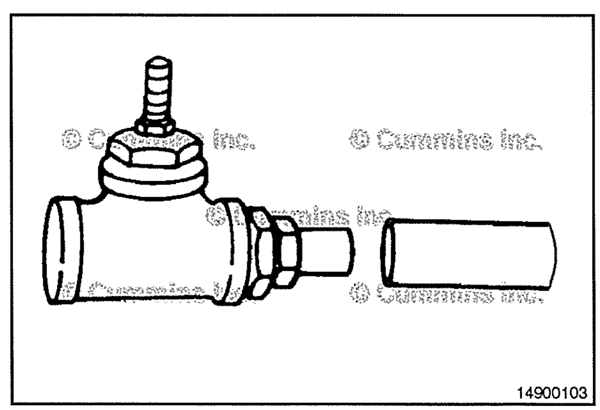
Check the engine oil level. If the level is too high, it can cause a higher than normal blowby pressure and/or excessive carryover. Refer to Procedure 007-011 in Section 7.

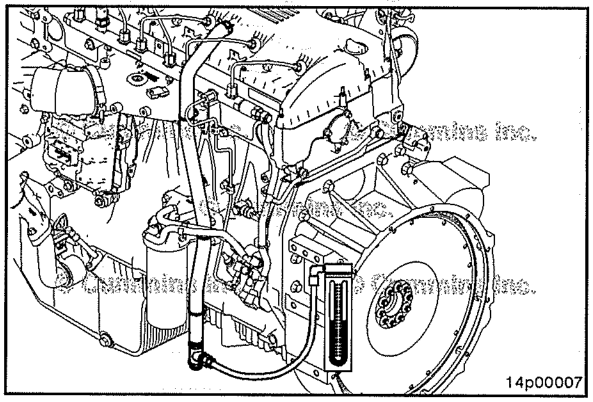


Measure

Choose the appropriate blowby measurement service tool to use for the engine being serviced.

Blowby Tool Part Number	Orifice Size
3822571	8.99 mm [0.354 in]



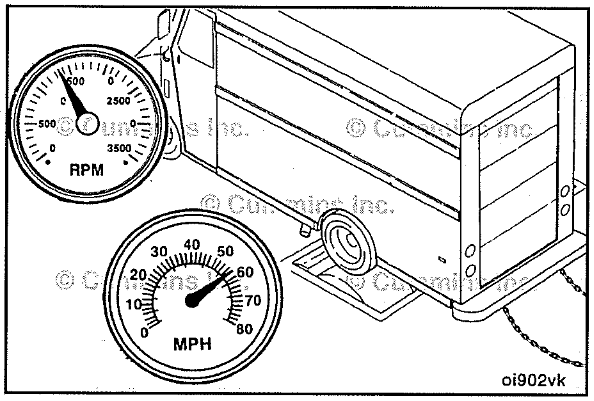

14p00007

To measure the crankcase/blowby pressure, connect a water manometer, Part Number ST1111-3, pressure gauge, or transducer to the blowby measurement service tool.

NOTE: The location of the crankcase breather tube can vary by engine configuration and/or application.

Install the appropriate blowby service tool(s):

- For open crankcase breather/ventilation systems, connect the appropriate blowby service tool to the end of the crankcase breather tube. Connect a water manometer pressure gauge or transducer to the blowby service tool.



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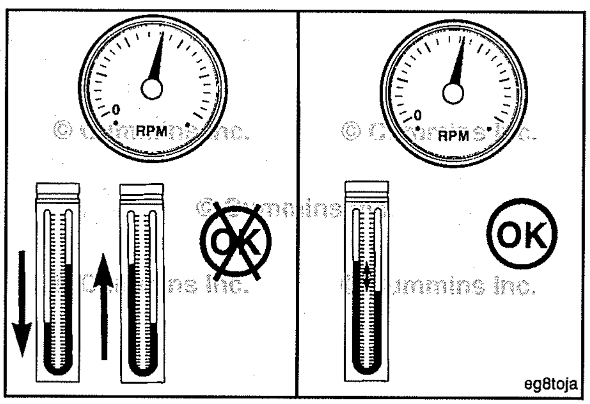
Check the following for engine blowby contribution.

Operate the engine at rated speed and under load by either:

- For engine run-in, a chassis dynamometer or engine dynamometer.
- For engine testing, a chassis dynamometer or engine dynamometer.
- A stall speed test (for engines equipped with automatic transmissions **only**).



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⚠CAUTION⚠

When measuring blowby and there is an excessive amount of oil coming out of the breather tube, the quantity of oil can affect the blowby measurement.

For specific instructions for the appropriate engine test, see the appropriate procedure number listed below.

- Refer to Procedure 014-004 in Section 14.
- Refer to Procedure 014-008 in Section 14.

Operate the engine at rated rpm and full load until a steady reading is obtained.

NOTE: When measuring blowby, the value can "spike" initially as the engine reaches peak power and rated speed. Wait for the blowby measurement to stabilize before taking a reading.

NOTE: For engine run-in, if a sudden increase in blowby occurs, or if blowby exceeds the maximum allowable limit during any run-in step, return to the previous step and continue the run-in. If blowby does **not** reach an acceptable level, discontinue the run-in and determine the cause.

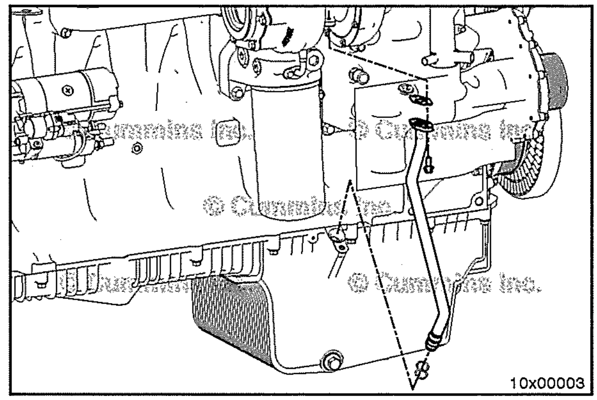
Record the steady blowby measurement.

Remove the engine blowby service tool and water manometer or pressure gauge, if the blowby is within specification.

Check the following for turbocharger blowby contribution.

With the engine blowby service tool and water manometer or pressure gauge still installed:

- Isolate the turbocharger, if equipped, to determine if the high blowby pressure is due to turbocharger seal leakage
- To measure the turbocharger blowby contribution, disconnect the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.



CAUTION

Do not operate the engine for more than 1 minute. Monitor the amount of oil accumulating in the container. The engine can be run out of lubricating engine oil and severe engine damage will result.

These steps describe the turbocharger isolation method.

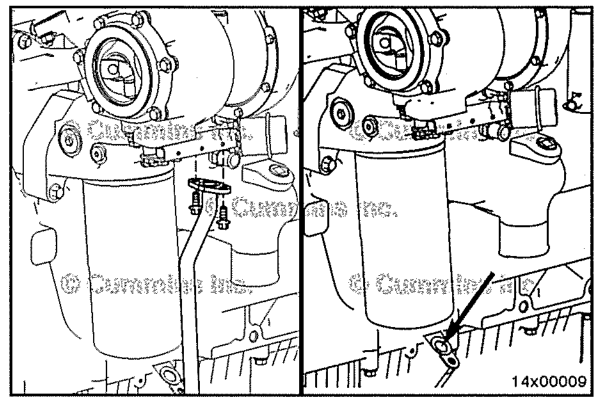
With the turbocharger oil drain line disconnected from the cylinder block, run the turbocharger drain line into a large container.

Plug the turbocharger oil drain port in the cylinder block.

Operate the engine at rated speed and under load by either:

- For engine testing, a chassis dynamometer or engine dynamometer
- A stall speed test (for engines equipped with automatic transmissions **only**).

Record the peak blowby pressure measurement.

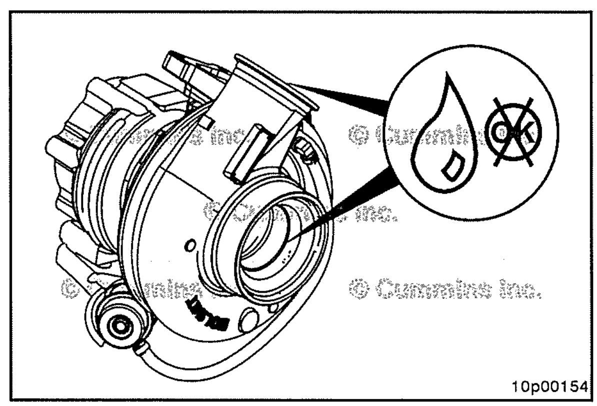


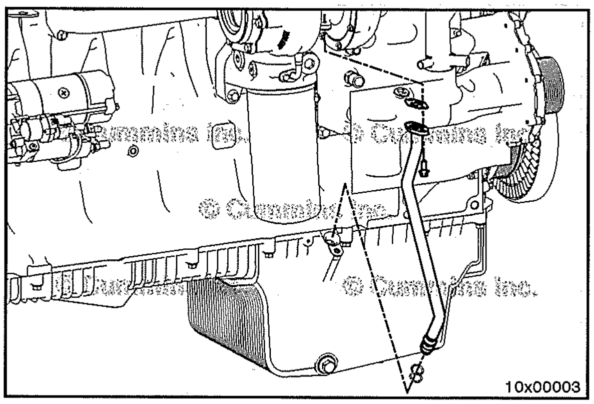
Determine the turbocharger blowby pressure contribution by determining the difference in the blowby pressure measurement with the turbocharger drain isolated, with the turbocharger oil drain line disconnected, and turbocharger drain **not** isolated, with the turbocharger oil drain line connected.

Blowby Pressure Differential	
Turbocharger Blowby Contribution	Maximum: 30%

If the turbocharger blowby contribution is out of specification, inspect the compressor and turbine areas of the turbocharger for signs of an oil leak. Replace the turbocharger, if necessary.

- Use the following procedure in the QSG12 CM2350 G110 Service Manual, Bulletin 4367323. Refer to Procedure 010-033 in Section 10.
- Use the following procedure in the QSG12 CM2350 G110 Service Manual, Bulletin 4367323. Refer to Procedure 010-033 in Section 10.

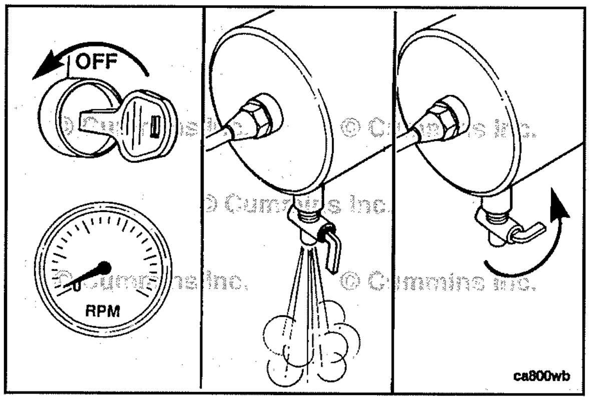




If installed, remove the turbocharger oil drain line assembly and shutoff valves.

Install the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.

Check the engine oil level and add oil if necessary.

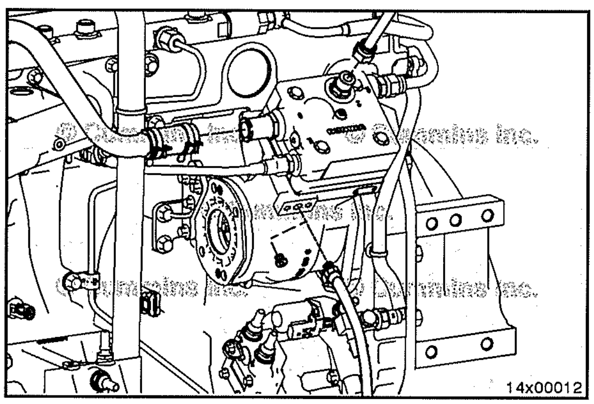


WARNING
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Check for air compressor blowby contribution, if equipped.

With the engine blowby service tool and water manometer or pressure gauge still installed, isolate the air compressor, if equipped, to determine if there is internal damage to the air compressor contributing to high engine crankcase pressure. The air compressor can be isolated by unloading the air compressor.

With the engine shut off, bleed the vehicle's air system down by opening the draincock on the wet tank to release compressed air from the system.



NOTE: The air compressor governor/unloader location can vary on each engine application. The air governor/ unloader can be air compressor mounted or chassis mounted.

Disconnect the air signal line from the air compressor governor/unloader air signal port.

Disconnect the air compressor discharge line and air intake hose from the air compressor.

NOTE: On turbocharged air compressors, make sure to plug the air intake hose going to the engine intake manifold or the engine will **not** reach full power during test.

To unload the air compressor, determine the pressure needed at the governor/unloader air signal port to start and stop the air compressor from pumping.

NOTE: Typically, the air governor cut-in pressure is 690 kPa [100 psi] and air governor cut-out pressure is 1000 kPa [145 psi]. See equipment manufacturer service information.

Connect a regulated shop air pressure line, with pressure gauge, to the air compressor governor/unloader air signal port.

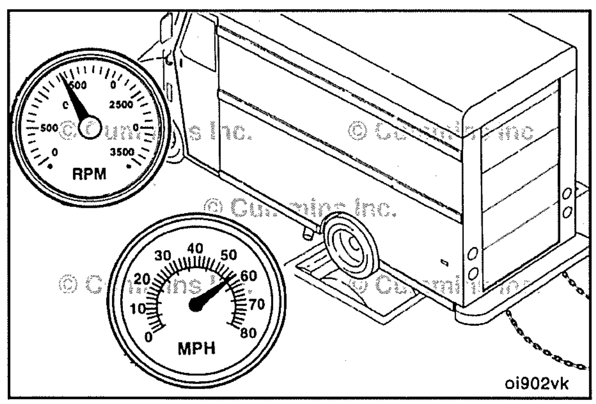
NOTE: When performing the test, make sure that the air system pressure does **not** exceed the manufacturer's maximum allowable pressure.

Run the engine and increase the signal pressure to the air governor/unloader to determine when the air compressor will stop pumping (system pressure stops rising at this point). Record the signal line pressure.

Reduce the signal pressure to determine when system pressure starts the air compressor pumping again (system pressure will begin to rise again at this point). Record the signal line pressure.

NOTE: Allow the air compressor to pump long enough to build enough pressure in the system to release and operate the air brakes.

With the regulated shop air pressure line still connected to the air compressor governor/unloader air signal port, regulate the signal pressure so that the air compressor starts pumping (system pressure will begin to rise again at this point). Use the pressure value recorded previously as a set point.



Operate the engine at rated speed and under load with either:

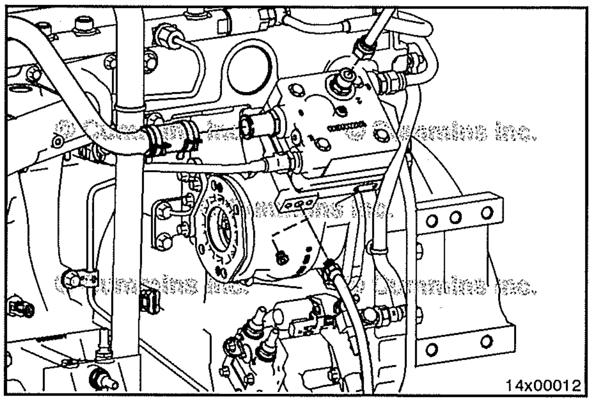
- For engine testing, a chassis dynamometer or engine dynamometer
- A stall speed test (for engines equipped with automatic transmissions **only**).

NOTE: When measuring blowby, the value can “spike” initially as the engine reaches peak power and rated speed. Wait for the blowby measurement to stabilize before taking a reading.

Continue operating the engine at rated speed and load. Increase the signal pressure (system pressure stops rising at this point). Use the pressure value recorded previously as a set point.

Operate the engine at rated rpm and full load until a steady reading is obtained.

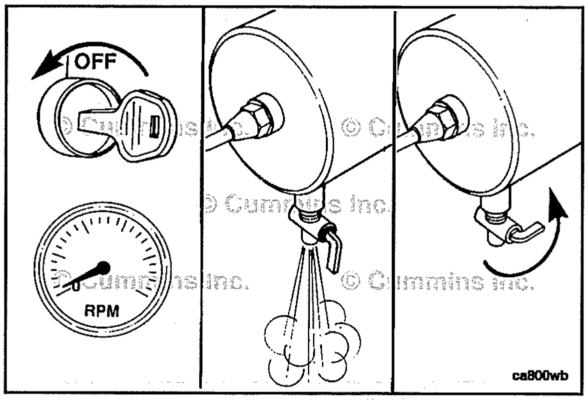
NOTE: When measuring blowby, the value can “spike” initially as the engine reaches peak power and rated speed. Wait for the blowby measurement to stabilize before taking a reading.



Determine the air compressor blowby pressure contribution by determining the difference in the blowby pressure measurement with the air compressor pumping and the air compressor **not** pumping.

Blowby Pressure Differential	
Air Compressor Contribution	Maximum: 30%

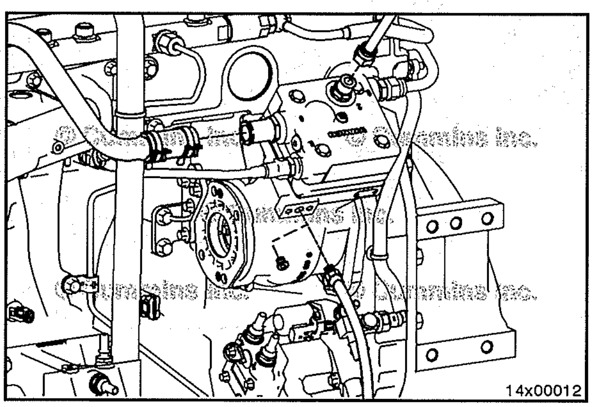
If the air compressor blowby contribution is out of specification, replace the air compressor. Refer to Procedure 012-014 in Section 12.



WARNING

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

With the engine shut off, bleed the vehicle's air system down by opening the draincock on the wet tank to release compressed air from the system.



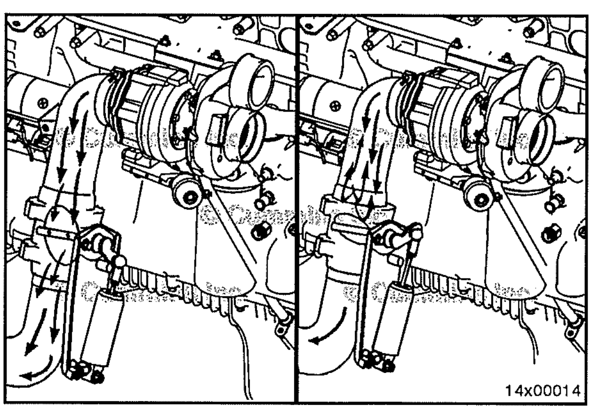
Disconnect the regulated shop air pressure line, with pressure gauge, from the air compressor governor/ unloader air signal port.

Connect the air signal line. See equipment manufacturer service information.

Remove the engine blowby service tool and water manometer or pressure gauge if the blowby is within specification.

NOTE: On turbocharged air compressors, make sure to remove the plug previously installed in the air intake hose going to the engine's intake.

Connect the air compressor discharge line and air intake hose from the air compressor.



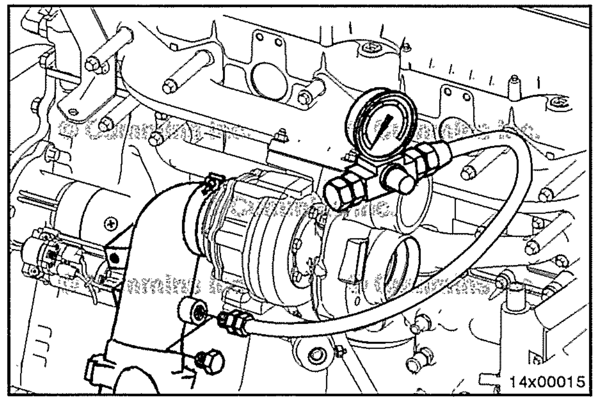
Exhaust Brake Blowby Contribution.

NOTE: **Not** all vehicles are equipped with an exhaust brake.

With the engine blowby service tool and water manometer or pressure gauge still installed, measure blowby pressure during exhaust brake operation, if equipped.

Operate the vehicle going down a long inclined road such as a highway or interstate off ramp. Begin exhaust brake operation at rated engine speed while measuring blowby pressure during exhaust brake operation.

Also, measure exhaust back pressure during exhaust brake operation.



Operate the engine until a steady reading is obtained.

NOTE: When measuring blowby, the value can "spike" initially as the engine reaches peak power and rated speed. Wait for the blowby measurement to stabilize before taking a reading.

If blowby pressure is above specification during exhaust brake operation and exhaust back pressure is above specification, repair or replace the exhaust brake. See the manufacturer's instructions.

If the blowby pressure is above specification during exhaust brake operation and the exhaust back pressure is within specification, check the turbocharger blowby contribution. See the turbocharger oil drain isolation step previously in this procedure.

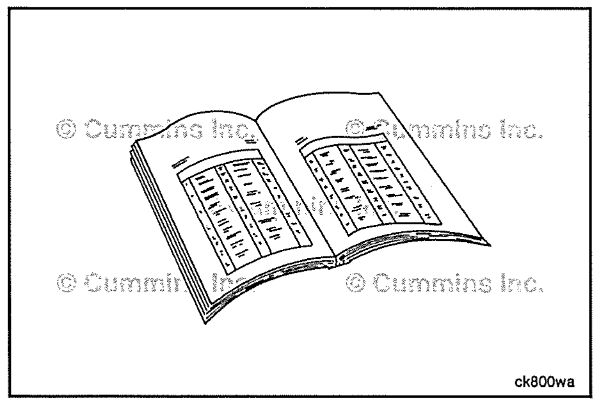
Remove the engine blowby service tool and water manometer or pressure gauge.

Remove the pressure gauge used to measure exhaust back pressure during exhaust brake operation.

Install a plug in the test port.

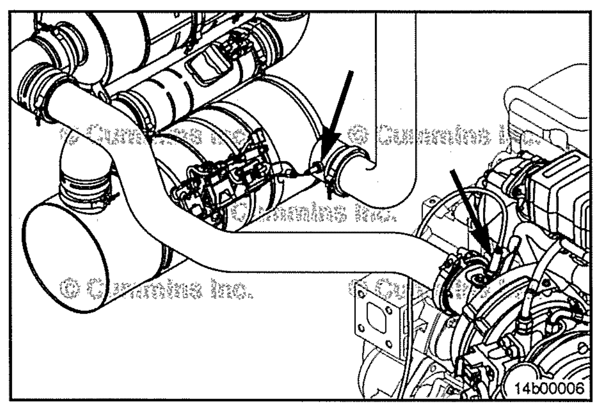
Aftertreatment Selective Catalytic Reduction (SCR) Performance Test (014-015)

General Information



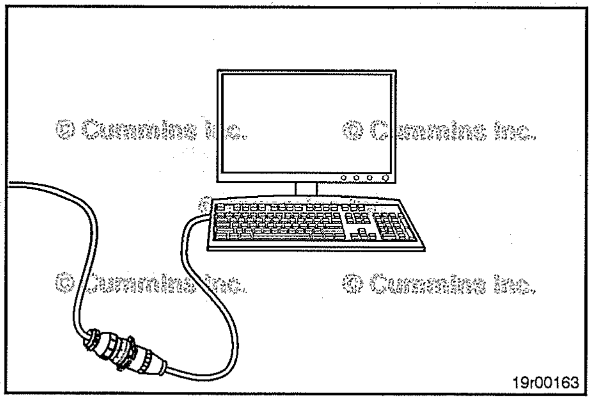
Use the following procedure for the QSG12 CM2350 G110 engine for additional information on the aftertreatment system. Refer to Procedure 011-999 in Section F.

Use the following procedure for the QSG12 CM2350 G110 engine for additional information on the aftertreatment system. Refer to Procedure 011-999 in Section F.



The following procedure contains information on how to perform an SCR Performance Test using INSITE™ electronic service tool.

The INSITE™ electronic service tool SCR Performance Test uses the Aftertreatment Intake NOx sensor and Aftertreatment Outlet NOx sensor readings to test the efficiency of the SCR catalyst.



Initial Check

Use INSITE™ electronic service tool to check for fault codes. If any fault codes are present, follow the corresponding troubleshooting tree before performing any part of this procedure.

The fault code troubleshooting tree, in some cases, will refer back to this procedure to complete the diagnostics.

Test

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.

Before performing an SCR Performance Test, follow the steps listed below:

1 Select an appropriate location to park the vehicle.
- a On a surface that will **not** burn or melt under high temperatures (such as clean concrete or gravel, **not** grass or asphalt)
- b Away from 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, and hydraulic lines)
  - No gas or vapors nearby that could burn, explode, or contribute to a fire (such as liquid petroleum gas, gasoline vapors, oxygen, and nitrous oxide).

2 Park the truck securely.
- a Set the parking brake.
- b Place the transmission in Park, if provided. Otherwise, place the transmission in Neutral.
- c Set the wheel chocks at the front and rear of at least one tire.

3 Set up a safe exhaust area.
- a If bystanders can possibly enter the area, use barriers to keep people at least 1.5 m [5 ft] from the exhaust outlet during regeneration.
- b When indoors, attach an exhaust discharge pipe rated for at least 800°C [1500°F].
- c Keep a fire extinguisher nearby.

4 Check exhaust system surfaces.
- a Confirm that nothing is on or near the exhaust system surfaces (such as tools, rags, grease, or debris).

5 Prepare for engine speed changes during regeneration.
- a Do **not** operate any PTO-powered devices. Disconnect these devices before starting regeneration.
- b Stay clear of the engine compartment.

6 Begin the SCR Performance Test.
- a The INSITE™ electronic service tool **must** be used to perform the SCR Performance Test.

b The engine will create enough heat to run the test. Engine speed will increase and the turbocharger can whistle loudly during the testing process. Once the test is complete, the engine will automatically return to normal idle speed.

7 Monitor the area.

a Make sure that the vehicle and surrounding area is monitored during regeneration. If any unsafe condition occurs, shut the engine OFF immediately.

To stop the test, engage the clutch, brake, or throttle pedal; or turn the engine OFF.

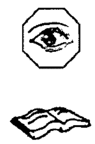
Once the test is complete, exhaust gas and exhaust surface temperatures will remain elevated for 3 to 5 minutes.

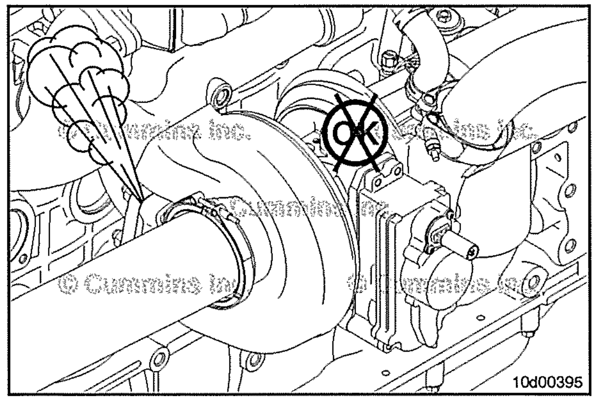
Use the following procedure for the QSG12 CM2350 G110 before starting the SCR Performance Test. Inspect the exhaust piping for leaks, cracks, and loose connections. Refer to Procedure 010-024 in Section 10.

Use the following procedure for the QSG12 CM2350 G110 before starting the SCR Performance Test. Inspect the exhaust piping for leaks, cracks, and loose connections. Refer to Procedure 010-024 in Section 10.

Tighten the exhaust clamps, if necessary. See equipment manufacturer service information for the correct torque value.

Any leaks in the exhaust system will cause the SCR Performance Test to be less efficient. This will result in the test running longer and possibly **not** completing.

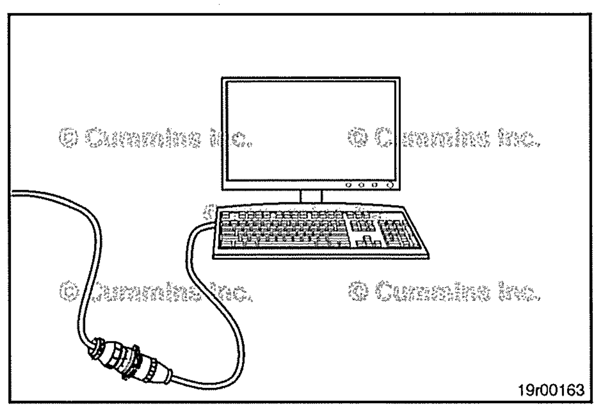


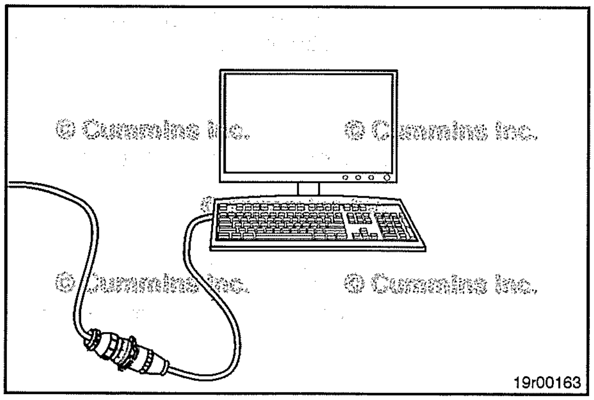


The test can be found under the ECM Diagnostics Test menu in INSITE™ electronic service tool. Follow the on-screen instructions to perform the test.

To stop the SCR Performance Test at any time during the test:

- Select the STOP button on the INSITE™ electronic service tool monitor screen.
- Depress the clutch, if equipped.
- Depress the brake.
- Depress the accelerator pedal.
- Turn the engine OFF.





The SCR Performance Test will perform the following actions:

Clean the aftertreatment system of any DEF deposits.

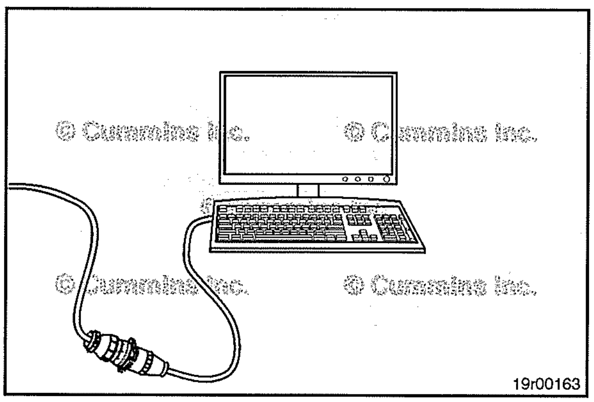
- Cleaning the aftertreatment system of DEF deposits can take up to 2 hours to complete. If deposits are detected after 2 hours of run time, the test will time out.

Perform a NOx sensor rationality test.

- The Aftertreatment Intake NOx sensor and Aftertreatment Outlet NOx sensor readings will be compared to determine if they are working properly.
- If one, or both, of the NOx sensors fail the rationality test, the test will stop and a pop-up message will be displayed, stating that the NOx sensor has failed and troubleshooting is required.

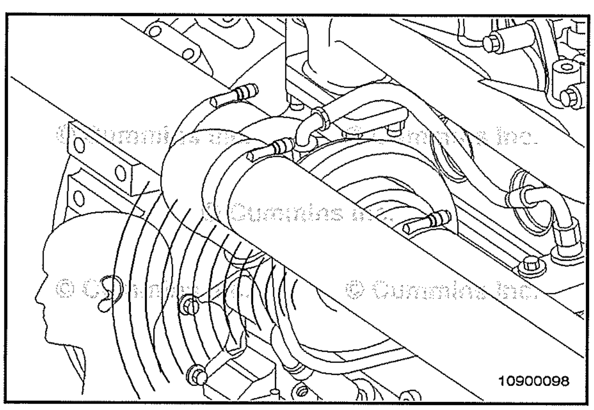
Check the SCR catalyst efficiency.

- DEF will be injected into the aftertreatment system and the Aftertreatment Outlet NOx sensor reading will be compared to the Aftertreatment Intake NOx sensor reading to determine the efficiency of the SCR catalyst.
- If the SCR catalyst fails the efficiency test, a pop-up message will be displayed, stating that the SCR Catalyst **must** be replaced.



During the SCR Efficiently Test, the following will be monitored:

- SCR catalyst inlet temperature
- SCR catalyst outlet temperature
- Aftertreatment intake NOx sensor reading
- Aftertreatment outlet NOx sensor reading.

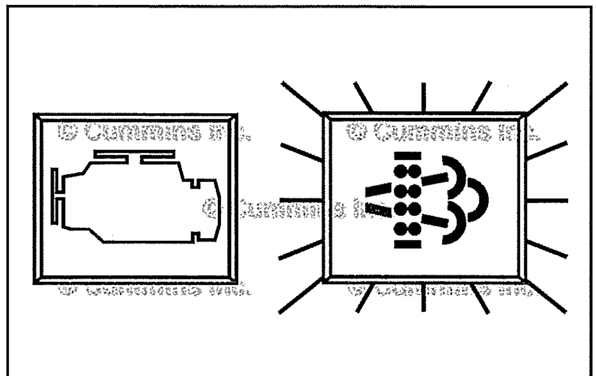


Once the SCR Performance Test is started, follow the INSITE™ electronic service tool on-screen instructions. When the test is started, the engine idle speed will be raised automatically to the required level.

Through engine controls, the engine will operate in a manner to build exhaust heat. The turbocharger will emit a slight whining noise during this test. This is normal.

Once the SCR Performance Test is complete, the engine will automatically return to normal idle speed.

Once the test is complete, check for active fault codes and/or engine indicator lamps. If any active fault codes are present, follow the appropriate fault code troubleshooting tree.



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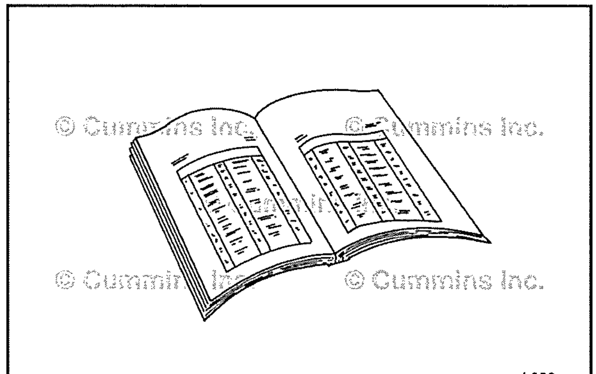
Aftertreatment Diesel Particulate Filter (DPF) Regeneration Test (014-016)

General Information



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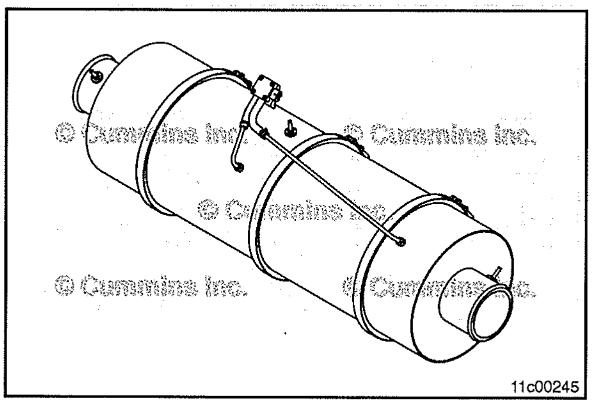
Use the following procedure for the QSG12 CM2350 G110 engine for additional information on the aftertreatment system. Refer to Procedure 011-999 in Section F.

Use the following procedure for the QSG12 CM2350 G110 engine for additional information on the aftertreatment system. Refer to Procedure 011-999 in Section F.

The following procedure contains information about how to inspect the aftertreatment diesel particulate filter and perform a stationary regeneration.



There are two main steps when checking the diesel particulate filter:

- The Initial Check section of this procedure is used to determine the condition of the aftertreatment DPF without removal of the filter. The Initial Check step should be used to determine if the aftertreatment DPF has malfunctioned due to progressive damage.
- The Test section of the procedure explains how to perform a stationary regeneration using an electronic service tool or an original equipment manufacturer (OEM)-provided stationary regeneration method. The Test step should **only** be performed when troubleshooting procedures and/or engine indicator lamps indicate this is necessary.

If the aftertreatment DPF requires replacement, before replacing:

- Troubleshoot and clear all fault codes.
- Verify the correct fuel type is being used.
- Troubleshoot **any** oil consumption complaint.
- Troubleshoot **any** coolant consumption complaint.
- Use the following procedure for the QSG12 CM2350 G110 engine to inspect the diesel oxidation catalyst (DOC). Refer to Procedure 011-049 in Section 11.
- Use the following procedure for the QSG12 CM2350 G110 engine to inspect the diesel oxidation catalyst (DOC). Refer to Procedure 011-049 in Section 11.

The INSITE™ electronic service tool Aftertreatment DPF Stationary Regeneration Test can be used to:

- Regenerate an aftertreatment DPF.
- Recover the aftertreatment DOC and aftertreatment DPF after coolant contamination.
- Reset the stored soot load in the engine control module (ECM).
- Check the aftertreatment DOC efficiency.
- Check for the presence of the aftertreatment DOC.
- Check for the correct installation of the aftertreatment temperature sensors.
- Check the drive train functionality.

The INSITE™ electronic service tool Aftertreatment DPF Stationary Regeneration Test can be used to regain functionality of the aftertreatment DOC and aftertreatment DPF, after either or both have been exposed to coolant.

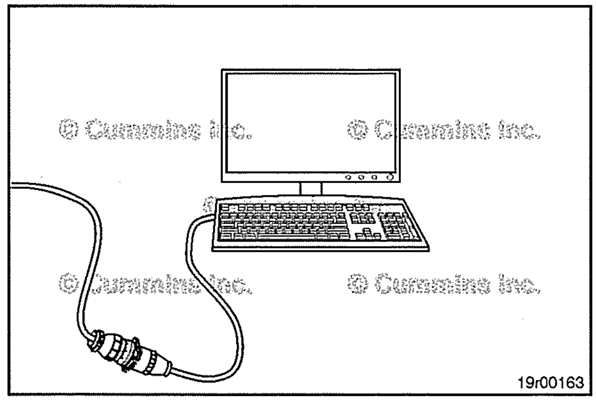
The temperatures that are achieved during regeneration are high enough to evaporate the coolant out of both components and return them to normal operating specifications.

NOTE: If these components are suspected of having coolant contamination, do **not** perform the snap acceleration test before performing the regeneration.

Initial Check

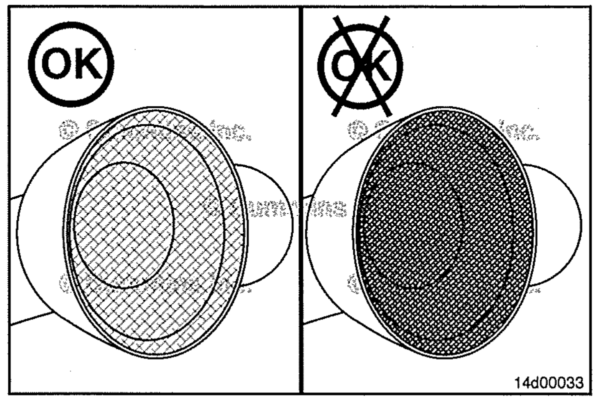
Use INSITE™ electronic service tool to check for fault codes. If **any** fault codes are present, follow the corresponding troubleshooting tree before performing **any** part of this procedure.

The fault code troubleshooting tree, in some cases, will refer back to this procedure to complete the diagnostics.



Exhaust System Outlet Inspection

- Inspection of the exhaust system outlet can reveal the condition of the aftertreatment DPF. The exhaust system outlet should appear clean with little to no exhaust residue/soot buildup.
- The aftertreatment DPF is **not** 100 percent efficient. Some accumulation of exhaust residue/soot is normal and does **not** indicate a malfunctioning aftertreatment DPF.
- A heavy buildup of exhaust residue/soot can indicate a malfunctioning aftertreatment DPF.



To determine if the exhaust residue/soot accumulation on the exhaust system outlet is the result of a malfunctioning aftertreatment DPF, perform one of the following:

- Snap Acceleration Test. Refer to Procedure 014-017 in Section 14.
- Clean the last 152 to 254 mm [6 to 10 in] of the exhaust system outlet. Operate the vehicle for one shift or trip and inspect the exhaust system outlet for exhaust residue/soot accumulation.
- Use the following procedure for the QSG12 CM2350 G110 engine to inspect the aftertreatment DPF. Refer to Procedure 011-041 in Section 11.
- Use the following procedure for the QSG12 CM2350 G110 engine to inspect the aftertreatment DPF. Refer to Procedure 011-041 in Section 11.

Test

WARNING

During regeneration, 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.

NOTE: If the stationary regeneration is being performed to recover either the DOC or DPF, or both, after coolant contamination, the DOC does **not** need to be removed or inspected unless there are active faults that require inspection as part of the fault code troubleshooting steps.

NOTE: Unless there are complaints of black smoke during operation and the exhaust stack is black, the DPF does **not** need to be removed or inspected during this process.

Before performing stationary regeneration, follow the steps listed below:

1 Select an appropriate location to park the vehicle.

a On a surface that will **not** burn or melt under high temperatures (such as clean concrete or gravel, **not** grass or asphalt)

b Away from 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, and hydraulic lines)

\- No gas or vapors nearby that could burn, explode, or contribute to a fire (such as liquid petroleum gas, gasoline vapors, oxygen, and nitrous oxide).

2 Park the truck securely.

a Set the parking brake.

b Place the transmission in Park, if provided. Otherwise, place the transmission in Neutral.

c Set the wheel chocks at the front and rear of at least one tire.

3 Set up a safe exhaust area.

a If bystanders can possibly enter the area, use barriers to keep people at least 1.5 m [5 ft] from the exhaust outlet during regeneration.

b When indoors, attach an exhaust discharge pipe rated for at least 800°C [1500°F].

c Keep a fire extinguisher nearby.

4 Check exhaust system surfaces.

a Confirm that nothing is on or near the exhaust system surfaces (such as tools, rags, grease, or debris).

5 Prepare for engine speed changes during regeneration.

a Do **not** operate **any** PTO-powered devices. Disconnect these devices before starting regeneration.

b Stay clear of the engine compartment.

6 Begin the stationary regeneration. This can be performed in two ways:

a The INSITE™ electronic service tool **must** be used to perform the SCR Performance Test.

b A manual non-mission regeneration switch can be found on the equipment. The manual non-mission regeneration switch can be a stand-alone switch, or it can be combined with a diagnostic switch, at the discretion of the vehicle manufacturer.

c INSITE™ electronic service tool can be used to perform regeneration by starting the Aftertreatment DPF Regeneration Test.

d In either case, the engine will create enough heat to regenerate the aftermarket DPF. Engine speed will increase and the turbocharger can whistle loudly during the regeneration process. Once the aftermarket DPF is regenerated, the engine will automatically return to normal idle speed.

e Make sure that the vehicle and surrounding area is monitored during regeneration. If **any** unsafe condition occurs, shut the engine off immediately.

7 Monitor the area.

a Make sure that the vehicle and surrounding area is monitored during regeneration. If **any** unsafe condition occurs, shut the engine OFF immediately.

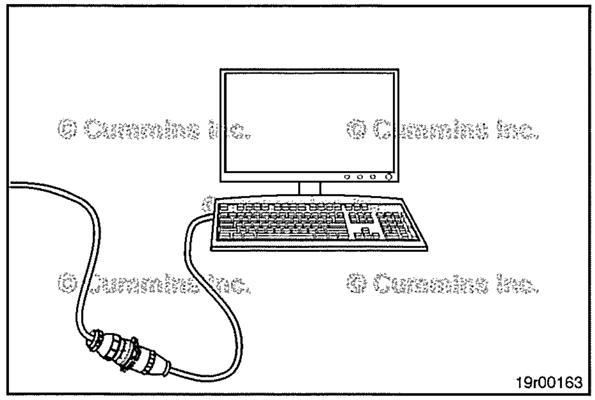
To stop a stationary regeneration, engage the clutch, brake, or throttle pedal; or turn off the engine.

Once regeneration is complete, exhaust gas and exhaust surface temperatures will remain elevated for 3 to 5 minutes.

The test can be found under the ECM Diagnostics Test menu in INSITE™ electronic service tool. Follow the on-screen instructions to perform the test.

To stop the stationary regeneration test at **any** time during the test:

1 Select the stop button on the INSITE™ electronic service tool monitor screen.
2 Depress the clutch, if equipped.
3 Depress the brake.
4 Depress the accelerator pedal.
5 Turn the engine off.

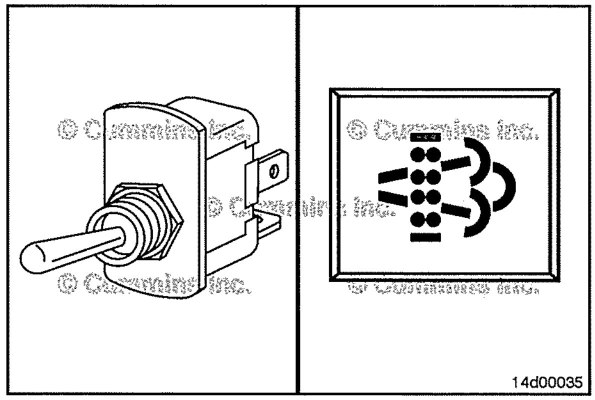


NOTE: If INSITE™ electronic service tool is **not** available, some vehicles can be equipped with an OEM-provided stationary regeneration method. The most common type is a stationary regeneration switch in the cab. The stationary regeneration switch can be a stand-alone switch, or can be combined with the diagnostic switch, at the discretion of the vehicle manufacturer.

The OEM stationary regeneration initiations vary. See equipment manufacturer service information for specific instructions.

In order for the stationary regeneration switch to function, the stationary regeneration switch parameter **must** be enabled in the ECM.

Unlike the Aftertreatment Stationary Regeneration Test with INSITE™ electronic service tool, this switch will **only** start a stationary regeneration if the soot load of the filter is high enough. This is indicated by an illuminated or flashing aftertreatment lamp.

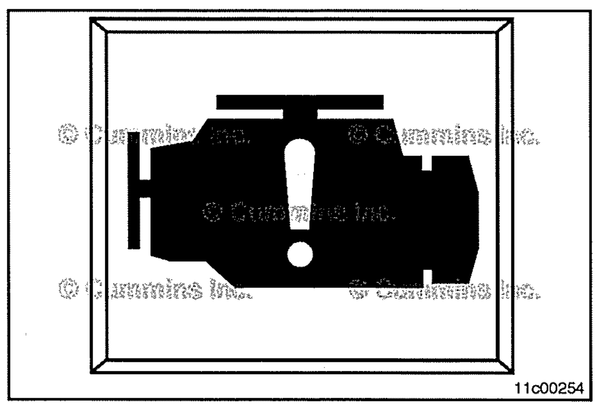


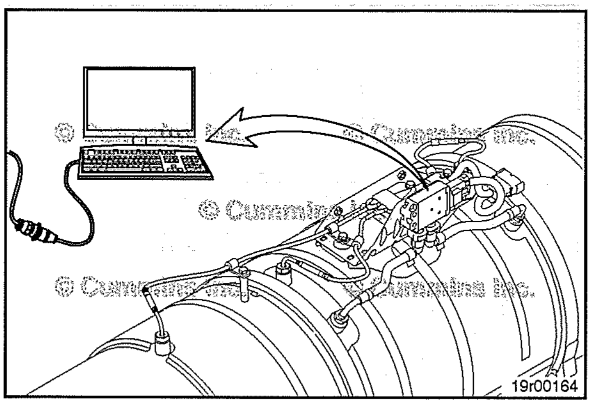
If the red STOP ENGINE indicator lamp is illuminated and an active Fault Code 1922 is present, indicating the aftertreatment DPF soot load is at the most severe level, the Aftertreatment DPF Regeneration Test should **not** be performed.

For the QSG12 CM2350 G110 engine, the aftertreatment DPF **must** be inspected. Refer to Procedure 011-041 in Section 11.

For the QSG12 CM2350 G110 engine, the aftertreatment DPF **must** be inspected. Refer to Procedure 011-041 in Section 11.

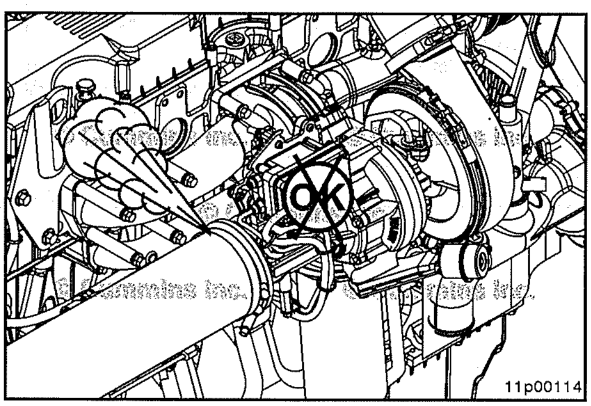
After the aftertreatment DPF is cleaned or replaced, the troubleshooting tree associated with the red STOP ENGINE lamp **must** be followed to reset the soot load value stored in the ECM.





During the Aftertreatment DPF Regeneration Test, the following will be monitored:

- Aftertreatment DPF Soot Load: Informs the user of the current soot load of the filter:
- Normal: No regeneration is necessary.
- Above Normal: Least Severe Level - A stationary regeneration can be performed.
- Above Normal: Moderately Severe Level - A stationary regeneration can be performed.
- Above Normal: Most Severe Level - A stationary regeneration should **not** be performed unless the filter is cleaned or a new filter has been installed and the troubleshooting steps indicate it should be performed.
- Aftertreatment DPF Outlet Temperature
- Aftertreatment DPF Inlet Temperature
- Aftertreatment Diesel Oxidation Catalyst Inlet Temperature.

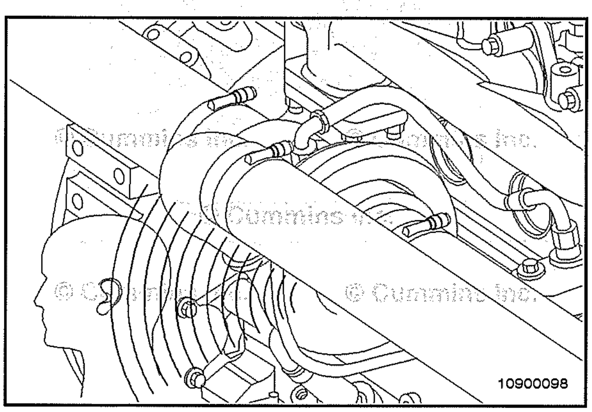


Use the following procedure for the QSG12 CM2350 G110 engine before starting the Aftertreatment DPF Regeneration Test. Inspect the exhaust piping for leaks, cracks, and loose connections. Refer to Procedure 010-024 in Section 10.

Use the following procedure for the QSG12 CM2350 G110 engine before starting the Aftertreatment DPF Regeneration Test. Inspect the exhaust piping for leaks, cracks, and loose connections. Refer to Procedure 010-024 in Section 10.

Tighten the exhaust clamps, if necessary. See equipment manufacturer service information for the correct torque value.

Any leaks in the exhaust system will cause the Aftertreatment DPF Test to be less efficient in reducing the soot load of the filter. This will result in the test running longer and possibly **not** completing.



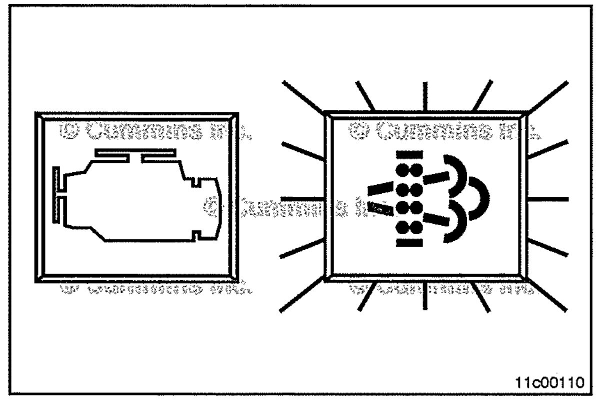
NOTE: If the Aftertreatment DPF Regeneration Test will **not** initiate, see the Stationary Regeneration - Will Not Activate troubleshooting symptom tree in Section TS.

Once the Aftertreatment DPF Regeneration Test is started, follow INSITE™ electronic service tool on-screen instructions. When the test is started, the engine idle speed will be raised automatically to the required level.

The engine will, through engine controls, operate in a manner to build exhaust heat. The turbocharger will emit a slight whining noise during this test. This is normal.

Once the Aftertreatment DPF Regeneration Test is complete, the engine will automatically return to normal idle speed.

Once the test is complete, check for active fault codes and/or engine indicator lamps for high aftertreatment diesel particulate soot load after performing the Aftertreatment DPF Regeneration Test. If **any** active fault codes are present, follow the appropriate fault code troubleshooting tree.



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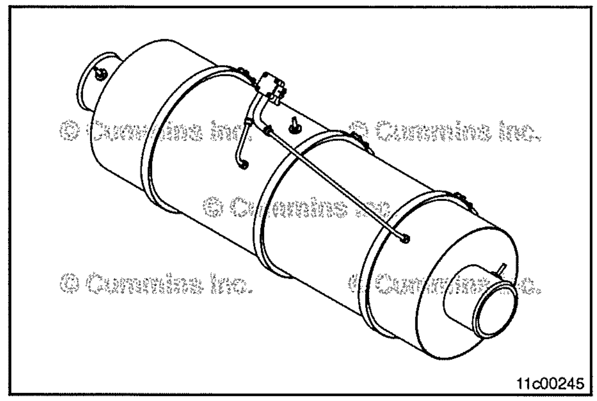
Snap Acceleration Test (014-017)

General Information

Use the following procedure for the QSG12 CM2350 G110 engine for additional information on the aftertreatment system. Refer to Procedure 011-999 in Section F.

Use the following procedure for the QSG12 CM2350 G110 engine for additional information on the aftertreatment system. Refer to Procedure 011-999 in Section F.

The following procedure contains information about how to perform a Snap Acceleration Test with the aftertreatment system connected and disconnected.



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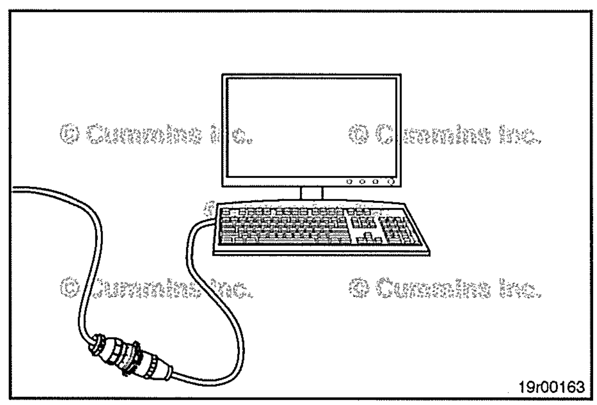
Initial Check

Use INSITE™ electronic service tool to check for fault codes. If **any** fault codes are present, follow the corresponding troubleshooting tree before performing **any** part of this procedure.

The fault code troubleshooting tree, in some cases, will refer back to this procedure to complete the diagnostics.



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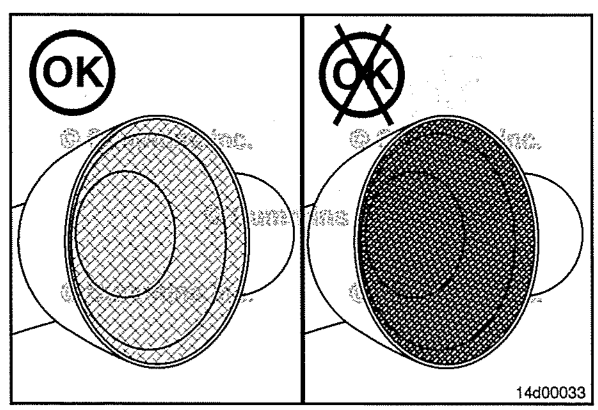
Exhaust System Outlet Inspection

- Inspection of the exhaust system outlet can reveal the condition of the aftertreatment diesel particulate filter (DPF). The exhaust system outlet should appear clean, with little to no exhaust residue/soot buildup.
- The aftertreatment DPF is **not** 100 percent efficient. Some accumulation of exhaust residue/soot is normal and does **not** indicate a malfunctioning aftertreatment DPF.
- A heavy buildup of exhaust residue/soot can indicate a malfunctioning aftertreatment DPF.



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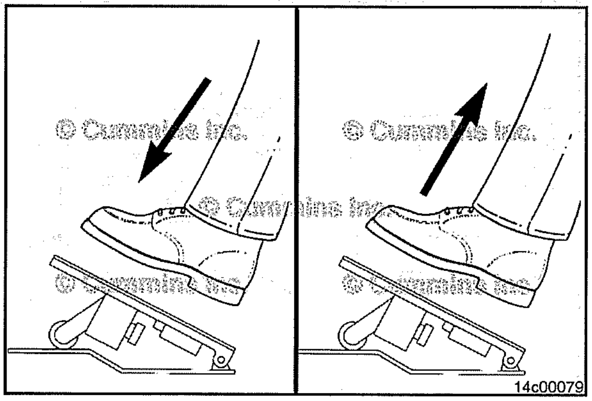


Test

Snap Acceleration - Aftertreatment Connected

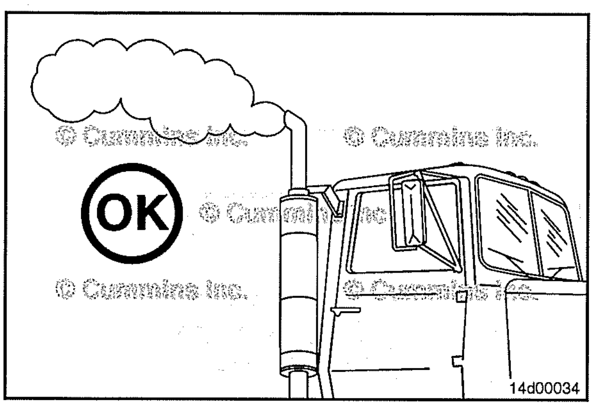
Monitoring the condition of the exhaust leaving the exhaust system outlet during a snap acceleration can reveal the condition of the aftertreatment DPF.

The engine **must** be at minimum operating temperature or above when completing this test. The vehicle transmission **must** be in neutral and the vehicle parking brake **must** be applied.

Start and idle the engine. Rapidly depress the accelerator pedal from 0 to 100 percent. This can be performed multiple times, if necessary.

During this test, check for black smoke exiting the exhaust stack, as the engine is accelerated from low idle to high idle.

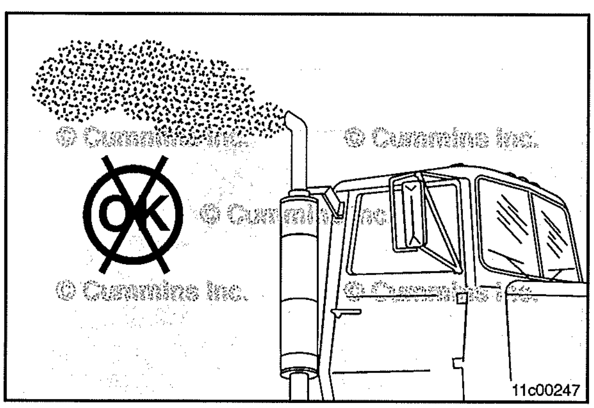
NOTE: In some applications, a Snap Acceleration Test may **not** provide the conditions necessary to reveal a malfunctioning aftertreatment DPF. If there is a heavy buildup of exhaust residue/soot on the exhaust system outlet and a snap acceleration does not reveal a condition outlined in the following steps, it may be necessary to perform a brief acceleration run under partial to full load and/or a stall test. Refer to Procedure 014-008 in Section 14.



NOTE: If an opacity meter is used to measure the condition of the exhaust gas leaving the exhaust system outlet, the engine and aftertreatment system **must** be at operating temperature.

White smoke can indicate condensation in the exhaust and/or some unburned fuel. White smoke is **not** an indication of a malfunction of the aftertreatment system.

If excessive white smoke is present, see the Engine Performance troubleshooting symptom tree in Section TS.



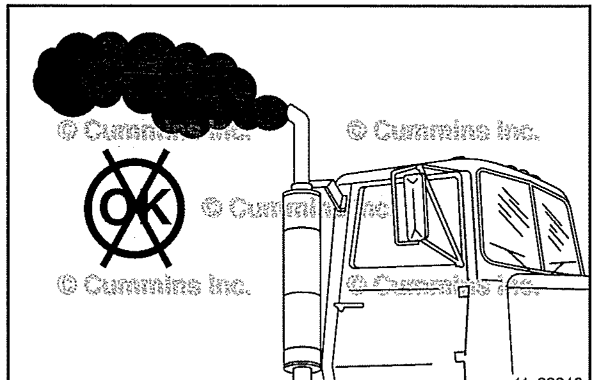
Use the following procedure for the QSG12 CM2350 G110 engine for visible gray smoke or faint black smoke out of the exhaust system outlet indicates that the aftertreatment DPF is damaged. Inspect the aftertreatment DPF. Refer to Procedure 011-041 in Section 11.

Use the following procedure for the QSG12 CM2350 G110 engine for visible gray smoke or faint black smoke out of the exhaust system outlet indicates that the aftertreatment DPF is damaged. Inspect the aftertreatment DPF. Refer to Procedure 011-041 in Section 11.

Visible black smoke out of the exhaust system outlet indicates a malfunction of the aftertreatment DPF.

NOTE: If the vehicle has experienced the diesel particulate lamp illuminating frequently, high exhaust temperature lamp, if equipped, illuminating frequently, and/or requires frequent stationary regenerations, use the appropriate troubleshooting symptom tree in Section TS.

Refer to Service Bulletin, Aftertreatment Diesel Oxidation Catalyst and Aftertreatment Diesel Particulate Filter Reuse Guidelines, Bulletin 4021600, for pass or fail guidelines.



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Snap Acceleration - Aftertreatment Disconnected

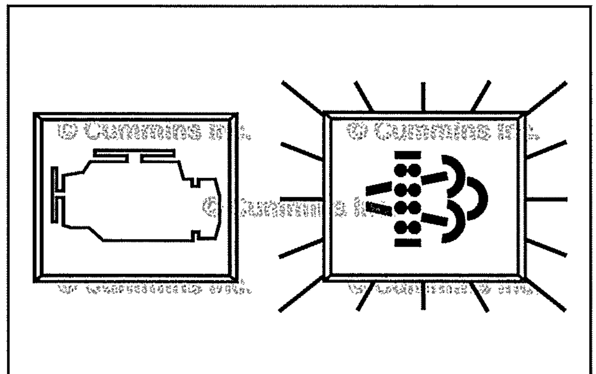
WARNING

The exhaust and exhaust components can remain hot after the engine has been shut down or secured. 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 might come in contact with hot exhaust or exhaust components.

One of the functions of the aftertreatment system is to remove particulates from the exhaust gas. This function prevents the use of black smoke as a diagnostic symptom.

The Snap Acceleration Test (aftertreatment disconnected) is used to check for abnormally high amounts of black smoke in the exhaust gas.

Disconnect the exhaust pipe from the turbocharger turbine outlet.


11c00110

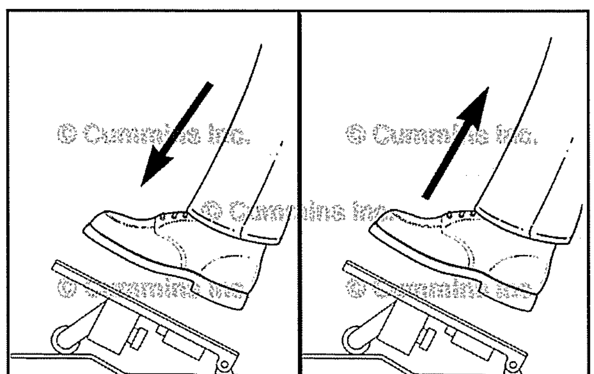
The vehicle transmission **must** be in neutral.

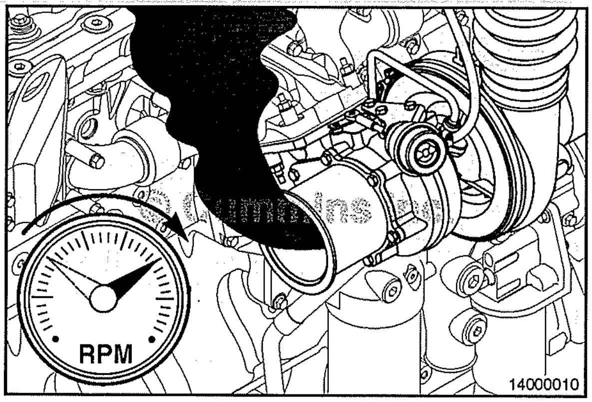
The vehicle parking brake **must** be applied.

It may be necessary to temporarily adjust the maximum engine speed with no vehicle speed sensor (VSS) parameter in INSITE™ electronic service tool to the high idle speed of the engine.

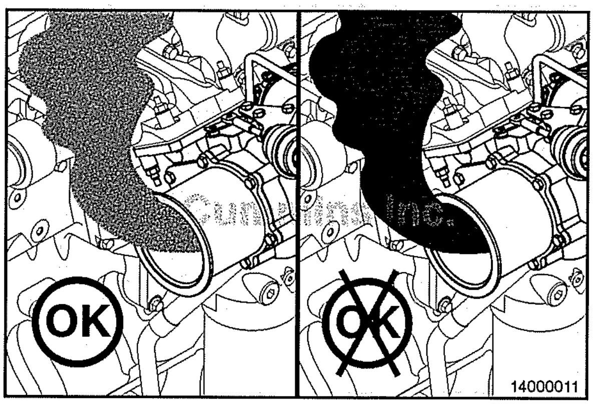
Start the engine and let it idle.

Quickly depress the accelerator pedal from 0 percent to 100 percent and hold for 5 seconds then release. This can be performed multiple times, if necessary.


14c00079



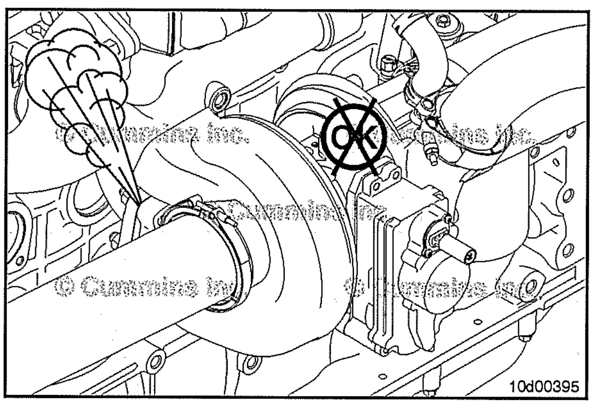
During this test, check for black smoke exiting the turbocharger turbine outlet as the engine is accelerated from low idle to high idle and at high idle.



A small puff of black smoke upon acceleration that clears at a steady high idle speed is normal.

White smoke during the Snap Acceleration Test does **not** indicate a malfunction. No repair is necessary.

Heavy black smoke indicates other upstream engine issues that need to be diagnosed. See the Black Smoke - Excessive troubleshooting symptom tree in Section TS.

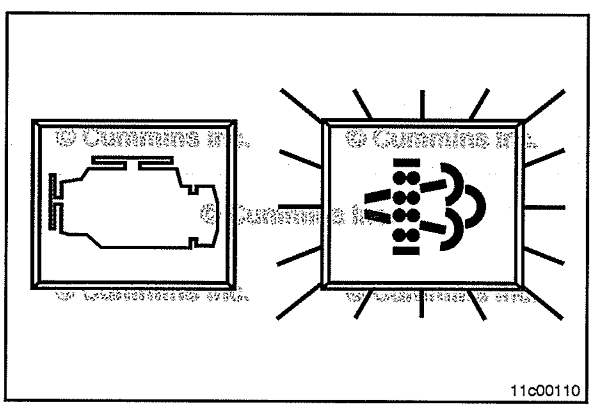


Reconnect the exhaust system.

Inspect the exhaust piping for leaks, cracks, and loose connections.

Tighten the exhaust clamps if necessary.

See equipment manufacturer service information for the correct torque value.



Once the test is complete, check for active fault codes and/or engine indicator lamps for high aftertreatment diesel particulate soot load after performing the Aftertreatment DPF Regeneration Test. If **any** active fault codes are present, follow the appropriate fault code troubleshooting tree.

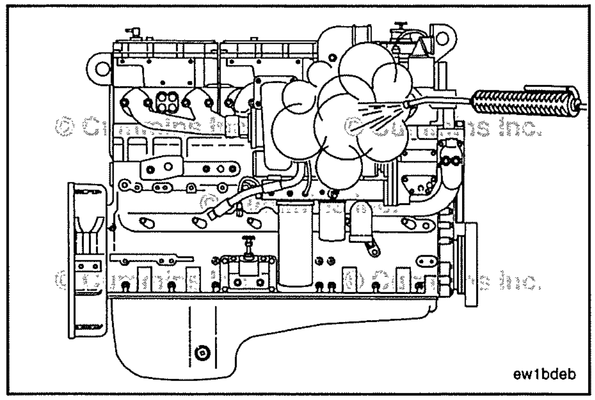
Fluorescent Tracer Dye Test (014-024)

General Information

NOTE: The illustrations in this procedure are generic and may not represent the hardware on all engines.

The Fluorescent Tracer Dye Test is used to aid in locating fluid leaks in the lubricating oil system, cooling system, and fuel system.

Preparatory Steps



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

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

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

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

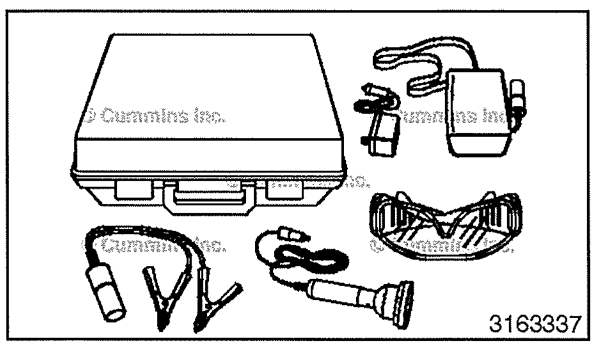
Some rust prevention oils applied at the factory have fluorescent tracer dyes, which can provide false test results. Check suspect areas with a black light to make sure there is not already fluorescent tracer dye present before adding fluorescent tracer dyes to the fluid under test.

Steam clean the affected areas on the engine.

Steam is the best choice for cleaning an engine. If steam is not available, use an appropriate solvent to clean the engine.

Setup

Initial Setup

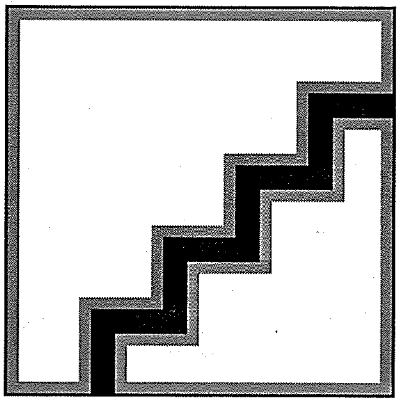


The Fluorescent Tracer Dye Test requires the use of leak test kit, Part Number 2892320, and fluorescent tracer dye.

- For lubricating oil or fuel use fluorescent tracer dye, Part Number 3376891.
- For coolant use fluorescent tracer dye, Part Number 3377438.

Use the instructions on the fluorescent tracer dye container to determine the ratio of fluorescent tracer dye to fluid being tested.

See the corresponding Cummins® Service Manual or the equipment manufacturer's service information to determine the total volume of lubricating oil, coolant, or fuel. Use the ratio and total fluid volume to determine the necessary amount of fluorescent tracer dye to add to the system being tested.



Lubricating Oil

⚠WARNING⚠

When the engine is running with the rocker lever covers removed, oil splashing can cause personal injury. To reduce the possibility of personal injury, wear eye and face protection.

⚠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.

For the lubrication oil system, remove the lubricating oil cap and add the appropriate amount of fluorescent tracer dye to the lubricating oil system. Install the lubricating oil fill cap.

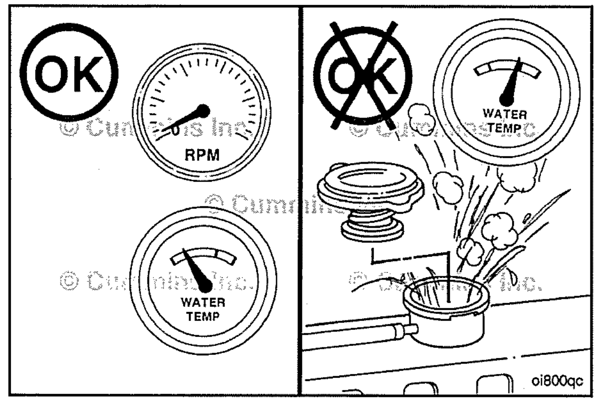
NOTE: Lubricating oil with high levels of soot may need to be changed in order to make the fluorescent tracer dye visible. Up to three times the standard amount of fluorescent tracer dye may be used if necessary. The use of fluorescent tracer dye does not interfere with engine performance and can be left in the engine lubricating oil after use.

Operate the engine in a manner to distribute the dye throughout the lubricating system evenly. This can typically be achieved by operating the engine at high idle for approximately 5 minutes.

Removal of components, such as the rocker lever cover, may be necessary to perform part of the fluorescent tracer dye test. In these cases, see the corresponding Cummins® Service Manual or the equipment manufacturer's service information.

If necessary, run the engine under load to create the conditions of the lubricating oil leak.

Coolant



⚠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.

⚠WARNING⚠

The coolant line(s) can be hot and under pressure. Do not disconnect the coolant lines while the engine is running or before the system has cooled down after engine shutdown. Heated coolant spray can cause personal injury. To reduce the possibility of personal injury, use eye and face protection, gloves and appropriate personal protective equipment.

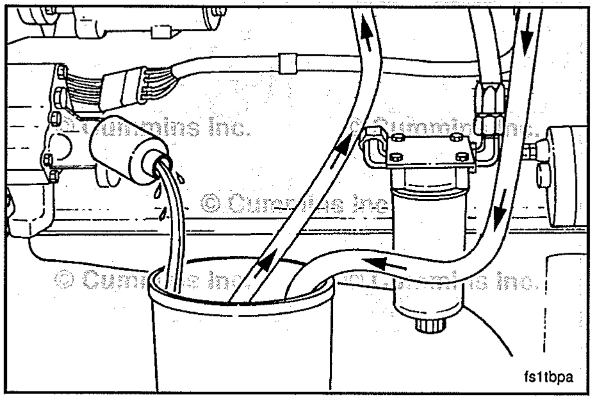
For the cooling system, verify the coolant temperature is below 50°C [120°F]. Remove the radiator cap.

Add the appropriate amount of fluorescent tracer dye to the cooling system. Install the radiator cap.

Operate the engine in a manner to evenly distribute the fluorescent tracer dye throughout the cooling system. This can typically be achieved by operating the engine at high idle while monitoring engine coolant temperature.

Coolant temperature will rise to around 100°C [212°F], the coolant thermostat will open and the coolant temperature will drop, coolant temperature will rise a second time and the coolant thermostat will open again.

The fluorescent tracer dye will be evenly distributed after the coolant thermostat has cycled 3 times.



Fuel

⚠WARNING⚠

Fuel can be returned at highly elevated temperatures. Wear safety glasses and protective gloves and clothing when performing this test. Avoid any contact with returned fuel.

⚠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.

NOTE: This section only applies to diesel fueled engines.

For the fuel system, remove the fuel filler cap and add the appropriate amount of fluorescent tracer dye to the fuel tank. Install the fill cap. It may be necessary to operate the vehicle or perform a short road test to evenly distribute the dye in the fuel.

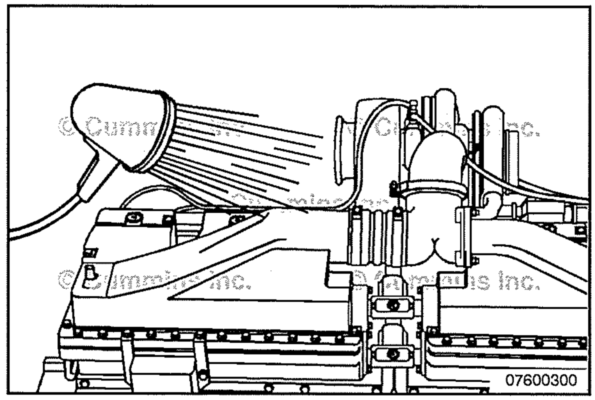
For the fuel system, an alternate method is to use a clean 14.8L [5 gallon] fuel container. Fill the fuel container with clean fuel. Add the appropriate amount of dye to treat 14.8L [5 gallons] of fuel. Mix the fuel and Fluorescent Tracer Dye for even distribution.

Disconnect the fuel supply and return lines from the engine. See Procedures 006-013 and 006-024 in Section 6.

Fabricate service fuel lines that will connect to the fuel inlet connection and the fuel return connection on the engine. Fuel lines **must** be long enough to reach from the connection point to the14.8L [5 gallon] fuel container on the ground below the connection point.

NOTE: Do not allow the engine to operate from a remote fuel source for more than 10 minutes.

Test



WARNING

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

WARNING

To reduce the possibility of personal injury, keep hands, long hair, jewelry, and loose-fitting or torn clothing away from fans and other moving parts.

NOTE: The lubricating oil contamination test is not effective on a cold engine, less than 21°C [70°F] coolant temperature, or with a loose overhead setting.

Use the black light from the Leak Test Kit, Part Number 2892320, to inspect for the presence of fluorescent tracer dye.

Operation of the engine may be necessary during the inspection process to determine the location of the origin of the fluorescent tracer dye.

Always start at the bottom of the engine or component being inspected and work toward the top. Liquids will flow to the lowest point before forming droplets. Follow the fluorescent tracer dye trail upward to determine the origin of the leak.

Fluorescent tracer dye may collect and distribute around areas like the lubricating oil pan rail, head gasket area, or the rocker lever cover rail before dripping or flowing downward. If a leak is suspected in these locations, make certain the fluorescent tracer dye trail does **not** originate from a location above.

Components like the cooling fan may create turbulence that will distribute the fluorescent tracer dye in a horizontal direction. In these cases, follow the fluorescent tracer dye in the opposite direction of flow to find the origin of the leak.

Components, like the flywheel or vibration damper, will distribute fluorescent tracer dye in a circular pattern. For this situation, determine if the fluorescent tracer dye is being dripped on the component from above and being redistributed, or if the leak originates at the seal near the center of the component.

Repair or replace the component or components that the fluorescent tracer dye originates from.

If the origin of the fluorescent tracer dye can **not** be found, consider cleaning the engine or component and test again.

If fluorescent tracer dye is **not** found during the inspection, no leak is present.

Finishing Steps

Install any components that were removed for access during the test.

To verify the repair, operate the engine or system in the same manner used to generate the leak.

Repeat the test to verify the leak has been repaired.

Notes

Section 16 - Mounting Adaptations - Group 16

Section Contents

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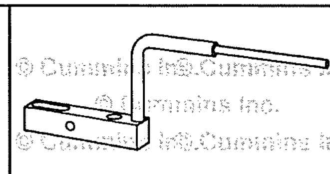
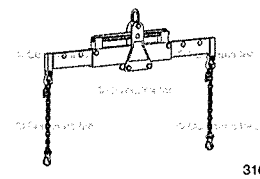
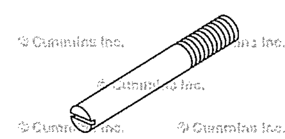
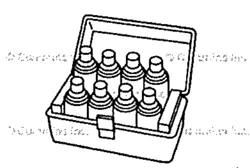
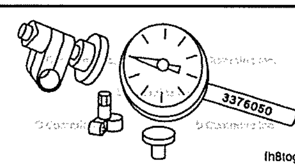
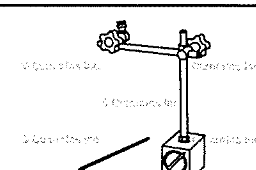
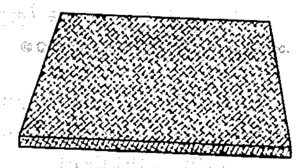
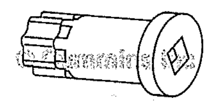
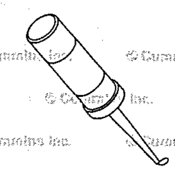
Service Tools

Mounting Adaptations

The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
ST-1325	**Dial Gauge Attachment** Used to check the bore and face of the flywheel and flywheel housing relative to the center line of the crankshaft.	
3162871	**Engine Lifting Fixture** Used with a hoist to lift the engine.	
3376638	**Guide Pin** This guide pin (M12x1.25, 150-mm long) is used during assembly and/or disassembly to align parts and aid in the control of parts.	
3375432	**Crack Detection Kit** Used to inspect components for cracks.	
3376050	**Dial Indicator and Sleeve Assembly** Used with dial gauge attachment Part Number 3377399 to measure flywheel and flywheel housing runout.	
3377399	**Magnetic Base Dial Indicator Holder** Used with Part Number 3376050, dial indicator and sleeve assembly.	

Tool No.	Tool Description	Tool Illustration
3823258	**Abrasive Pad** Used to remove small nicks and burrs.	
4919092	**Engine Barring Tool** Used to bar the engine by hand.	
5298588	**Loctite® 509** Used to create a seal between two mating surfaces.	

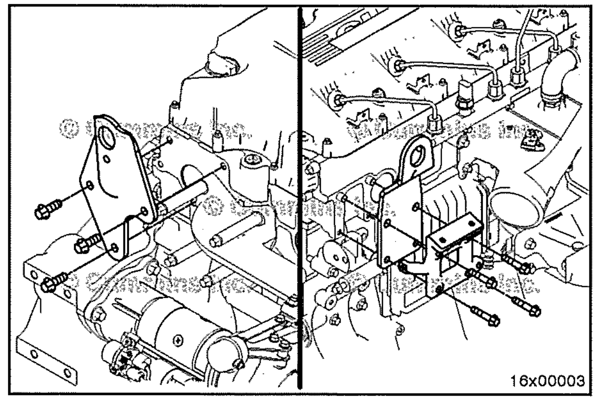
Engine Lifting Brackets (016-001)

Remove

Remove the capscrews, spacer, and the rear lifting bracket.

Remove the accessory support bracket. Refer to Procedure 013-003 in Section 13.

Remove the front lifting bracket.



16x00003

Clean and Inspect for Reuse

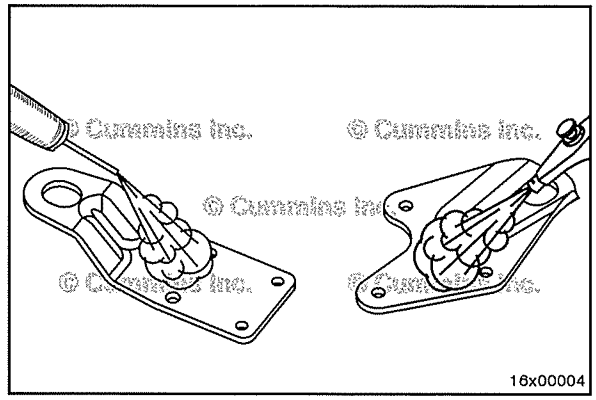
⚠WARNING⚠
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

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

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

Use steam or solvent to clean the lifting brackets.

Dry with compressed air.

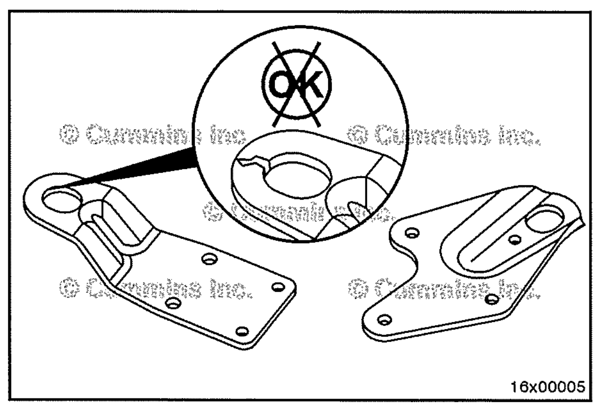


16x00004

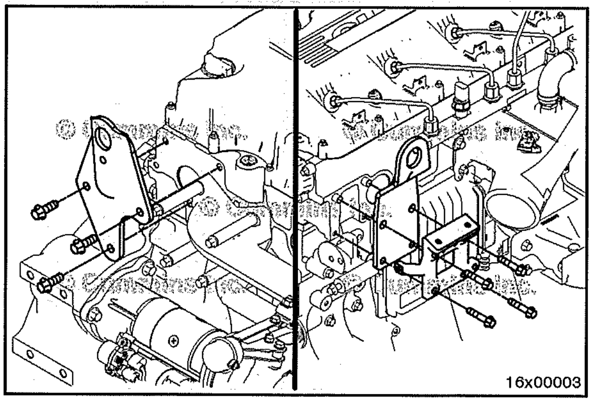
⚠WARNING⚠
Do not use a cracked or damaged bracket. Do not weld a cracked bracket. Personal injury can result.

Inspect the brackets for cracks or other damage.

Replace the bracket if it is damaged.



16x00005



Install

Install the rear lifting bracket, spacer, and capscrews.

Orientate the spacer to align with the mounting holes.

Tighten the capscrews.

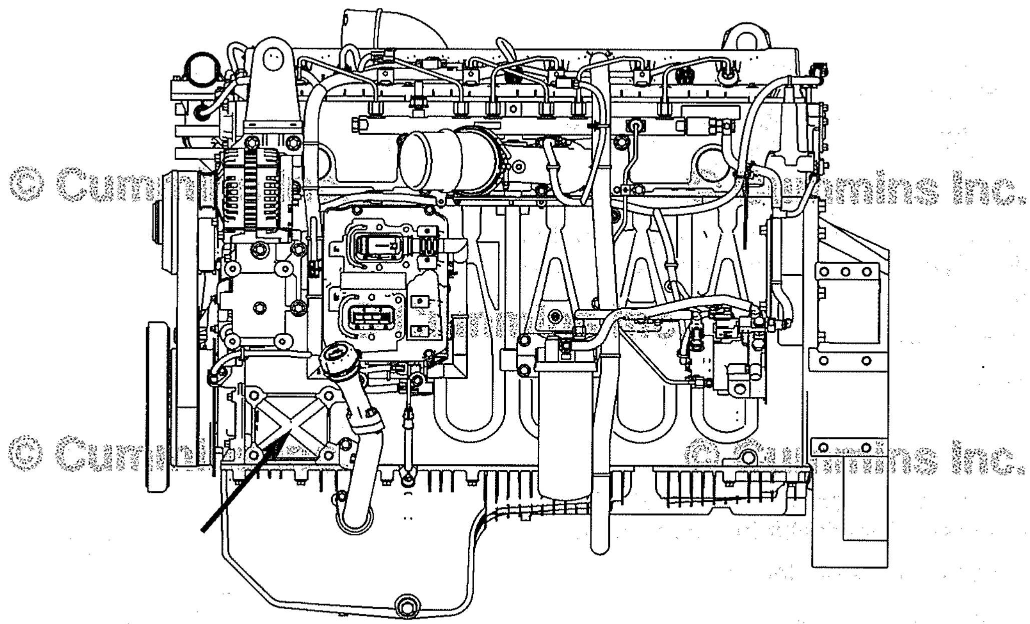
Torque Value: 80 N•m [59 ft-lb]

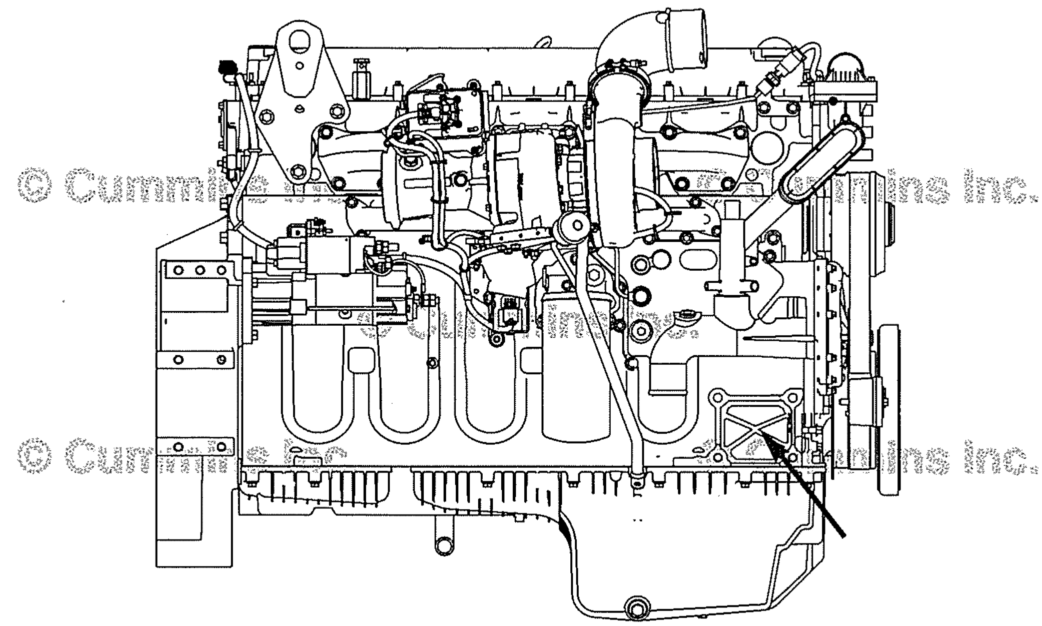
Install the front lifting bracket and the accessory support bracket. Refer to Procedure 013-003 in Section 13.

Engine Support Bracket, Front (016-002)

General Information

The following shows the locations of the Front Engine Support Brackets on each side.





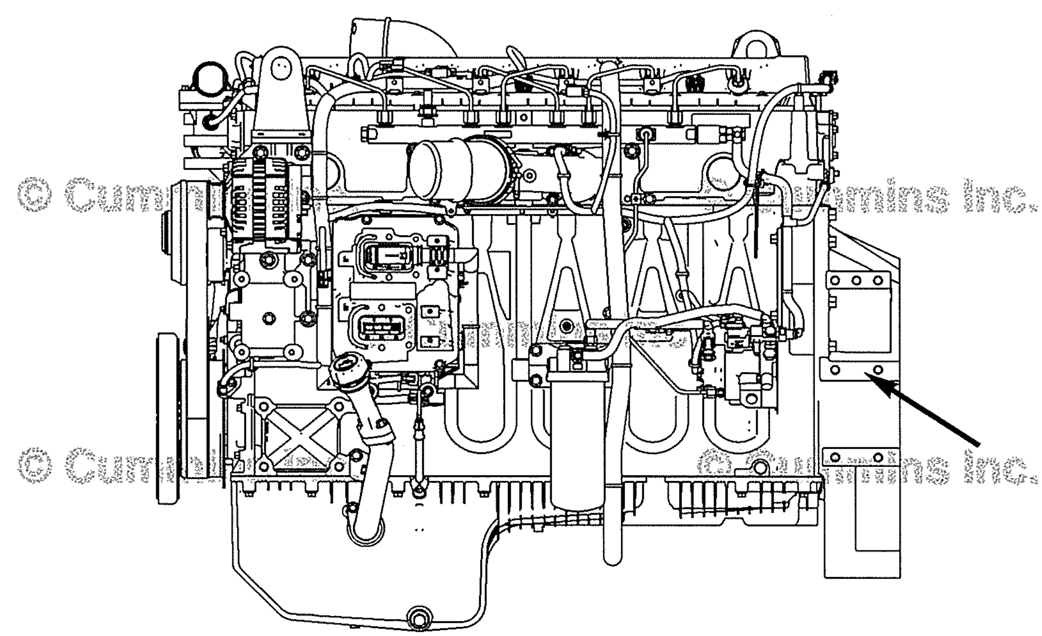
16p00024

Use M14X2 mounting capscrews, grade 10.9, torqued to 180 N•m [133 ft-lb] when installing the support brackets. See equipment manufacturer service information for removal and installation procedures.

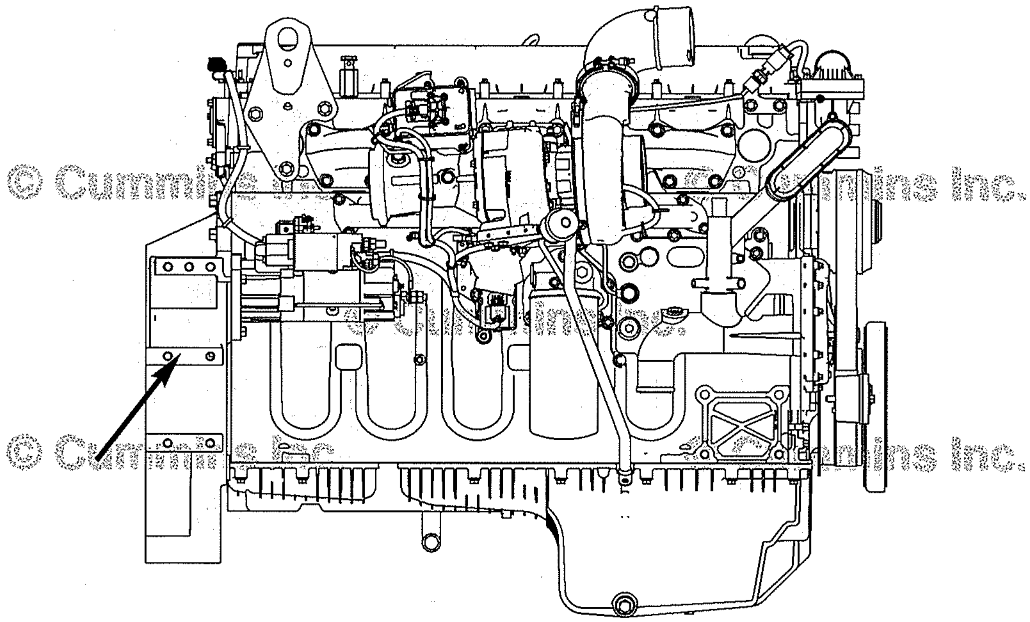
Engine Support Bracket, Rear (016-003)

General Information

The following images show the locations of the Rear Engine Support Brackets on each side.



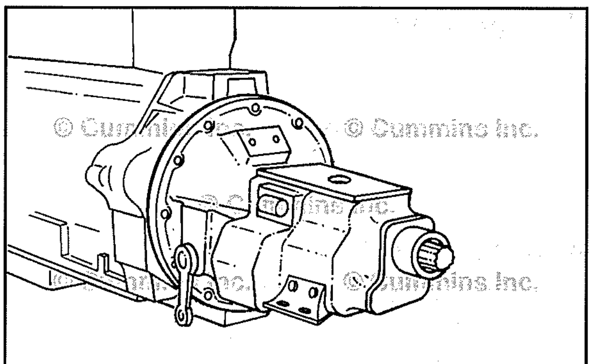
16p00021



16p00022

Use M14X2 mounting capscrews, Grade 10.9, torqued to 180 N•m [133 ft-lb] when installing the support brackets.

See equipment manufacturer service information for removal and installation procedures.



tr400wa

Flywheel (016-005)

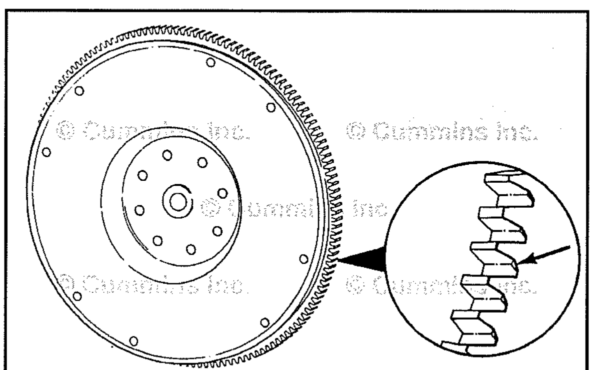
Preparatory Steps

WARNING

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

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.

Remove the transmission and all related components (if equipped). See equipment manufacturer service information.



fh9gewb

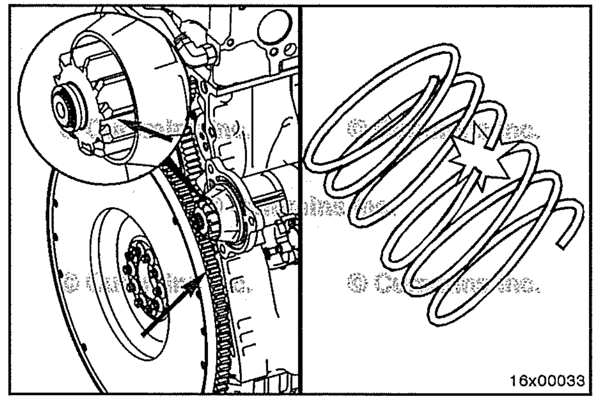
Initial Check

Inspect the flywheel ring gear teeth for damage.

If the flywheel ring gear is damaged, inspect the following possible causes.

Mechanical

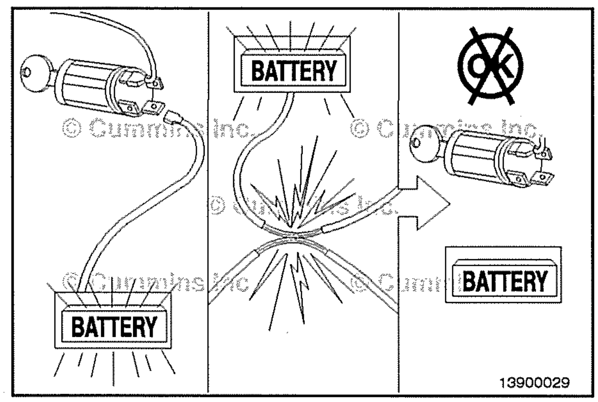
Gear ring wear can be identified by a visual inspection of the ring gear teeth. Damage typically occurs of the flywheel in three distinct locations for six cylinder engines (commonly called 120 degree milling). The following could be causes for gear ring wear.


16x00033

1 There can be interference between the ring gear land area and the starting motor pinion. The wrong starting motor can be installed. See equipment manufacturer service information.
2 There can be a defect with the starter motor pinion. Inspect the pinion for nicks and burrs. If replacement of the starting motor is necessary. Refer to Procedure 013-020 in Section 13.
3 The ring gear can be improperly installed or damaged. Refer to Procedure 016-008 in Section 16.
4 The flywheel face runout can be out of specification. See the Measure section of this procedure.
5 There can be an incorrect starting motor pinion to flywheel ring gear pitch/teeth match. See equipment manufacturer service information.

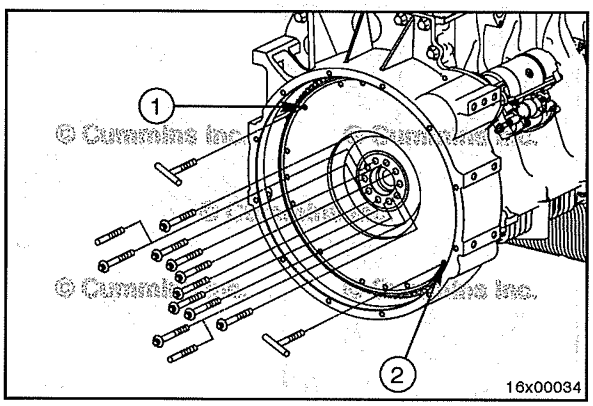
Electrical

Electrical problems can be identified by a visual inspection of the ring gear on the flywheel 360 degrees around the circumference of the ring gear (commonly called 360 degree milling). The following could be causes for electrical issues:



13900029

1 Operator is attempting to start engine while engine is already running. Check if a starter lockout feature is available through the OEM (activated with INSITE™ electronic service tool) or the starting motor manufacturer.
2 Key switch is causing intermittent starting motor engagement when the engine is running. Inspect the key switch. Refer to Procedure 013-030 in Section 13.
3 The starter relay is oriented so that the direction of the pull contact is in the direction of the vehicle's travel. This results in intermittent starter motor engagement when the engine is running. Relocate the starter relay. See equipment manufacturer service information.
4 There can be intermittent starter motor wiring issues. See equipment manufacturer service information.



Remove

NOTE: Use the barring tool, Part Number 4919092, to hold the flywheel to prevent rotation.

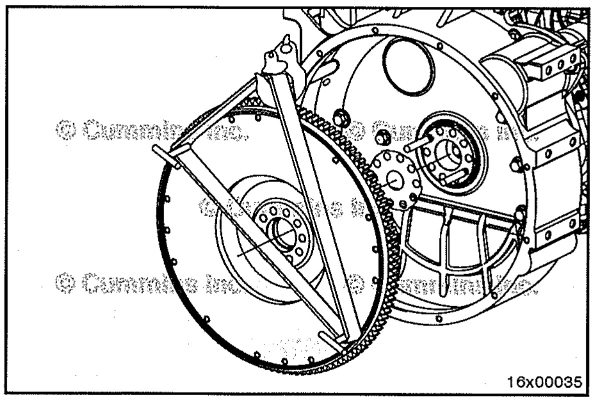
Remove two capscrews 180 degrees apart.

Install two M12x1.25, 150-mm guide pins, Part Number 3376638.

Determine the capscrew thread design and size, and install two T-handles in the flywheel (at points 1 and 2).

Remove the remaining eight flywheel mounting capscrews.

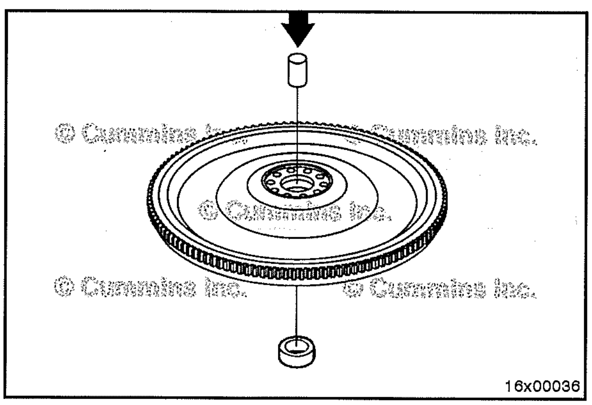
Remove and discard the friction shim.



⚠WARNING⚠

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

Remove the flywheel from the guide pins.



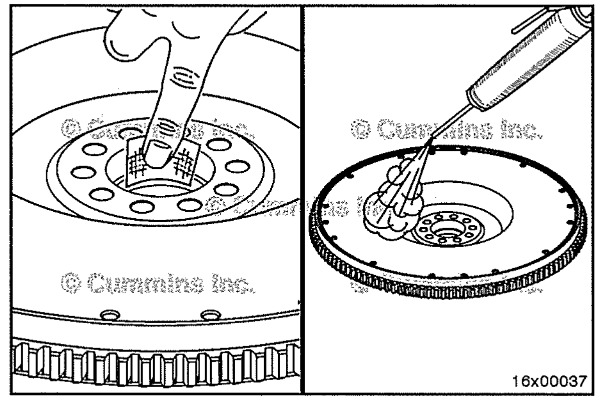
Disassemble

NOTE: Removal of the pilot bearing is **only** necessary if damaged or when installing a new or rebuilt clutch.

Remove the pilot bearing.

Use a mandrel and hammer to remove the pilot bearing.

Clean and Inspect for Reuse



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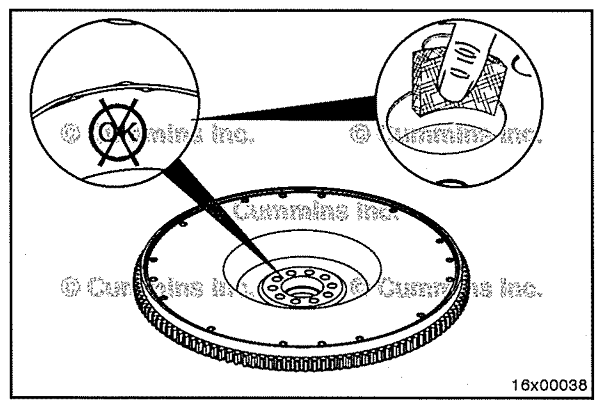
WARNING
Some solvents are flammable and toxic. Read the manufacturer's instructions before using.

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

Use an abrasive pad, Part Number 3823258, or equivalent, to clean the pilot bearing bore, if removed.

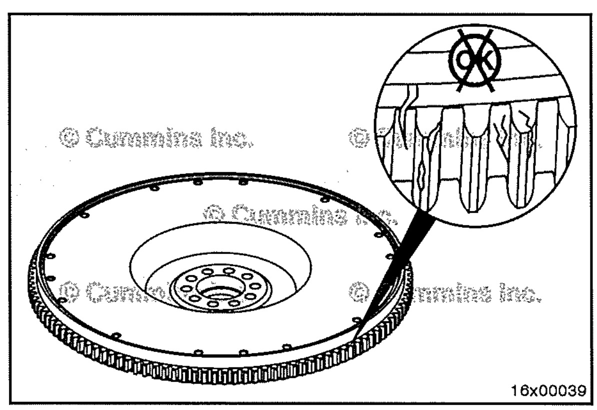
Use steam or solvent to clean the flywheel.

Dry with compressed air.



Inspect for nicks or burrs.

Use abrasive pad, Part Number 3823258, or equivalent, to remove small nicks and burrs.

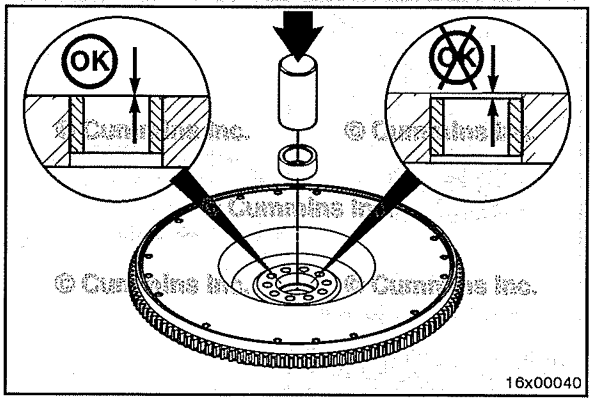


WARNING
Do not use a cracked flywheel. A cracked flywheel can break and cause personal injury or property damage.

Inspect the flywheel ring gear teeth for cracks and chips.

Use the crack detection kit, Part Number 3375432, to check for cracks in the flywheel. Follow the instructions provided with the kit.

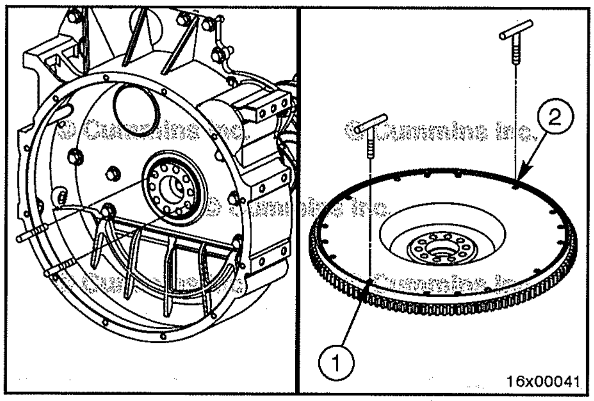
If the ring gear teeth are cracked or broken, the ring gear **must** be replaced. Refer to Procedure 016-008 in Section 16.



Assemble

If removed, install a new pilot bearing.

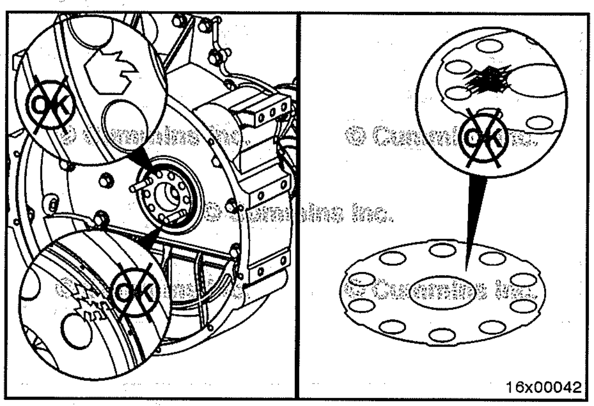
Use a mandrel and hammer to install the pilot bearing. The pilot bearing **must** be installed evenly with the pilot bore surface.



Install

Install two M12x1.25, 150-mm, Part Number 3376638, guide pins into the crankshaft flange 180 degrees apart.

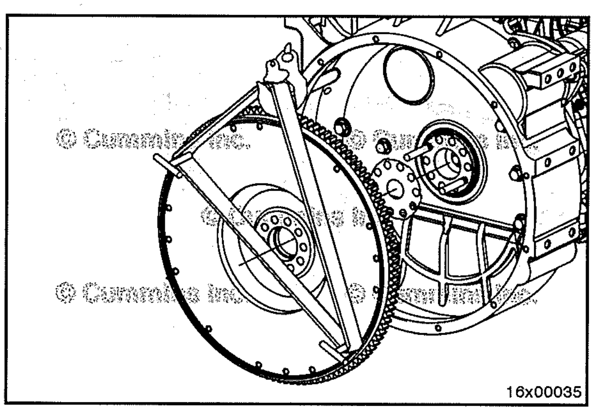
Determine the capscrew thread design and size, and install two T-handles into the flywheel (at points 1 and 2).



⚠CAUTION⚠

Friction shim, flywheel, and crank gear interconnecting surfaces must be free of grease upon installation or engine damage may occur.

Inspect the rear face of crankshaft gear, friction shim, and flywheel mounting flange for cleanliness and raised nicks or burrs.



⚠WARNING⚠

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

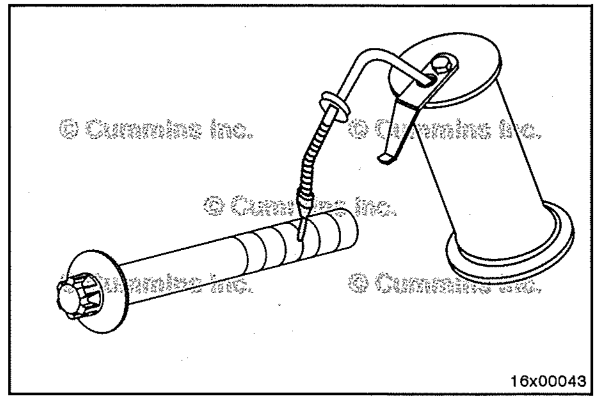
⚠CAUTION⚠

Friction shim must be properly installed or engine damage may occur.

Install new friction shim onto the guide pins between the flywheel and crankshaft gear.

Install flywheel onto the guide pins and slide into place.

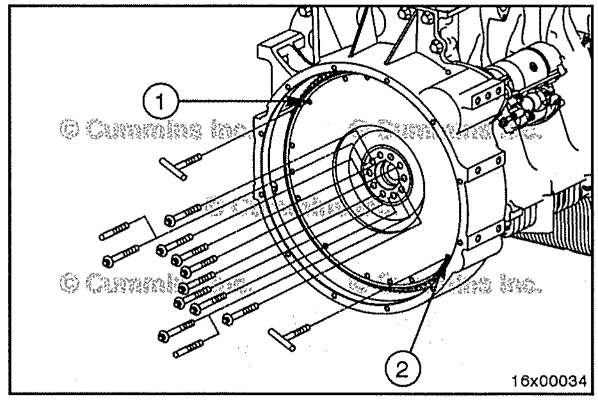
Lubricate the threads of the capscrews and the surface of the built-in washers with clean lubricating engine oil. Wipe off excess oil with a clean cloth.



Install the eight capscrews.

Remove the T-handles and guide pins.

Install the remaining capscrews into the holes from which the guide pins were removed.

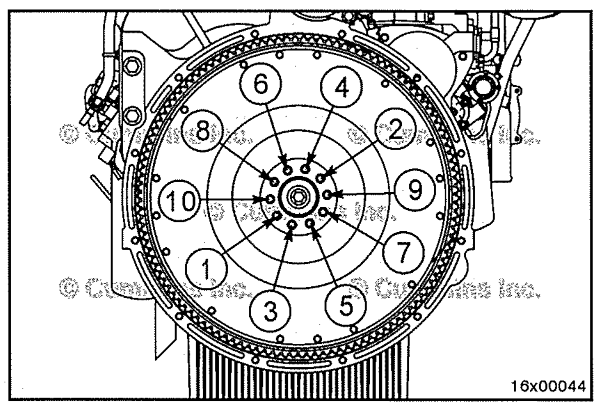


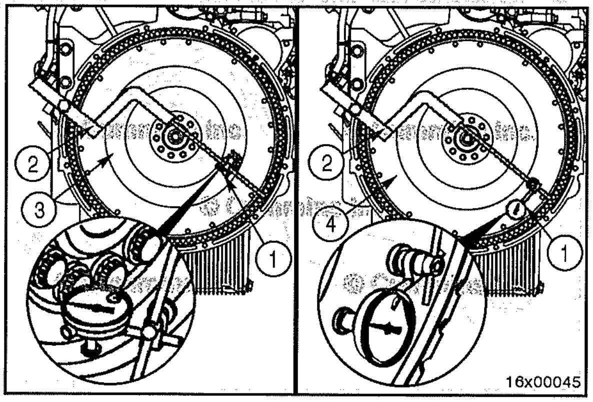
NOTE: Use the barring tool, Part Number 4919092, to hold the flywheel to prevent rotation.

Tighten the capscrews in a star pattern.

Torque Value:

Step 1	85 N•m	[63 ft-lb]
Step 2	Plus 90-degree turn.	





Measure

Flywheel Bore Runout

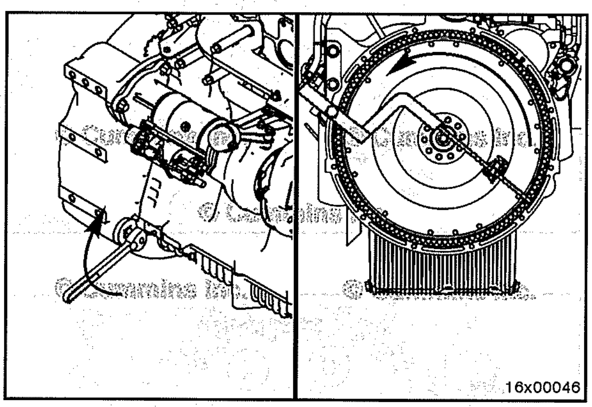
Use the dial indicator gauge (1), Part Number 3376050, or equivalent, and dial gauge attachment (2), Part Number ST-1325, to inspect the flywheel bore (3) and the surface (4) runout.

NOTE: The dial indicator can be mounted by a magnetic base, Part Number 3377399, or any other method that holds the extension bar of the indicator rigid, so it does **not** sag. If the bar sags, the indicator slips, or the base moves, the readings obtained will **not** be accurate.

Install the attachment to the flywheel housing.

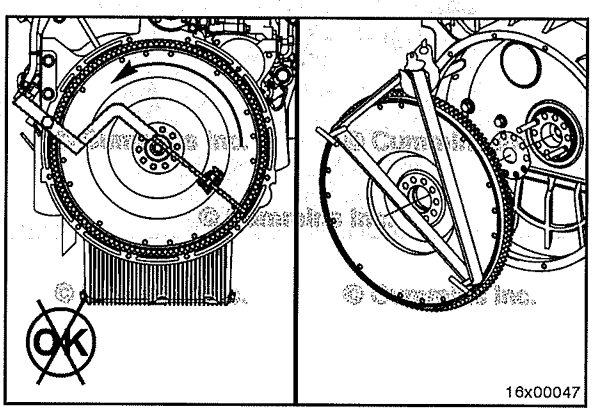
Install the gauge on the attachment.

Install the contact tip of the indicator against the inside diameter of the flywheel bore, and set the dial indicator at zero.



Use the barring tool, Part Number 4919092, to rotate the crankshaft one complete revolution.

Flywheel Total Indicator Reading		
mm		in
0.127	MAX	0.0050



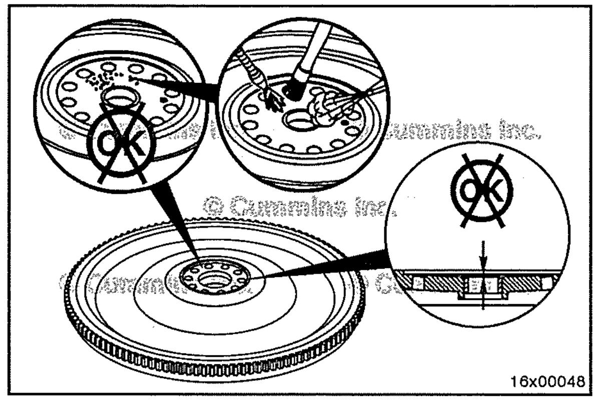
WARNING

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

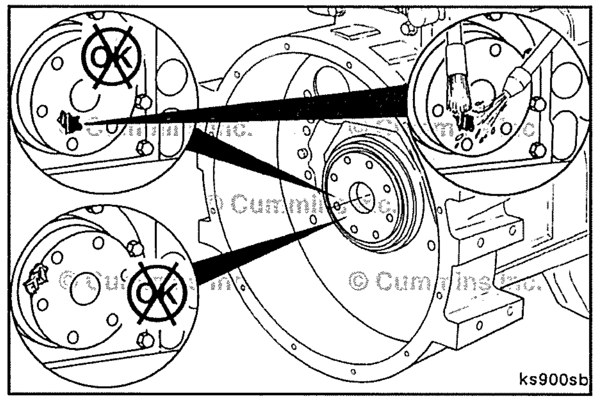
If the total indicator reading is greater than the specification, do the following:

- Remove the flywheel. See the removal section of this procedure.

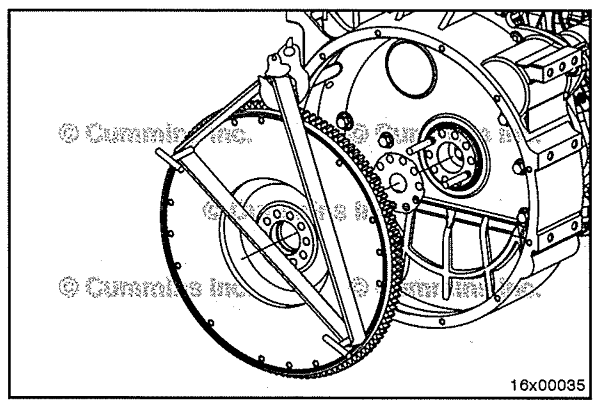
- Inspect the flywheel mounting surface for dirt or damage.



- Inspect the crankshaft for dirt or damage.



- Install the flywheel. See the installation section of this procedure.
- Inspect the bore runout again. See the Flywheel Bore Runout Inspection Section of this procedure.

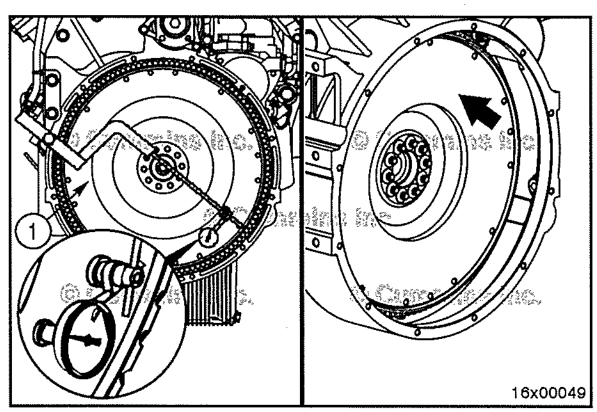


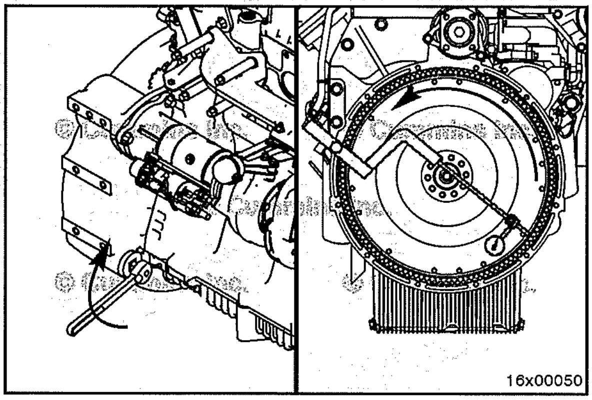
Flywheel Face Runout

Install the contact tip of the indicator against the flywheel face.

When locating the contact tip, see the Flywheel Face Runout Total Indicator Reading Table later in this procedure. Locate the contact tip so that it corresponds with a radius listed in the table, but is still as close to the outside diameter of the flywheel as possible, to inspect the flywheel face (1) runout.

Push the flywheel forward to remove the crankshaft end clearance. Adjust the dial on the indicator until the needle points to zero.



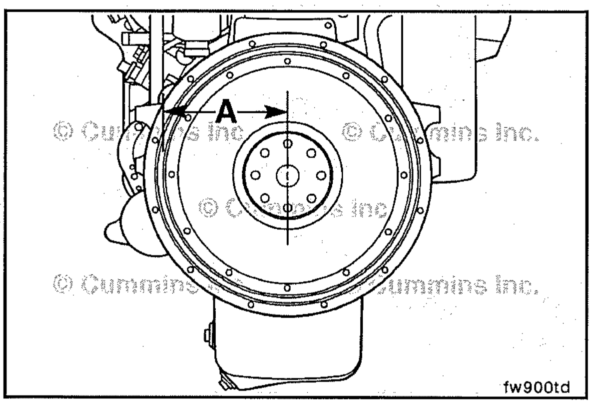


Use the barring tool, Part Number 4919092, to rotate the crankshaft one complete revolution. Measure and record the flywheel runout at four equal points on the flywheel.

The flywheel **must** be pushed toward the front of the engine to remove the crankshaft end clearance each time a point is measured.

Determine the total indicator reading (TIR).

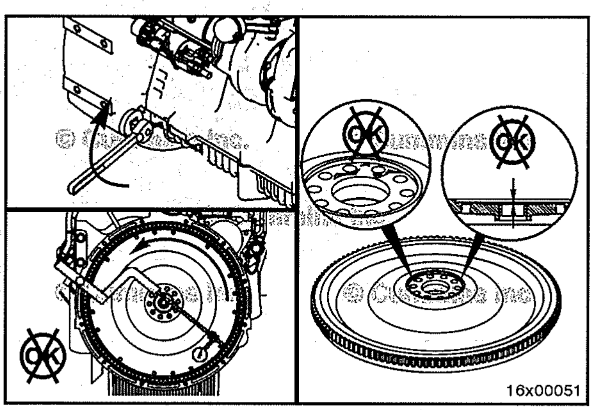
TIR is determined by calculating the difference between the highest and lowest measurement from the four locations measured.



Measure the distance from the center of the flywheel to the contact tip of the indicator (A). Use this measurement to determine which specification to use from the table below.

The total indicator reading **must not** exceed the following specifications:

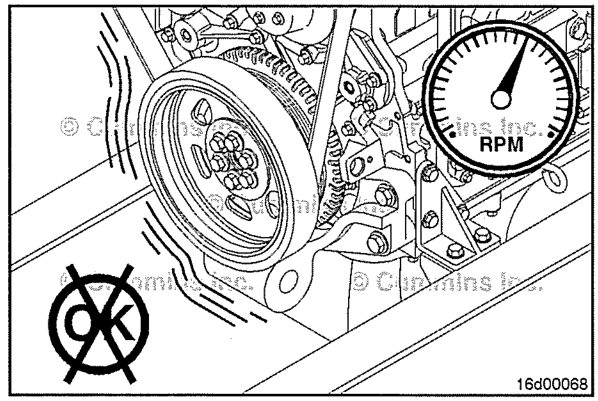
Flywheel Radius (A)		**Maximum Total Indicator Reading of Flywheel Face**	
mm	**in**	**mm**	**in**
101.6	4	0.140	0.0055
152.4	6	0.156	0.006
203.2	8	0.208	0.008
254	10	0.26	0.01



If the flywheel face runout is **not** within specifications, remove the flywheel. First check for nicks, burrs, or foreign material between the flywheel mounting surface and the crankshaft flange.

Replace the flywheel if the runout is **not** within specification.

Finishing Steps



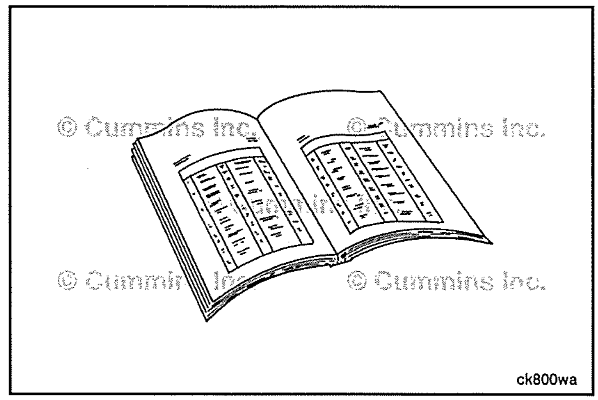
⚠WARNING⚠

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 transmission and all related components (if equipped). See equipment manufacturer service information.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Operate the engine and check for noise or vibration.

Flywheel Housing (016-006)

Preparatory Steps



⚠WARNING⚠

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

⚠WARNING⚠

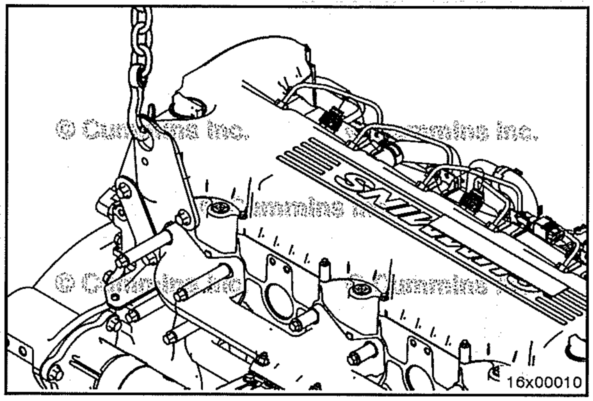
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

⚠WARNING⚠

Support the rear of the engine using the rear support attached to the rear of the cylinder block. Failure to support the engine can cause personal injury.

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Remove the starting motor. Refer to Procedure 013-020 in Section 13.
- Remove the Oil Pan. Refer to Procedure 007-025 in Section 7.
- Remove the transmission, clutch, and all related components, if equipped. See equipment manufacturer service information.
- Remove the flywheel assembly. Refer to Procedure 016-005 in Section 16.
- Remove any OEM attached components (mufflers, shift mechanisms, air filters) to the flywheel housing. See equipment manufacturer service information.

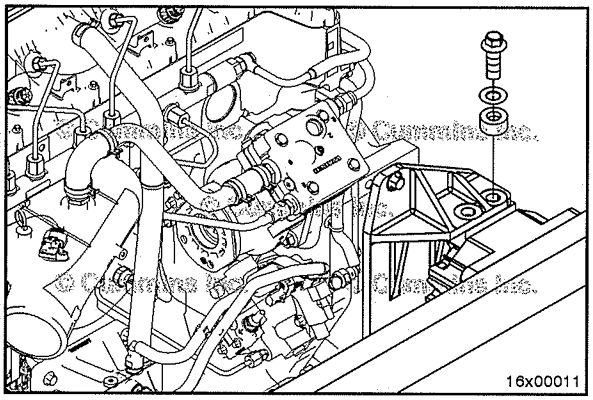
Remove



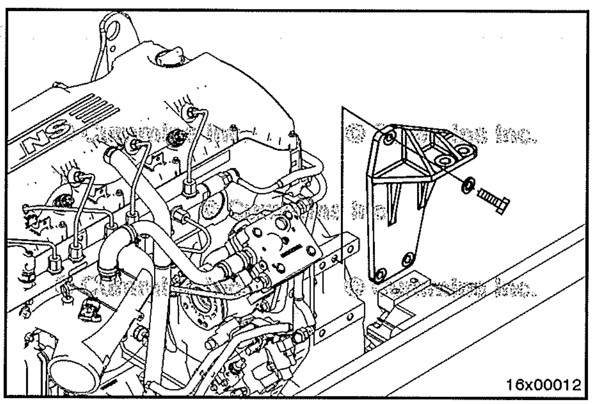
⚠WARNING⚠

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

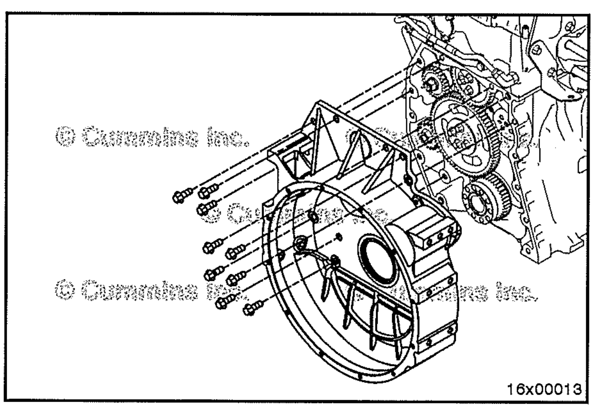
Use a hoist or lifting fixture to support the rear of the engine.



Remove the rear engine supports. Refer to Procedure 016-003 in Section 16.



Remove the rear engine brackets. Refer to Procedure 016-003 in Section 16.



⚠WARNING⚠

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

Loosen the flywheel housing capscrews, but do **not** remove.

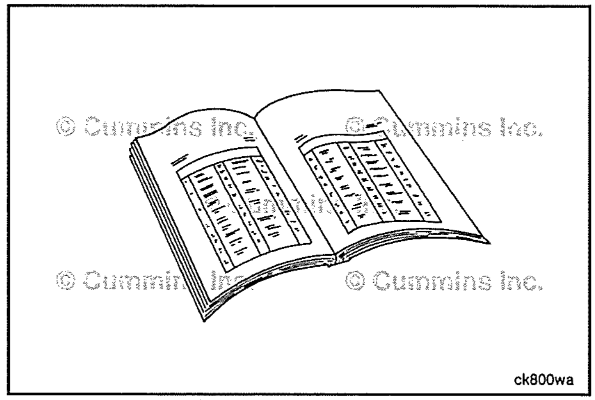
Use a rubber hammer to loosen the flywheel housing so that the seal is broken between the flywheel housing and rear gear housing.

While supporting the flywheel housing, remove the mounting capscrews and the flywheel housing.

NOTE: Make sure to note the position of any locating dowel rings.

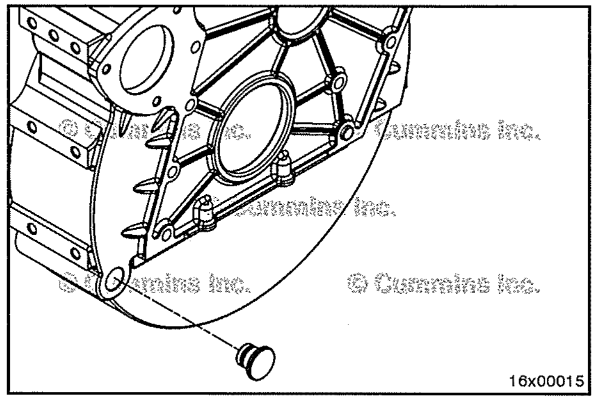
Disassemble

Remove the rear crankshaft seal. Refer to Procedure 001-024 in Section 1.



ck800wa

Remove the plug from the barring gear hole. Discard the o-ring.



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Clean and Inspect for Reuse

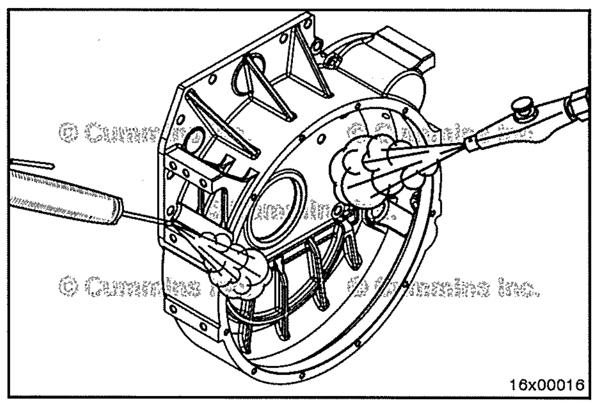
⚠WARNING⚠
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

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

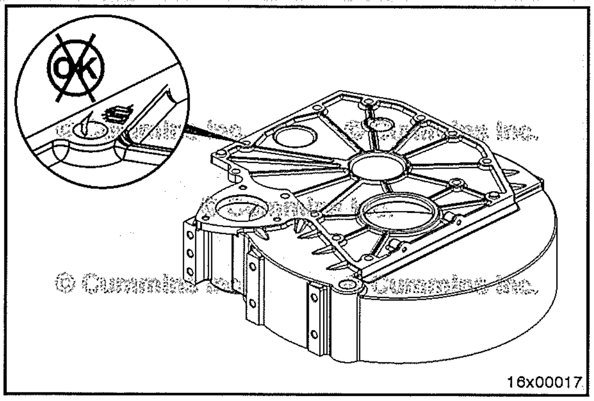
⚠WARNING⚠
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Use steam or solvent to clean the flywheel housing.

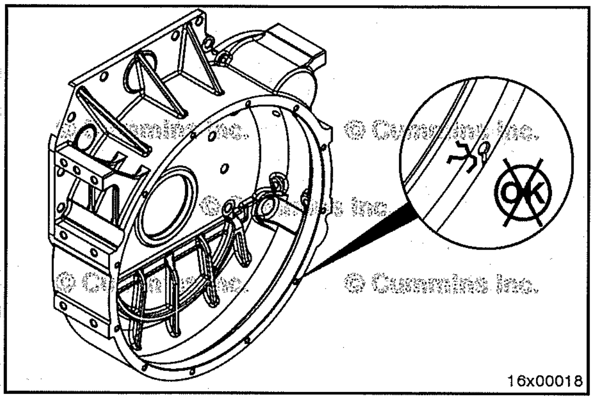
Dry with compressed air.



16x00016



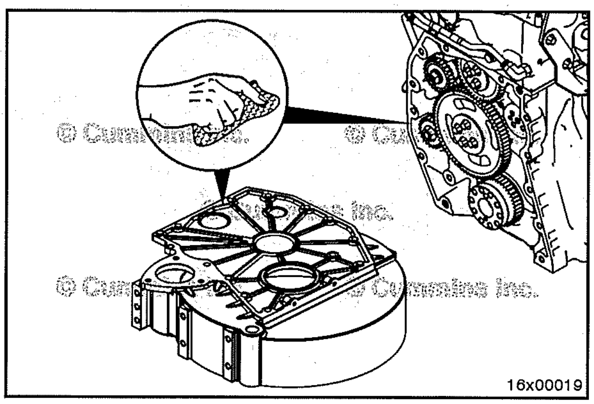
Inspect the flywheel housing for cracks, especially in the area of the flywheel housing that mounts to the cylinder block or rear gear housing.



Inspect the flywheel housing transmission/drive unit mounting surface for cracks.

Also inspect for damaged threads commonly caused by cross-threaded capscrews or installing an incorrect capscrew.

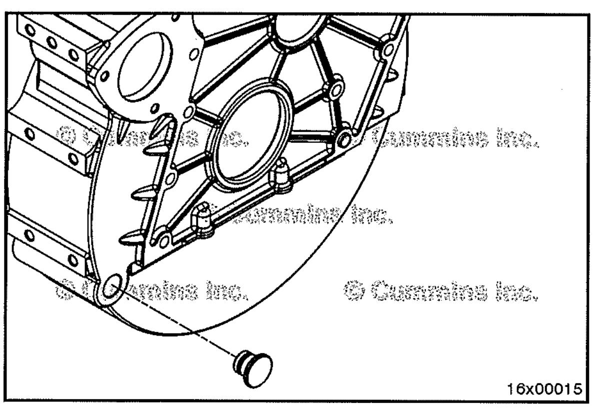
NOTE: Helicoils are available to repair damaged threads.



Inspect the rear face of the gear housing and flywheel housing mounting surface for cleanliness and raised nicks or burrs.

Use an abrasive pad, Part Number 3823258, to remove small nicks and burrs.

Thoroughly clean the flywheel housing and gear housing mating surfaces. These surfaces **must** be clean of oil and debris.



Assemble

Install the barring gear hole plug. Use a new o-ring.

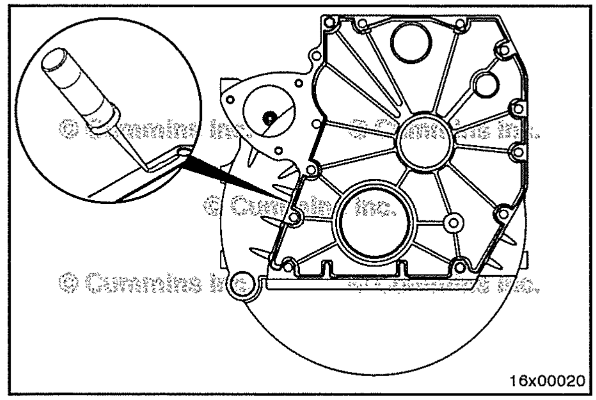
Install

NOTE: If the flywheel housing (or rear gear housing for rear gear train engines) is being replaced or if troubleshooting a vibration/alignment issue, reference the Measure section of this procedure below. Alternative steps **must** be performed before installing a new flywheel housing or if the dowel rings were removed during a previous repair.

Ensure all mating surfaces are cleaned and free from debris, lubrication and preservative.

Apply a 1- to 2-mm silicon bead of Loctite™ 509, Part Number 5298588, or equivalent, to the rear flywheel mounting surface, as shown.

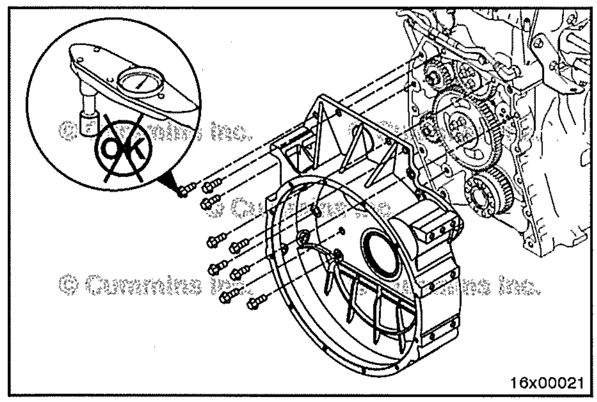
NOTE: Make sure silcon bead path is close to the lower edge as indicated in image



NOTE: Before installing the flywheel housing, make sure any locating dowel rings are in the same position as when the flywheel housing was removed. If the locating dowel rings are found to be damaged after a visual inspection, replace the dowel rings.

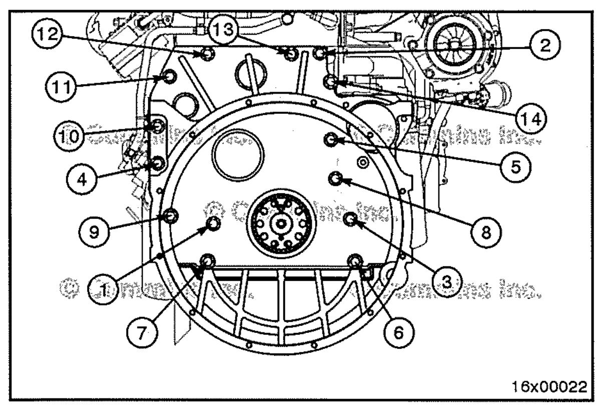
Install the flywheel housing and capscrews.

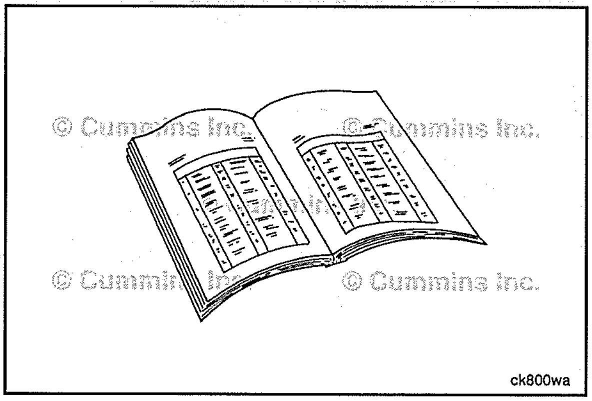
Tighten the flywheel housing capscrews finger tight.



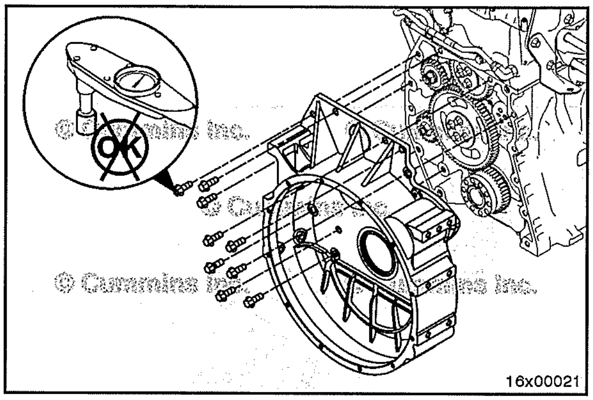
See the illustration for the flywheel housing capscrew torque sequence.

Torque Value:
M14 127 N•m [94 ft-lb]





Install a new rear crankshaft seal. Refer to Procedure 001-024 in Section 1.



Measure

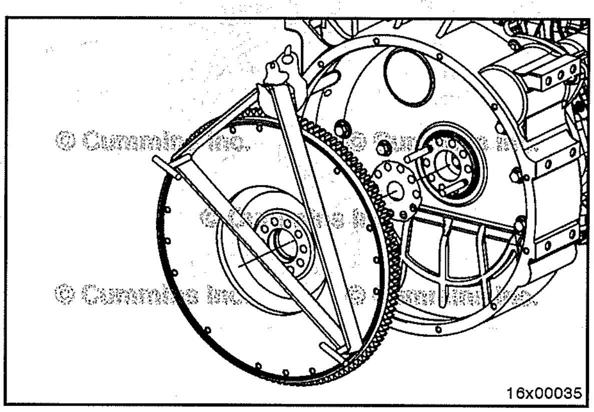
⚠CAUTION⚠

When barring the engine using service tool, Part Number 4919092, be careful to not apply excessive side loading to the flywheel housing. This may cause the flywheel housing to move and cause inaccurate measurement readings.

NOTE: Follow this step **only** if troubleshooting a vibration/ alignment issue.

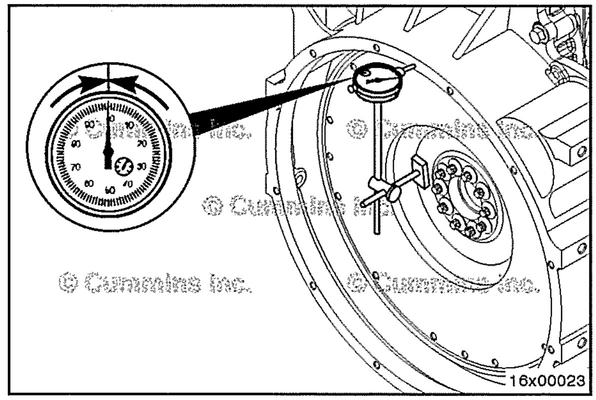
Install the flywheel housing following the Install Step of this procedure, but do **not** torque the capscrews. **Only** tighten the capscrews enough to hold the flywheel wheel in place.

Service Tip: For rear gear train engines, when installing a new flywheel housing to check flywheel housing bore alignment and face alignment, do **not** apply sealant to the flywheel housing prior to installing for measurement.



- Install the flywheel and inspect the flywheel face and bore runout. Refer to Procedure 016-005 in Section 16.
- If the flywheel is within specifications, proceed with measuring the flywheel housing alignment.

Face Alignment



⚠CAUTION⚠

The dial indicator tip must not enter the capscrew holes, or the gauge will be damaged.

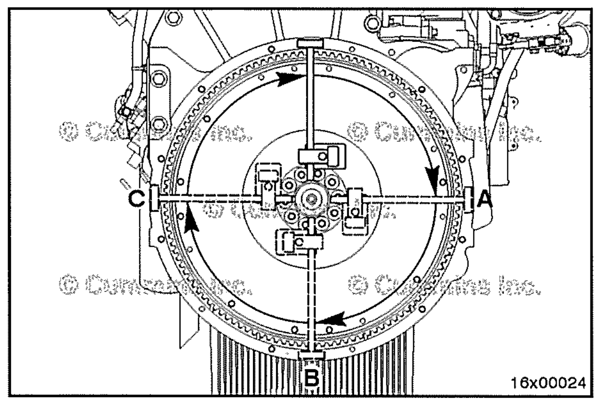
Face alignment is determined by calculating the total indicator reading (TIR).

Attach the dial indicator gauge, Part Number 3376050, mounted by a magnetic base, Part Number 3377399, to the flywheel as illustrated.

NOTE: The dial indicator can be mounted by any method that holds the extension bar of the indicator rigid, so it does **not** sag. If the bar sags, the magnetic base moves, or the indicator slips, the readings obtained will **not** be accurate.

Position the indicator at the 12-o'clock position, and zero the gauge.

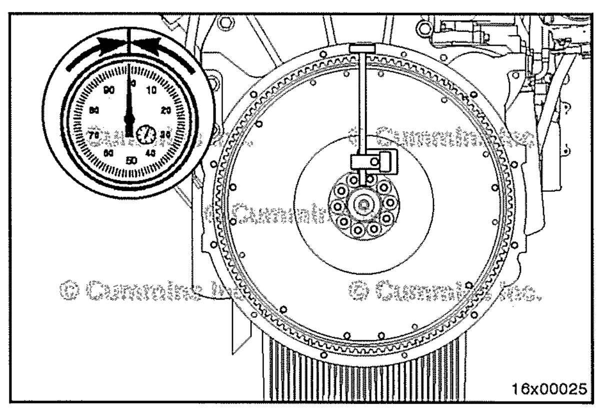
NOTE: The crankshaft **must** be pushed toward the front of the engine to remove the crankshaft end clearance each time a position is measured.



Use the barring tool, Part Number 4919092, to slowly rotate the crankshaft.

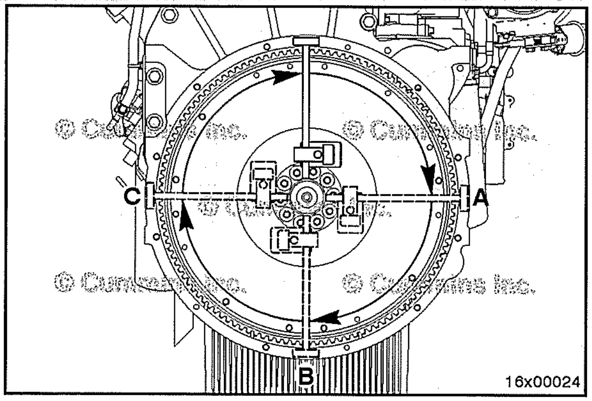
Record the readings at the 3-o'clock (A), 6-o'clock (B) , and 9-o'clock positions (C).

The values for A, B, and C could be positive or negative.



Continue to rotate the crankshaft until the indicator is at the 12-o'clock position.

Check the indicator to make sure the needle points to zero. If it does **not**, the readings will be incorrect and the procedure will have to be completed again.



Determine the total indicator reading (TIR).

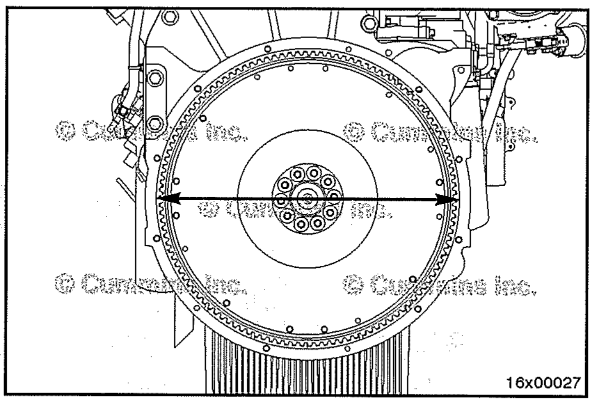
TIR is determined by calculating the difference between the highest and lowest measurement from the four locations measured.

As the example below illustrates, the TIR would be:

+0.08 mm - (-0.05 mm) = 0.13 mm

[+0.003 in - (-0.002 in) = 0.005 in]

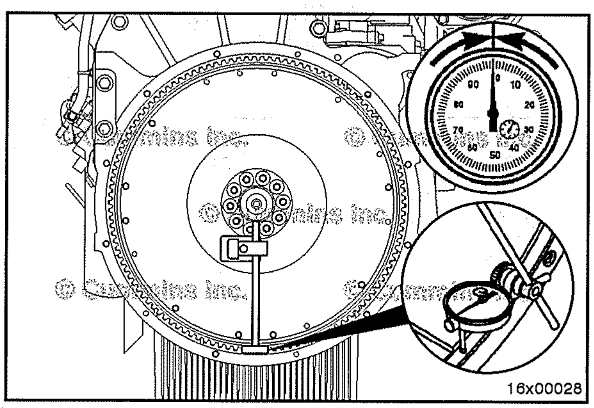
Example:		
12 o'clock	0.00 mm	[0.000 in]
3 o'clock	+0.08 mm	[+0.003 in]
6 o'clock	-0.05 mm	[-0.002 in]
9 o'clock	+0.08 mm	[+0.003 in]
Equals TIR	0.13 mm	[0.005 in]



The maximum allowable total indicator reading (TIR) is determined by the diameter of the housing bore. If out of specifications, replace the housing.

NOTE: For rear gear train engines, the rear gear housing may also be the cause of the TIR being out of specification.

Flywheel Housing Bore and Face Runout				
SAE	**Bore Diameter**		**Total Indicator Reading Maximum**	
Number	mm	in	mm	in
1	510.98 to 511.38	20.117 to 20.133	0.36	0.014



Bore Alignment

Attach the dial indicator gauge, Part Number 3376050, mounted by a magnetic base, Part Number 3377399, to the flywheel as illustrated.

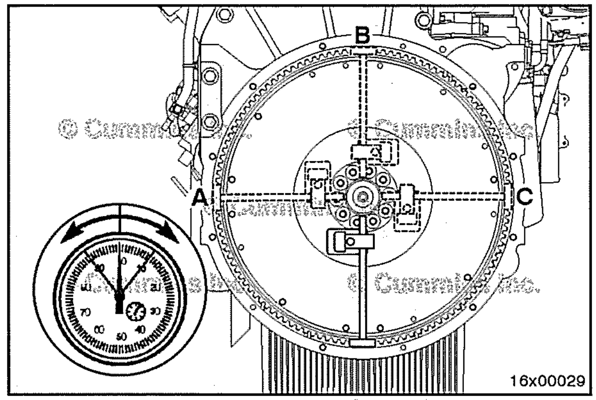
NOTE: The dial indicator can be mounted by any method that holds the extension bar of the indicator rigid, so it does **not** sag. If the bar sags, the magnetic base moves, or the indicator slips, the readings obtained will **not** be accurate.

Position the indicator in the 6-o'clock position, and zero the gauge.

Slowly rotate the crankshaft. Record the readings obtained at the 9-o'clock, 12-o'clock, and 3-o'clock positions as A, B, and C in the concentricity worksheet.

Recheck zero at the 6-o'clock position. If it does **not**, the readings will be incorrect and the procedure will have to be completed again.

The values for A, B, and C could be positive or negative. See the illustration to determine the correct sign when recording these values.

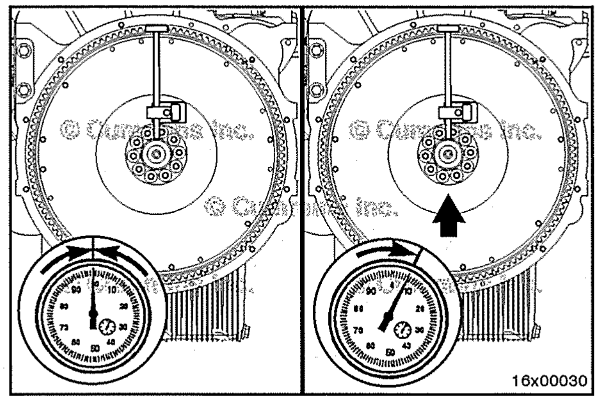


⚠CAUTION⚠

Do not force the crankshaft beyond the point where the bearing clearance has been removed. Do not pry against the flywheel housing. These actions could cause false bearing clearance readings and result in engine damage.

Rotate the crankshaft until the dial indicator is at the 12-o'clock position and zero the gauge.

Use a pry bar to raise the rear of the crankshaft to its upper limit. Record the value as D on the concentricity worksheet. This is the vertical bearing clearance adjustment, which will **always** be positive.



Create a concentricity worksheet, as illustrated, to determine the values for the "total vertical" and "total horizontal" values.

NOTE: The values listed in the concentricity worksheet illustrated are for example **only** and are listed in inches. The actual numbers measured may differ.

Input the values recorded for A, B, C and D into the concentricity worksheet.

The total horizontal is the 9-o'clock reading (A) minus the 3-o'clock reading (C).

The total vertical is the 12-o'clock reading (B) plus the bearing clearance (D).

Concentricity Worksheet

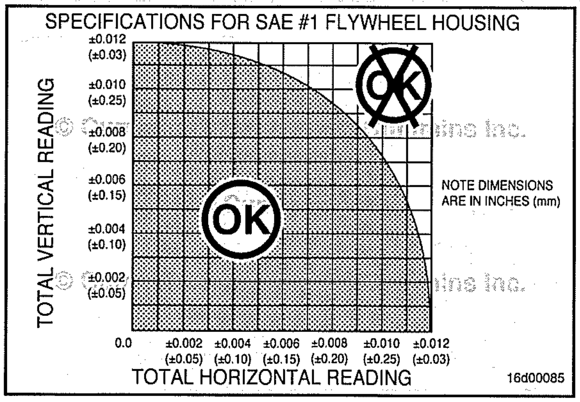
9 o'clock	a = 0.004
3 o'clock	c = -0.002
Total Horizontal	a – c = .006
12 o'clock	b = .003
Bearing Clearance	d = .002
Total Vertical	b + d = .005

oi900vf

Example:

- 6 o'clock = reference = 0
- 9 o'clock = (A) = 0.004
- 12 o'clock = (B) = 0.003
- 3 o'clock = (C) = (-0.002)

Use the worksheet and the numbers from the example, the total horizontal value equals 0.006 and the total vertical value equals 0.005.



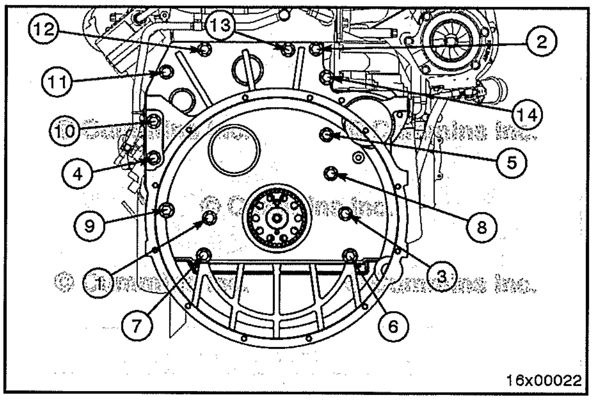
NOTE: Use the corresponding chart for the SAE 1 flywheel housing being measured.

Use the illustration, mark the total horizontal value on the horizontal side of the chart and the total vertical on the vertical side of the chart.

Use a straightedge to find the intersection point of the total horizontal and total vertical values. The intersection point **must** fall within the shaded area for the flywheel housing concentricity to be within specification.

Use the total horizontal and total vertical values from the previous example, the intersection point falls within the shaded area. Therefore, the flywheel housing concentricity is within specification.

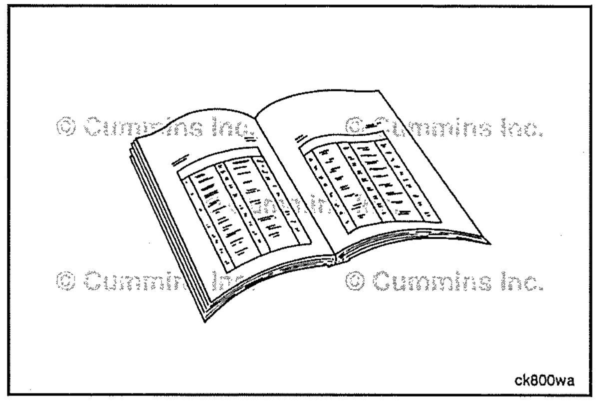
NOTE: Make sure to use the correct total indicator reading (TIR) specifications for the flywheel housing being measured when comparing measurements.



Tighten the capscrews in the sequence shown.

Torque Value:
M14 127 N•m [94 ft-lb]

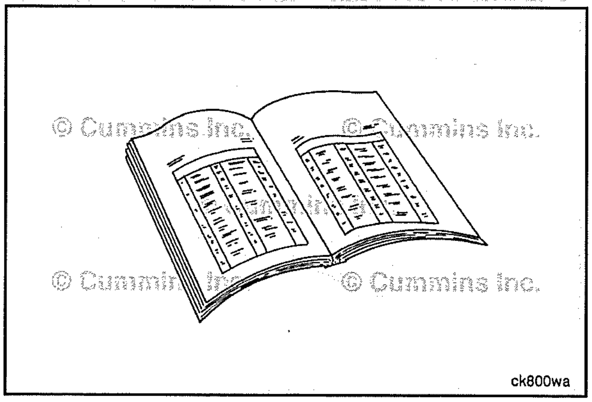
Finishing Steps



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.

- Install the rear engine support brackets. Refer to Procedure 016-003 in Section 16.
- Install the flywheel assembly. Refer to Procedure 016-005 in Section 16.
- Install the starting motor. Refer to Procedure 013-020 in Section 13.
- Install the oil pan. Refer to Procedure 007-025 in Section 7.
- Install the transmission and related components, if equipped. See equipment manufacturer service information.
- If previously removed, attach any OEM components (mufflers, shift mechanisms, air filters) to the flywheel housing. See equipment manufacturer service information.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Operate the engine and check for leaks.



Flywheel Housing, REPTO (016-007)

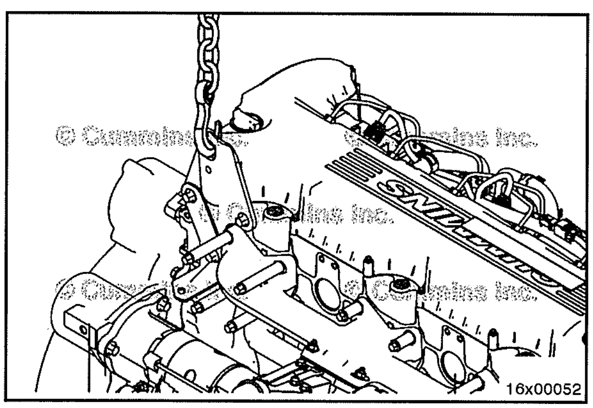
Preparatory Steps

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

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

WARNING
Support the rear of the engine using the rear support attached to the rear of the cylinder block. Failure to support the engine can cause personal injury.

- Disconnect the batteries. Refer to Procedure 013-009 in Section 13.
- Remove the starting motor. Refer to Procedure 013-020 in Section 13.
- Remove the Oil Pan. Refer to Procedure 007-025 in Section 7.
- Remove the transmission, clutch, and all related components, if equipped. See equipment manufacturer service information.
- Remove the flywheel assembly. Refer to Procedure 016-005 in Section 16.
- Remove the REPTO. Refer to Procedure 009-022 in Section 9.
- Remove any OEM attached components (mufflers, shift mechanisms, air filters) to the flywheel housing. See equipment manufacturer service information.

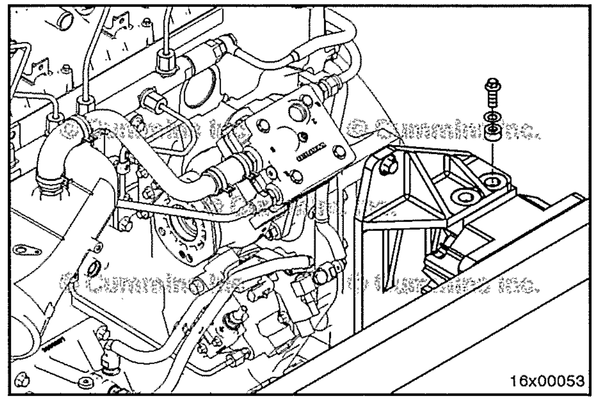


Remove

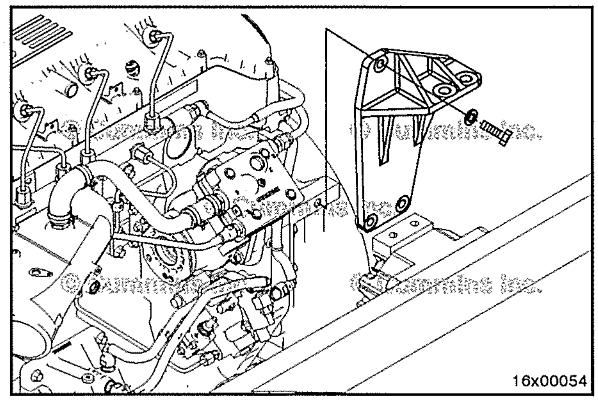
WARNING
The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

Use a hoist or lifting fixture to support the rear of the engine.

Remove the rear engine supports. Refer to Procedure 016-003 in Section 16.



Remove the rear engine brackets. Refer to Procedure 016-003 in Section 16.



WARNING

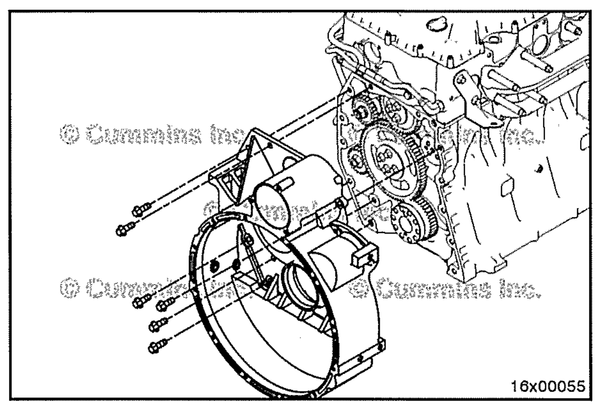
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

Loosen the flywheel housing capscrews, but do **not** remove.

Use a rubber hammer to loosen the flywheel housing so that the seal is broken between the flywheel housing and rear gear housing.

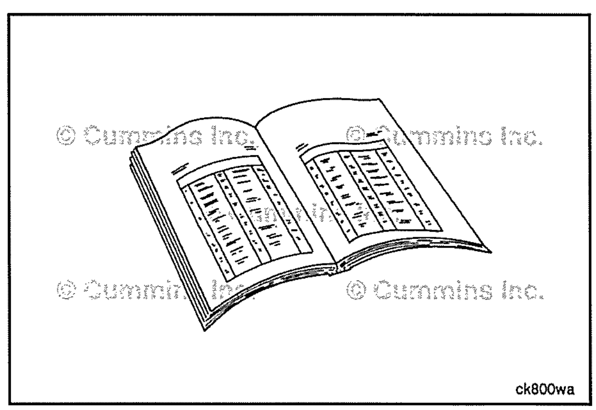
While supporting the flywheel housing, remove the mounting capscrews and the flywheel housing.

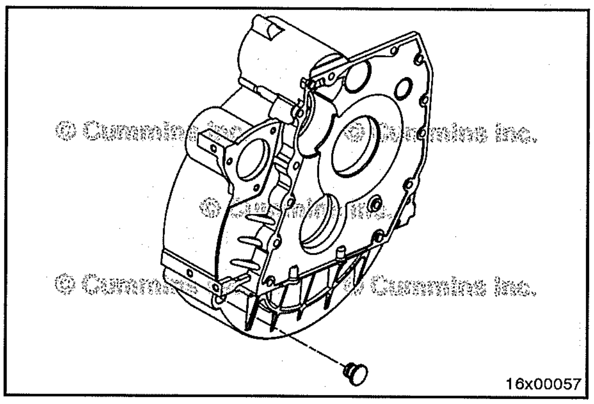
NOTE: Make sure to note the position of any locating dowel rings.



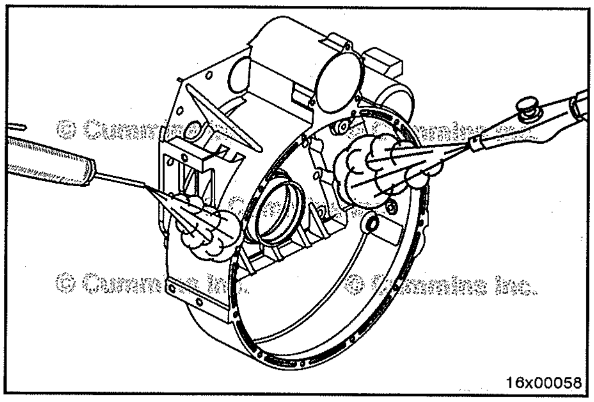
Disassemble

Remove the rear crankshaft seal. Refer to Procedure 001-024 in Section 1.




16x00057

Remove the plug from the barring gear hole. Discard the o-ring.


16x00058

Clean and Inspect for Reuse

WARNING

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

WARNING

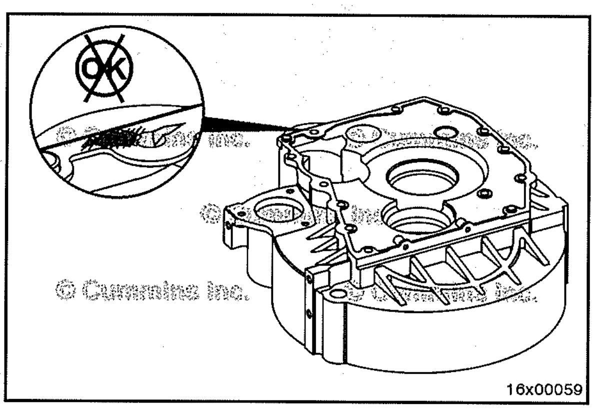
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

Use steam or solvent to clean the flywheel housing.

Dry with compressed air.



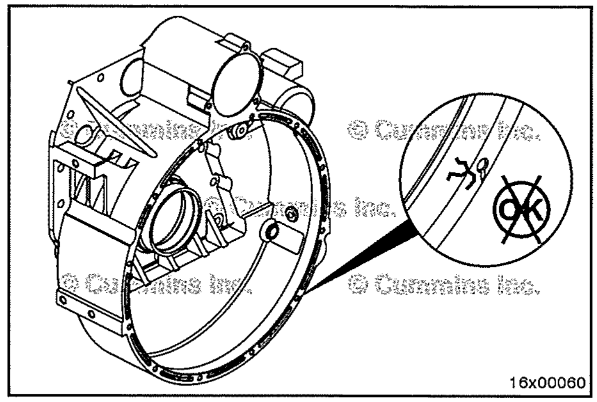
16x00059

Inspect the flywheel housing for cracks, especially in the area of the flywheel housing that mounts to the cylinder block or rear gear housing.

Inspect the flywheel housing transmission/drive unit mounting surface for cracks.

Also inspect for damaged threads commonly caused by cross-threaded capscrews or installing an incorrect capscrew.

NOTE: Helicoils are available to repair damaged threads.

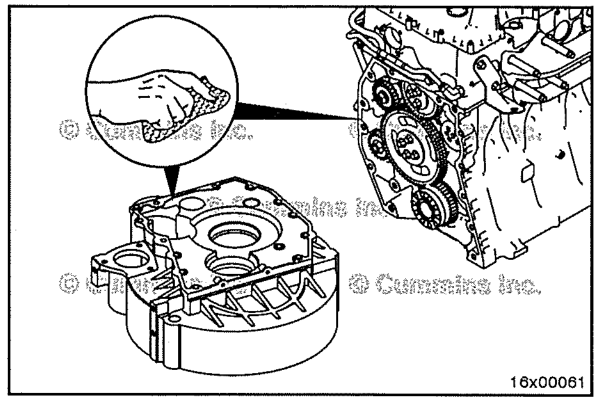


16x00060

Inspect the rear face of the gear housing and flywheel housing mounting surface for cleanliness and raised nicks or burrs.

Use an abrasive pad, Part Number 3823258, to remove small nicks and burrs.

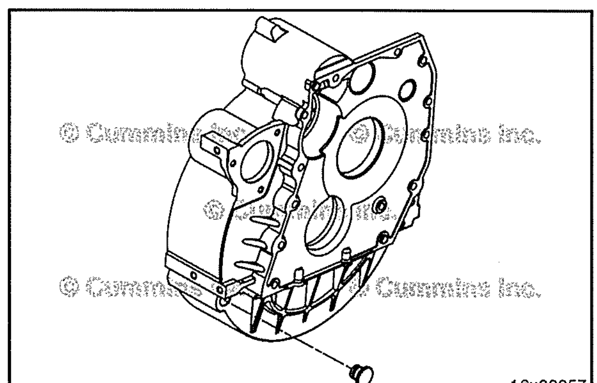
Thoroughly clean the flywheel housing and gear housing mating surfaces. These surfaces **must** be clean of oil and debris.



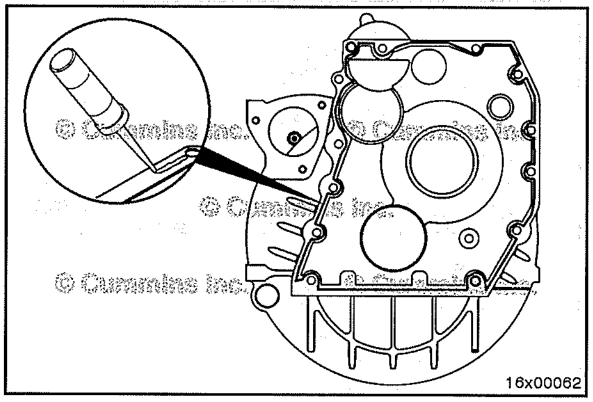
16x00061

Assemble

Install the barring gear hole plug. Use a new o-ring.



16x00057



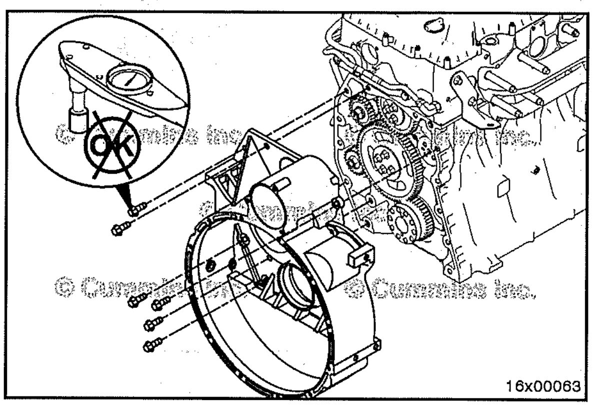
Install

NOTE: If the flywheel housing (or rear gear housing for rear gear train engines) is being replaced or if troubleshooting a vibration/alignment issue, reference the Measure section of this procedure below. Alternative steps **must** be performed before installing a new flywheel housing or if the dowel rings were removed during a previous repair.

Ensure all mating surfaces are cleaned and free from debris, lubrication and preservative.

Apply a 1- to 2-mm silicon bead of Loctite™ 509, Part Number 5298588, or equivalent, to the rear flywheel mounting surface, as shown.

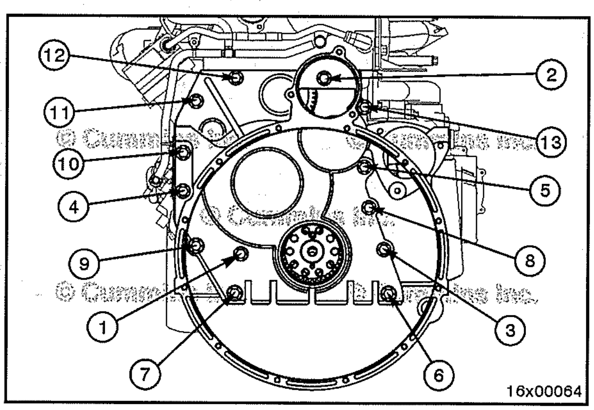
NOTE: Make sure loctite path is close to the lower edge as indicated in image.



NOTE: Before installing the flywheel housing, make sure any locating dowel rings are in the same position as when the flywheel housing was removed. If the locating dowel rings are found to be damaged after a visual inspection, replace the dowel rings.

Install the flywheel housing and capscrews.

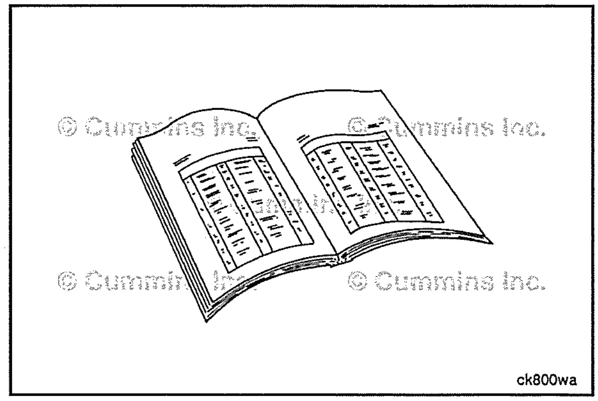
Tighten the flywheel housing capscrews finger tight.



See the illustration for the flywheel housing capscrew torque sequence.

Torque Value: 127 N•m [94 ft-lb]

Install a new rear crankshaft seal. Refer to Procedure 001-024 in Section 1.



Measure

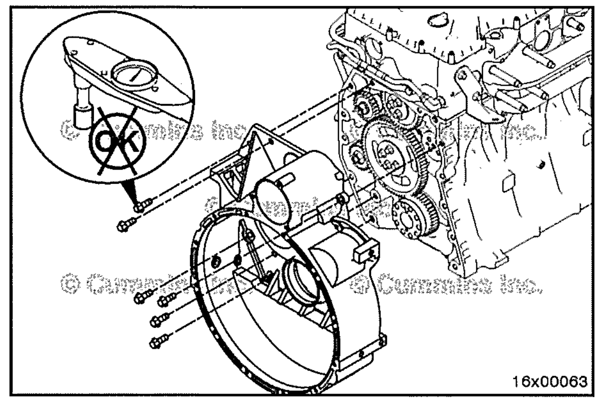
⚠CAUTION⚠

When barring the engine using service tool, Part Number 4919092, be careful to not apply excessive side loading to the flywheel housing. This may cause the flywheel housing to move and cause inaccurate measurement readings.

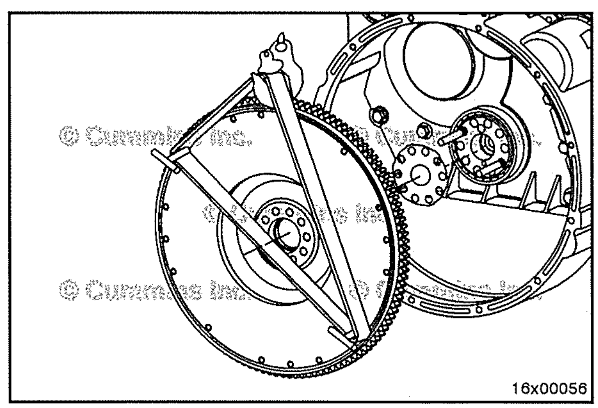
NOTE: Follow this step **only** if troubleshooting a vibration/alignment issue.

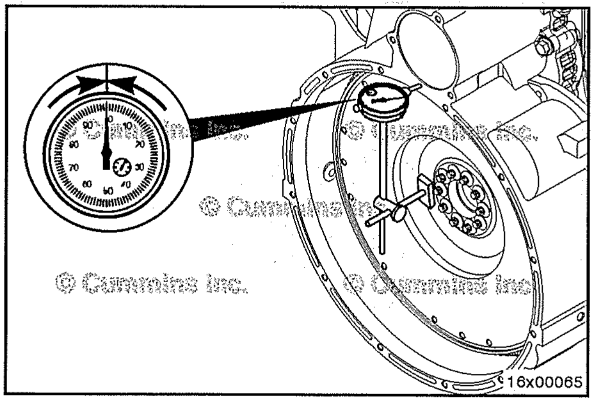
Install the flywheel housing following the Install Step of this procedure, but do **not** torque the capscrews. **Only** tighten the capscrews enough to hold the flywheel wheel in place.

Service Tip: For rear gear train engines, when installing a new flywheel housing to check flywheel housing bore alignment and face alignment, do **not** apply sealant to the flywheel housing prior to installing for measurement.



- Install the flywheel and inspect the flywheel face and bore runout. Refer to Procedure 016-005 in Section 16.
- If the flywheel is within specifications, proceed with measuring the flywheel housing alignment.





Face Alignment

CAUTION

The dial indicator tip must not enter the capscrew holes, or the gauge will be damaged.

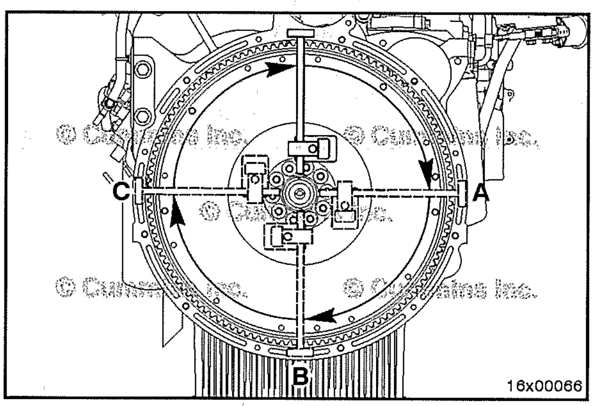
Face alignment is determined by calculating the total indicator reading (TIR).

Attach the dial indicator gauge, Part Number 3376050, mounted by a magnetic base, Part Number 3377399, to the flywheel as illustrated.

NOTE: The dial indicator can be mounted by any method that holds the extension bar of the indicator rigid, so it does **not** sag. If the bar sags, the magnetic base moves, or the indicator slips, the readings obtained will **not** be accurate.

Position the indicator at the 12-o'clock position, and zero the gauge.

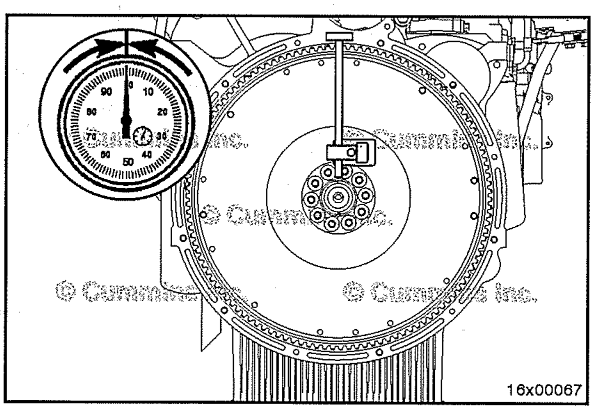
NOTE: The crankshaft **must** be pushed toward the front of the engine to remove the crankshaft end clearance each time a position is measured.



Use the barring tool, Part Number 4919092, to slowly rotate the crankshaft.

Record the readings at the 3-o'clock (A), 6-o'clock (B) , and 9-o'clock positions (C).

The values for A, B, and C could be positive or negative.



Continue to rotate the crankshaft until the indicator is at the 12-o'clock position.

Check the indicator to make sure the needle points to zero. If it does **not**, the readings will be incorrect and the procedure will have to be completed again.

Determine the total indicator reading (TIR).

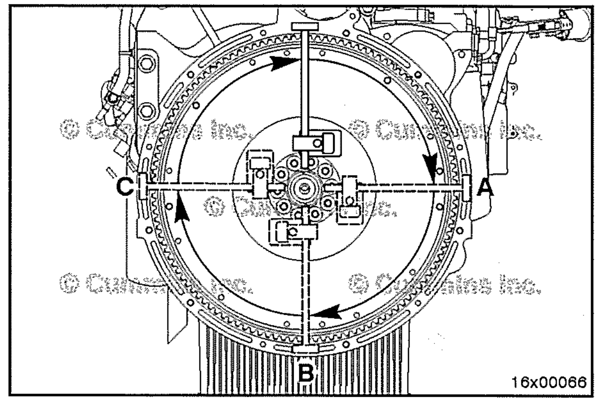
TIR is determined by calculating the difference between the highest and lowest measurement from the four locations measured.

As the example below illustrates, the TIR would be:

+0.08 mm - (-0.05 mm) = 0.13 mm

[+0.003 in - (-0.002 in) = 0.005 in]

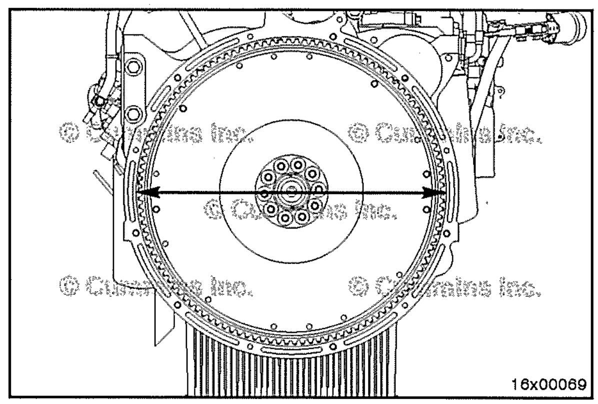
Example:		
12 o'clock	0.00 mm	[0.000 in]
3 o'clock	+0.08 mm	[+0.003 in]
6 o'clock	-0.05 mm	[-0.002 in]
9 o'clock	+0.08 mm	[+0.003 in]
Equals TIR	0.13 mm	[0.005 in]



The maximum allowable total indicator reading (TIR) is determined by the diameter of the housing bore. If out of specifications, replace the housing.

NOTE: For rear gear train engines, the rear gear housing may also be the cause of the TIR being out of specification.

Flywheel Housing Bore and Face Runout				
SAE	**Bore Diameter**		**Total Indicator Reading Maximum**	
Number	mm	in	mm	in
1	510.98 to 511.38	20.117 to 20.133	0.36	0.014

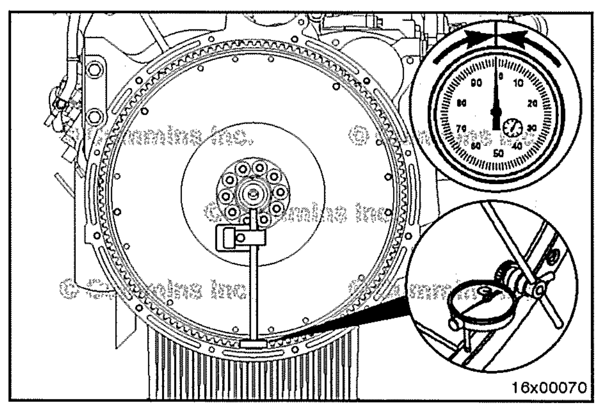


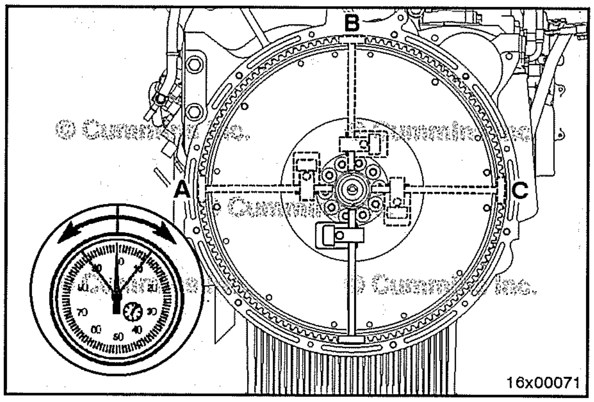
Bore Alignment

Attach the dial indicator gauge, Part Number 3376050, mounted by a magnetic base, Part Number 3377399, to the flywheel as illustrated.

NOTE: The dial indicator can be mounted by any method that holds the extension bar of the indicator rigid, so it does **not** sag. If the bar sags, the magnetic base moves, or the indicator slips, the readings obtained will **not** be accurate.

Position the indicator in the 6-o'clock position, and zero the gauge.

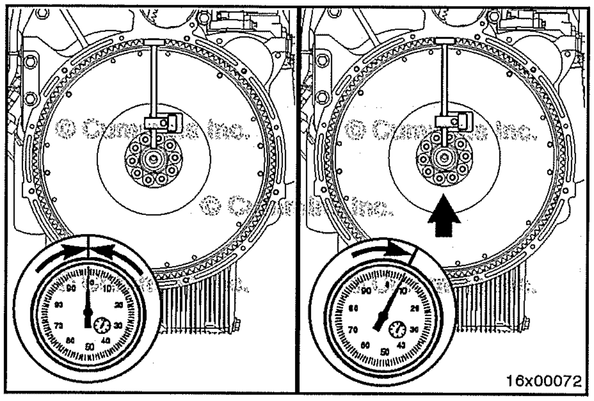




Slowly rotate the crankshaft. Record the readings obtained at the 9-o'clock, 12-o'clock, and 3-o'clock positions as A, B, and C in the concentricity worksheet.

Recheck zero at the 6-o'clock position. If it does **not**, the readings will be incorrect and the procedure will have to be completed again.

The values for A, B, and C could be positive or negative. See the illustration to determine the correct sign when recording these values.



CAUTION

Do not force the crankshaft beyond the point where the bearing clearance has been removed. Do not pry against the flywheel housing. These actions could cause false bearing clearance readings and result in engine damage.

Rotate the crankshaft until the dial indicator is at the 12-o'clock position and zero the gauge.

Use a pry bar to raise the rear of the crankshaft to its upper limit. Record the value as D on the concentricity worksheet. This is the vertical bearing clearance adjustment, which will **always** be positive.

Concentricity Worksheet

9 o'clock 3 o'clock	a = 0.004 c = -0.002
Total Horizontal	a − c = .006
12 o'clock Bearing Clearance	b = .003 d = .002
Total Vertical	b + d = .005

oi900vf

Create a concentricity worksheet, as illustrated, to determine the values for the "total vertical" and "total horizontal" values.

NOTE: The values listed in the concentricity worksheet illustrated are for example **only** and are listed in inches. The actual numbers measured may differ.

Input the values recorded for A, B, C and D into the concentricity worksheet.

The total horizontal is the 9-o'clock reading (A) minus the 3-o'clock reading (C).

The total vertical is the 12-o'clock reading (B) plus the bearing clearance (D).

Example:

- 6 o'clock = reference = 0
- 9 o'clock = (A) = 0.004
- 12 o'clock = (B) = 0.003
- 3 o'clock = (C) = (-0.002)

Use the worksheet and the numbers from the example, the total horizontal value equals 0.006 and the total vertical value equals 0.005.

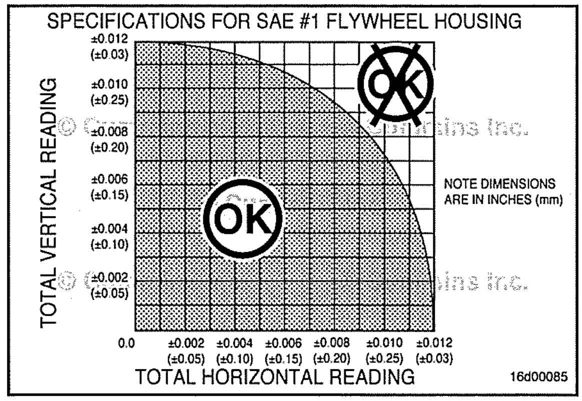
NOTE: Use the corresponding chart for the SAE 1 flywheel housing being measured.

Use the illustration, mark the total horizontal value on the horizontal side of the chart and the total vertical on the vertical side of the chart.

Use a straightedge to find the intersection point of the total horizontal and total vertical values. The intersection point **must** fall within the shaded area for the flywheel housing concentricity to be within specification.

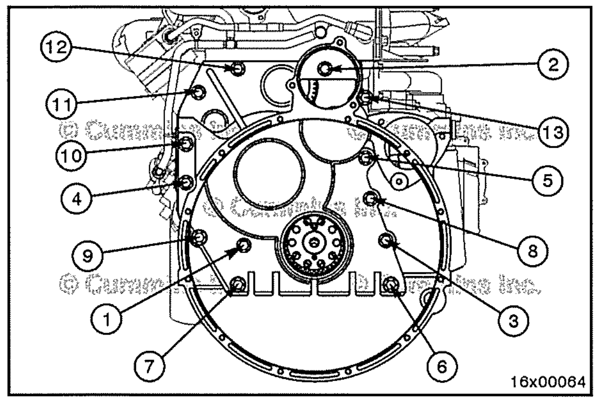
Use the total horizontal and total vertical values from the previous example, the intersection point falls within the shaded area. Therefore, the flywheel housing concentricity is within specification.

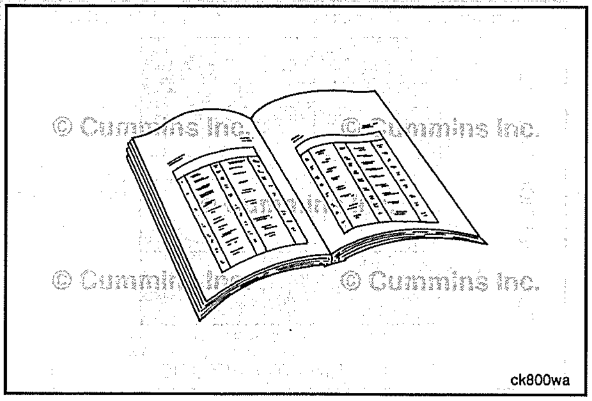
NOTE: Make sure to use the correct total indicator reading (TIR) specifications for the flywheel housing being measured when comparing measurements.



Tighten the capscrews in the sequence shown.

Torque Value: 127 N•m [94 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.

- Install the rear engine support brackets. Refer to Procedure 016-003 in Section 16.
- Install the REPTO. Refer to Procedure 009-022 in Section 9.
- Install the flywheel assembly. Refer to Procedure 016-005 in Section 16.
- Install the starting motor. Refer to Procedure 013-020 in Section 13.
- Install the oil pan. Refer to Procedure 007-025 in Section 7.
- Install the transmission and related components, if equipped. See equipment manufacturer service information.
- If previously removed, attach any OEM components (mufflers, shift mechanisms, air filters) to the flywheel housing. See equipment manufacturer service information.
- Connect the batteries. Refer to Procedure 013-009 in Section 13.
- Operate the engine and check for leaks.

Flywheel Ring Gear (016-008)

General Information

Prior to removing the damaged flywheel ring gear, first check if:

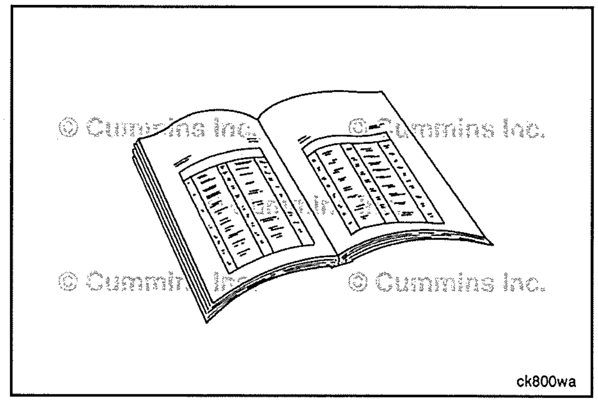
1 The ring gear is removable/replaceable.

2 A replacement ring gear is available.

It can be necessary to replace the entire flywheel assembly.

Preparatory Steps

- Remove the flywheel. Refer to Procedure 016-005 in Section 16.



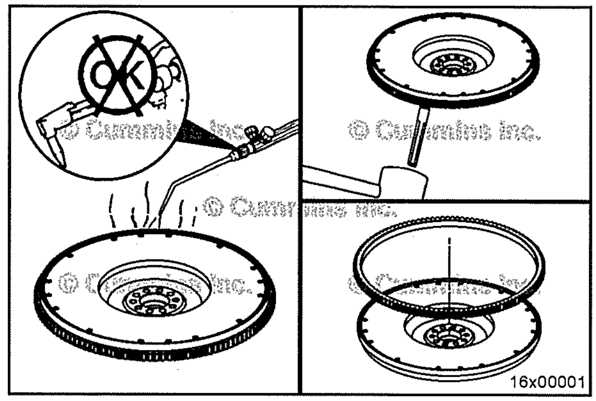
Remove

⚠WARNING⚠
To reduce the possibility of personal injury, wear goggles and protective clothing.

⚠CAUTION⚠
Do not use a cutting torch to heat the ring gear. The flywheel can be damaged.

Heat the outside surface of the ring gear with a heating torch.

Use a hammer and blunt chisel to remove the gear from the flywheel.



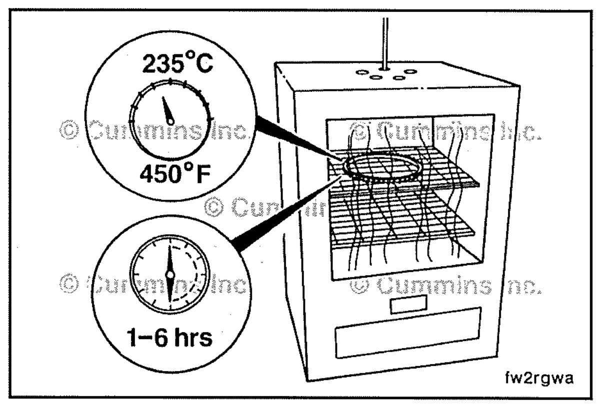
Install

Do **not** attempt to install the ring gear without using heat.

Use an oven to heat the new ring gear for a minimum of one hour. Do **not** heat the ring gear for more than 6 hours.

Oven Termperture		
°C		°F
235	NOM	455

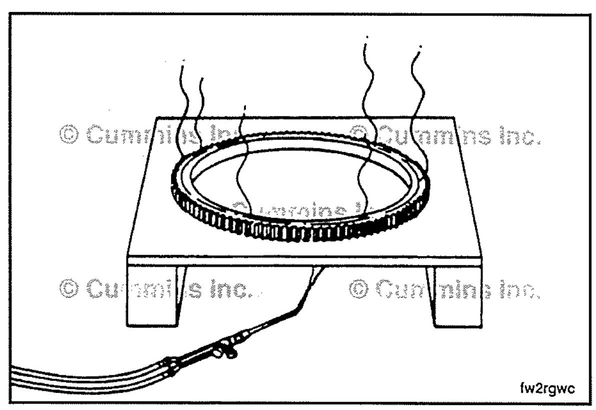
Do **not** exceed the specified time or temperature.

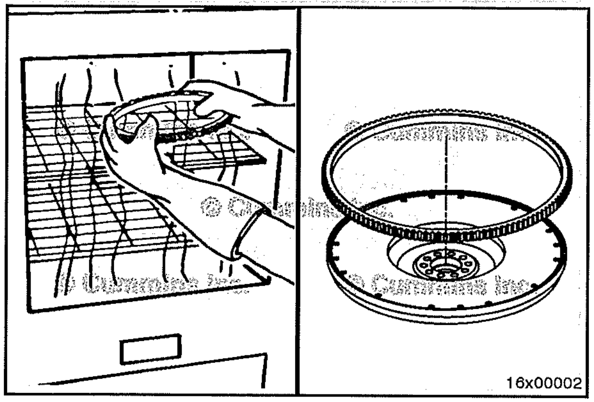


If an oven is **not** available, use a heating torch to heat the gear. Use a Tempilstik™ crayon, or equivalent, to check the temperature of the gear.

A more even temperature is obtained by placing the ring gear on a metal plate and then heating the bottom side of the plate with the torch. Do **not** exceed the specified temperature.

Temperature		
°C		°F
235	NOM	455



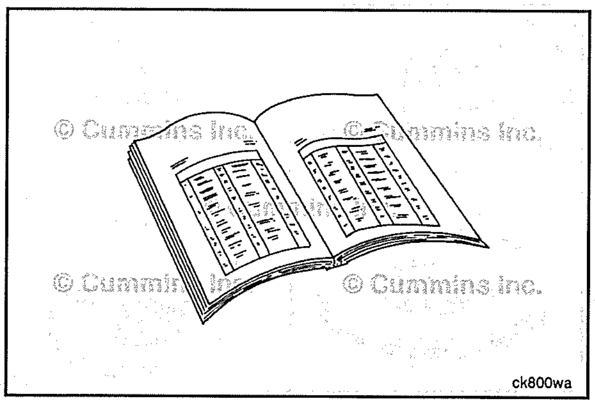

16x00002

WARNING

To reduce the possibility of severe burns, wear protective gloves when installing the heated ring gear.

The ring gear **must** be installed so the bevel on the teeth is toward the crankshaft side of the flywheel.

Install the ring gear on the flywheel before it cools. Allow the air to cool the gear. Do **not** use water or oil to reduce the cooling time.


ck800wa

Finishing Steps

- Install the flywheel. Refer to Procedure 016-005 in Section 16.

Engine Mounts (016-010)

General Information

Some vibration exists in all piston type engines, due to the pulsating power inputs and reciprocating components. Some of these vibrations are internal to the engine and are compensated, or balanced, by opposing forces within the engine structure. These are generally **not** of interest to vibration isolation designs. The vibrations that are offset or balanced internally will cause shaking moments and forces that **must** be reacted to by the engine mounts. If these moments and forces are **not** adequately reduced by the engine mounting and isolation systems, they can cause customer dissatisfaction and/or damage, due to component fatigue.

The effectiveness of an engine mounting system in isolating the vehicle structure from engine vibration depends on the relationship between the frequency of the vibration coming from the engine and the natural frequency of the engine mounting system. The mounting system effectiveness is commonly measured with the term “transmissibility”. Transmissibility is the amount of engine vibration which is transmitted through the mounting system to the vehicle structure.

Transmissibility values greater than one indicate the engine mounting system is actually transmitting more vibration into the vehicle structure than is coming from the engine. This is possible if the natural frequency of the mounting system is close to the frequency of the engine vibration. This can result in the mounting system operating at or near resonance, with a resulting magnification of the input vibration. This is obviously an undesirable situation.

Transmissibility values of less than one indicate the mounting system is transmitting **only** a fraction of the vibration input from the engine, thus isolating the vehicle from engine vibration. Good engine mounts will reduce the amount of engine vibration transmitted to the chassis frame by at least 50 percent at idle.

Stiffness (durometer) and size of the isolator, along with the weight of the engine or component applied, are the determining factors when designing a mounting system. An isolator that is correct for one engine can **not** be right for another. Likewise, because of weight differential, a particular isolator designed for the rear of an engine probably will **not** be ideal for the front. Hard engine mounts will give little or no isolation, and can actually magnify the vibration transmitted to the chassis.

The following are illustrations of typical FRONT engine mounts.

1 Bolt.

2 Supported member.

3 Snubbing washer (or flat bracket surface of equal diameter).

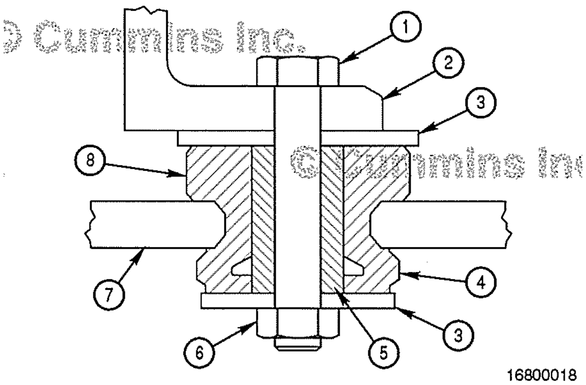
4 Rebound tail.

5 Bonded metal center.

6 Locknut.

7 Supporting member.

8 Rubber mount.



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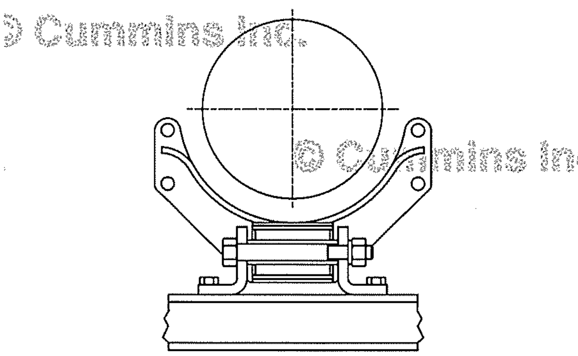

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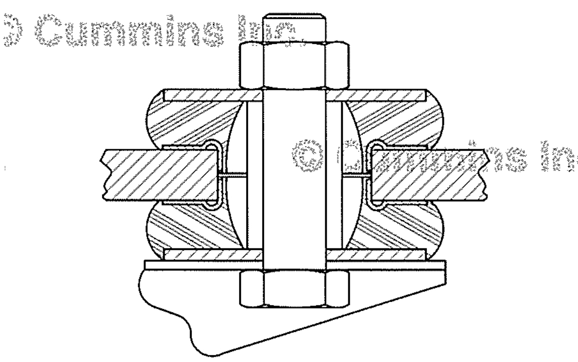

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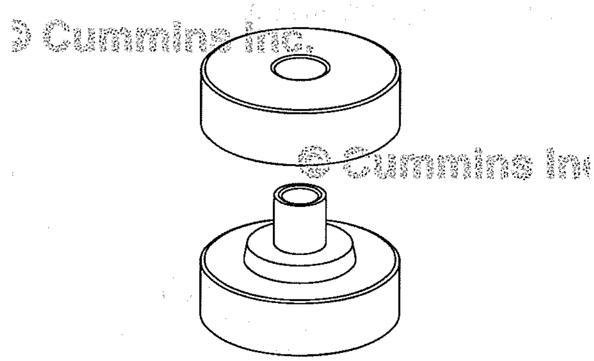

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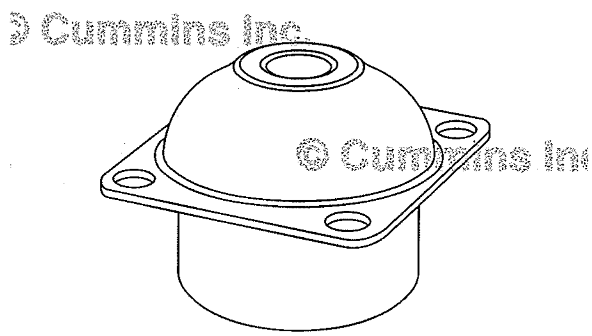
The following are illustrations of typical REAR engine mounts.



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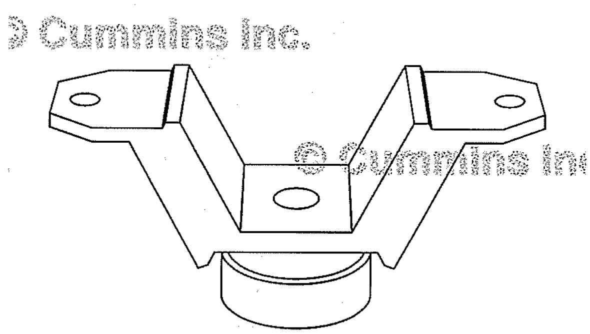

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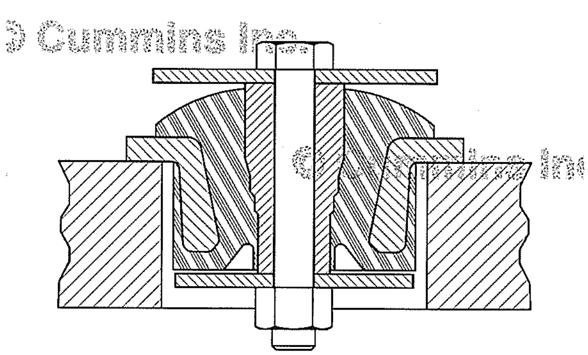

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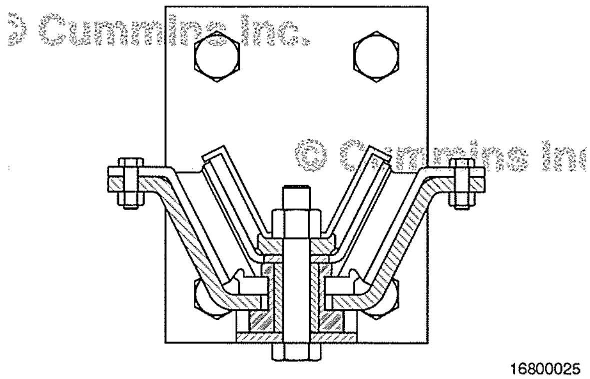


16800025

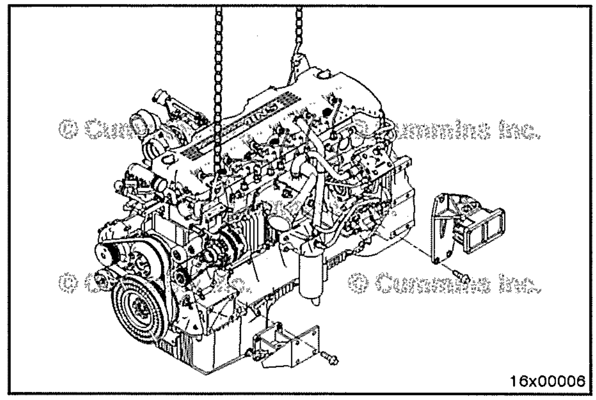
Remove

WARNING

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

WARNING

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



16x00006

Use a hoist or lifting fixture, Part Number 3162871, to support the engine.

NOTE: When removing the engine mount fasteners, note the location of any shims or spacers used.

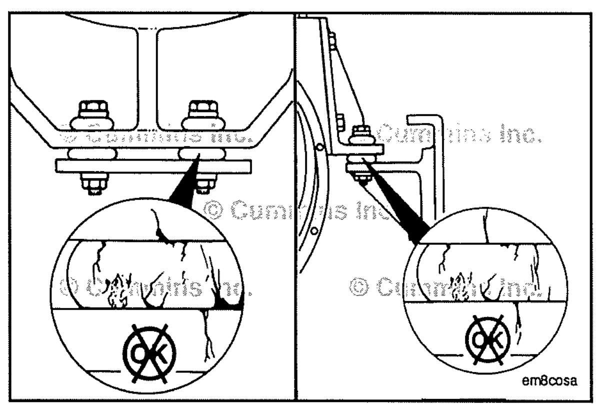
Remove the capscrews from the engine mounts.

NOTE: Certain applications will require loosening of the rear engine mount fasteners to allow removal of the front engine support bracket.

Inspect for Reuse

CAUTION

Damaged engine mounts and brackets can cause engine misalignment. Drivetrain component damage can result in excessive vibration complaints.



em8cosa

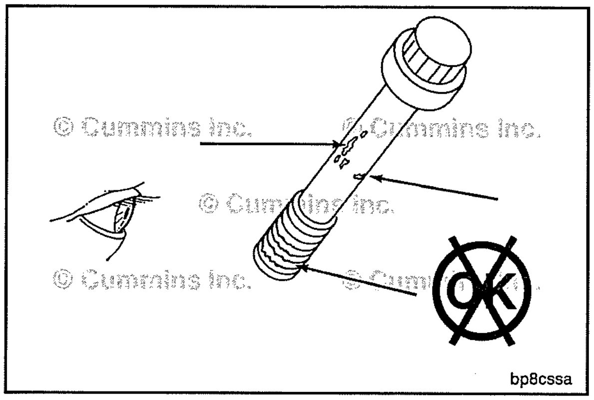
Inspect all rubber-cushioned mounts for cracks and other damage. Look for interference or contact between metal components.

Inspect all mounting brackets for cracks and damaged bolt holes.

Inspect the mounting capscrew to make sure it is **not** too long, which will **not** provide enough preload on the mount.

Replace any damaged parts as necessary.

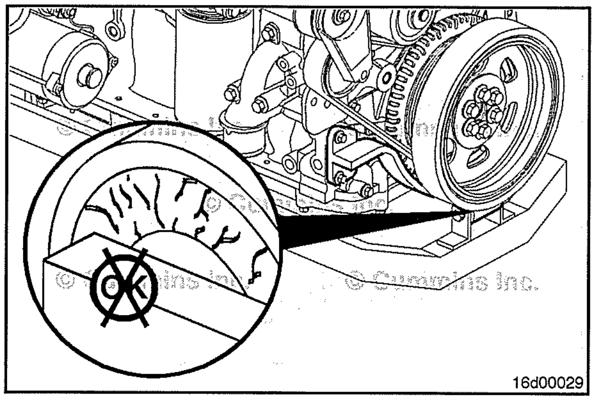
NOTE: Damaged engine mounts, brackets, and mounting hardware can cause the engine to move out of alignment and damage the driveline components in the equipment. This can result in vibration complaints.



Inspect the capscrew for the following:

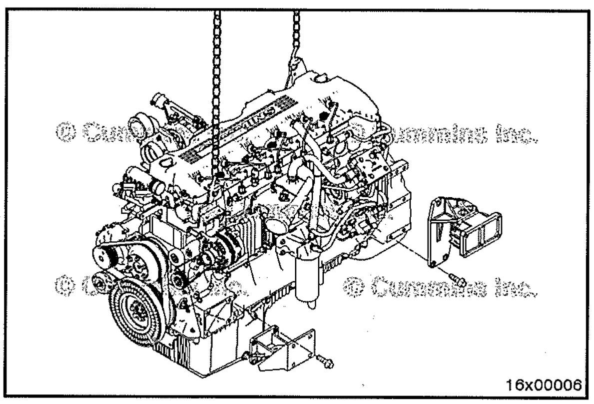
- Damaged threads.
- Rust or corrosion-caused pitting.
- Nicked, bent, stretched, or galled.

The capscrew **must** be replaced if it has any of the listed damages.



For barrel mounts, inspect for signs of contact between the side brackets and the front engine support bracket.

Contact between the engine mount and side brackets can cause vibration complaints. If contact is found, replace the front engine support bracket.



Install

NOTE: Make sure to install any shims or spacers in the same location as removed.

Align the engine in the chassis.

Install the engine mount fasteners and tighten. See equipment manufacturer service information for torque specifications.

Remove the lifting fixture or hoist from the engine lifting brackets.

Connect all engine and chassis mounted accessories that were removed.

Section 17 - Miscellaneous - Group 17

Section Contents

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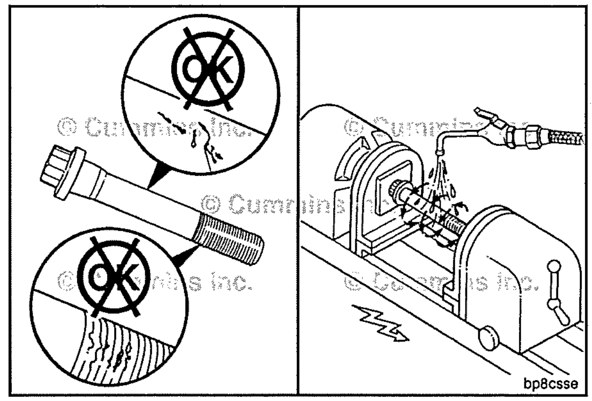
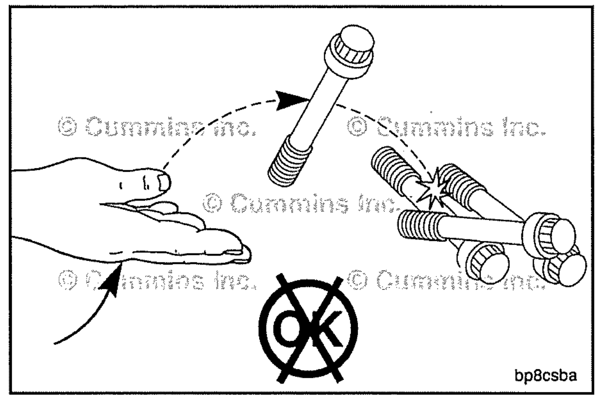
Capscrew (017-001)

Magnetic Crack Inspect



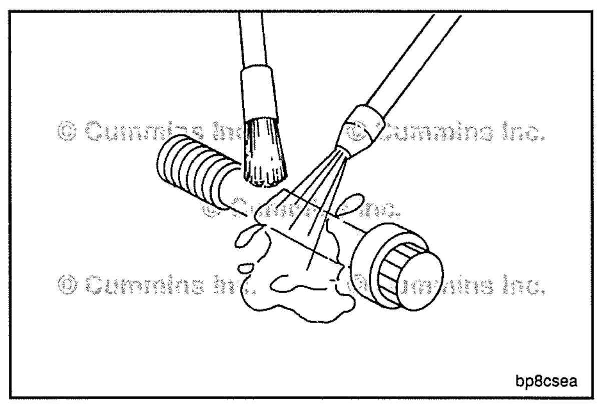
This procedure describes the visual and magnetic particle inspection of special and high strength capscrews for the:

- Cylinder head
- Main bearing cap
- Flywheel
- Connecting rod
- Crankshaft pulley or adapter
- Lifting bracket
- Crankshaft counterweight.



CAUTION

Prevent damage to the capscrews. Nicks in the body of the capscrew can cause an area of stress that can fail during engine operation. Damage to the threads will cause torque values to be incorrect and will damage the mating parts.



WARNING

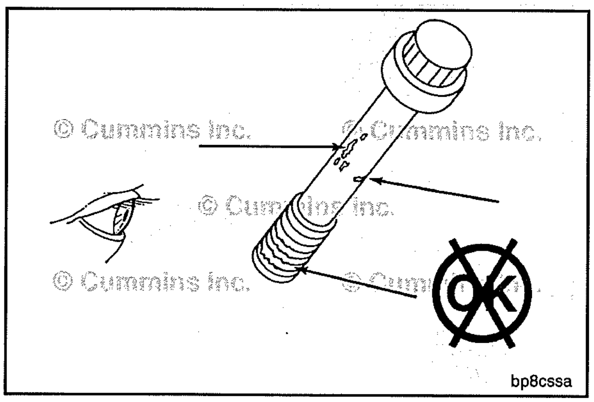
When using solvents, acids or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING

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

If necessary, use a wire wheel to remove all rust, corrosion, and dirt from the capscrews.

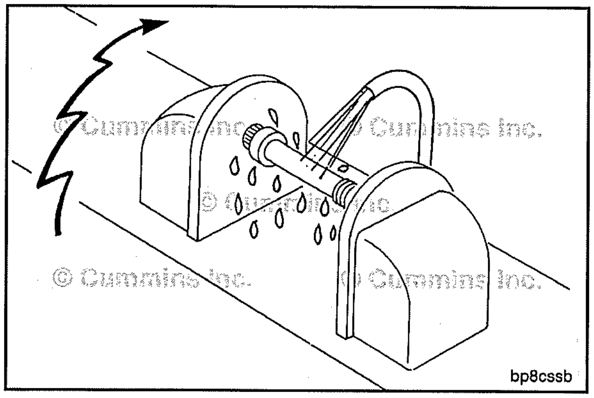
Use solvent to clean the capscrew and dry with compressed air.



Check the capscrew. The capscrew **must** be replaced if:

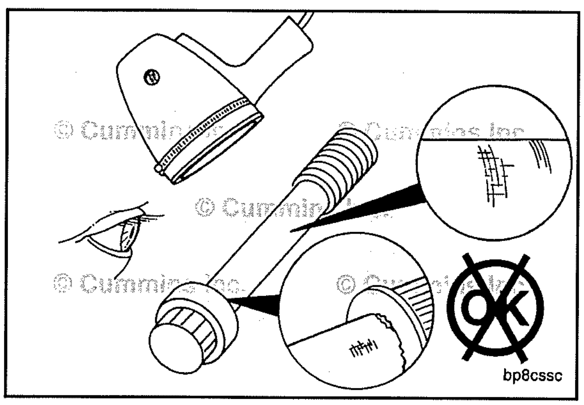
- Threads are damaged
- Rust or corrosion has caused pitting in the body
- The body is nicked, galled, bent, or stretched.

Some capscrews (cylinder head, main bearing cap, connecting rods) have threads that have been formed by a rolling operation during manufacture. Repair of rolled threads by use of a thread die is **not** recommended. The thread die can create a sharp corner on the minor diameter (root) of the threads. This sharp corner can cause an area of increased stress.



Use a magnetic particle testing machine such as Magnaflux.

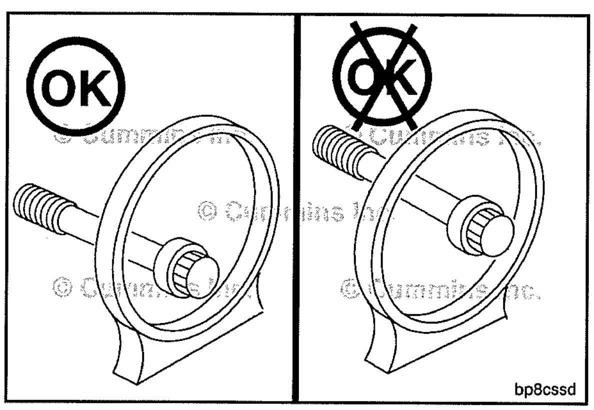
Use the continuous method. Apply a head shot of 300 to 400 amperes VDC or rectified VAC.



Use an ultraviolet light. Check for indications of cracks.

The magnetic particles tend to form on sharp corners and edges. Do **not** mistake these for cracks.

Any indications of cracks are **not** acceptable.



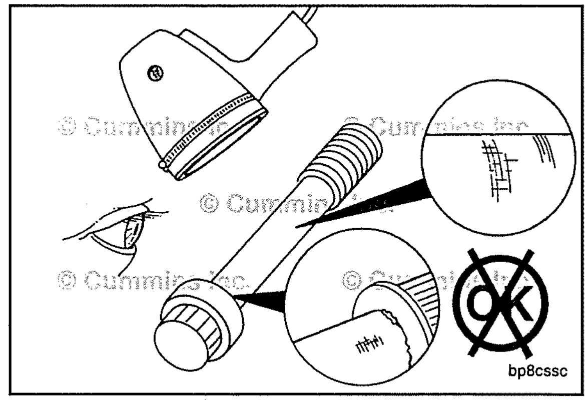
Prepare the machine for a coil shot.

Make sure the capscrew is near one side of the coil and **not** in the center.

Apply 1000 to 1350 ampere-turns.

Use an ultraviolet light. Check for indications of cracks.

Any indications of cracks are **not** acceptable.



⚠WARNING⚠

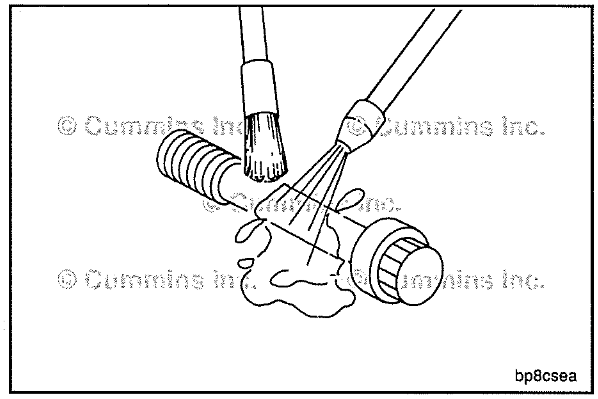
When using solvents, acids or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

⚠WARNING⚠

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

Demagnetize the capscrew thoroughly.

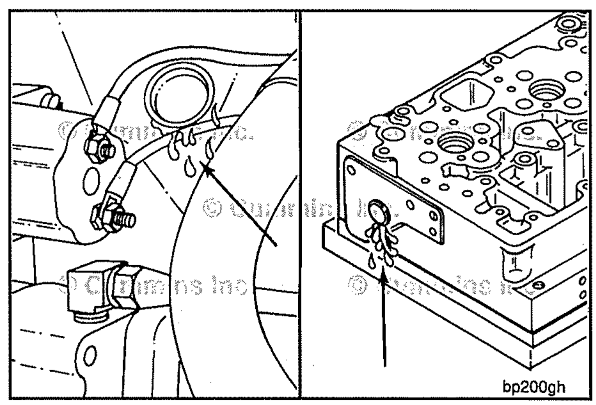
Use solvent to clean the capscrew and dry with compressed air.



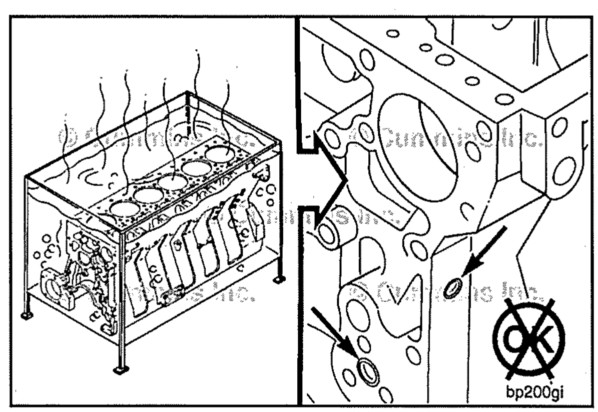
Cup Plug (017-002)

General Information

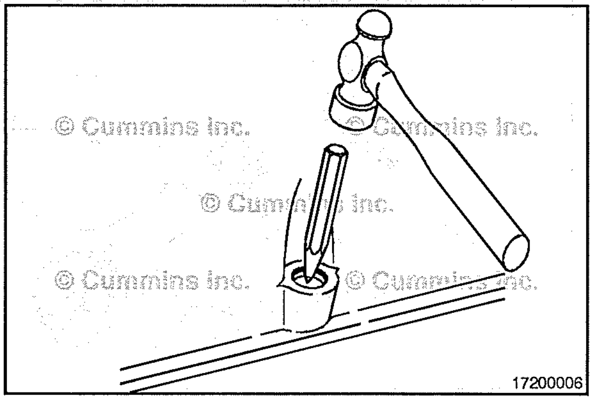
This repair method pertains to components that have leakage at a cup plug, due to incorrect fit of the cup plug in the cup plug bore.



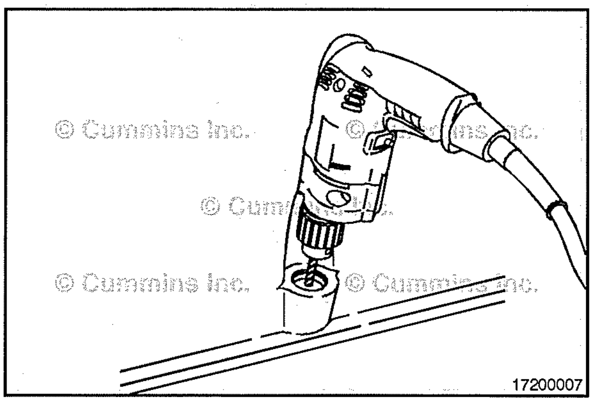
All cup plugs **must** be replaced if the component is cleaned in a "hot tank", spray washer, or similar equipment. This cleaning activity can interrupt the sealing capacity of the sealant.



Remove



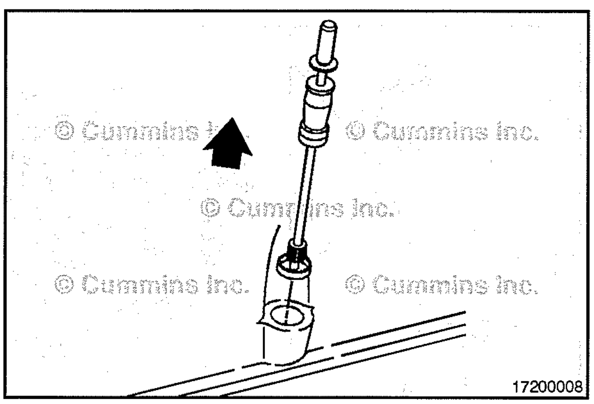
Use a center punch to mark the cup plug for drilling.



CAUTION

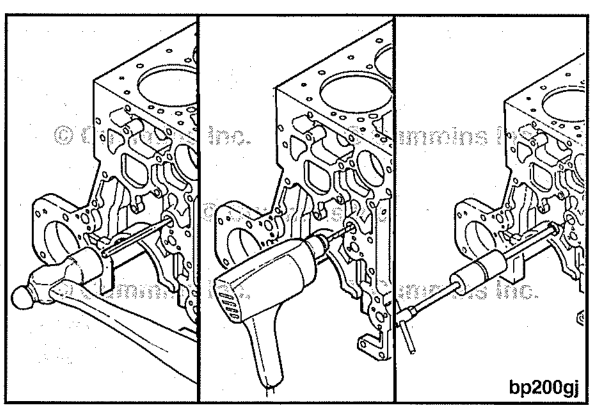
Do not allow metal shavings to fall inside the engine when drilling a hole in the cup plug. Damage to engine components can occur.

Drill a 1/8-inch hole in the cup plug.



Use a dent puller to remove the plug.

Discard all used cup plugs. Do **not** use them again.



CAUTION

Do not allow metal shavings to fall inside the engine when drilling a hole in the cup plug. Damage to engine components can occur.

Cup plugs can be removed by using a center punch to mark the cup plug for drilling.

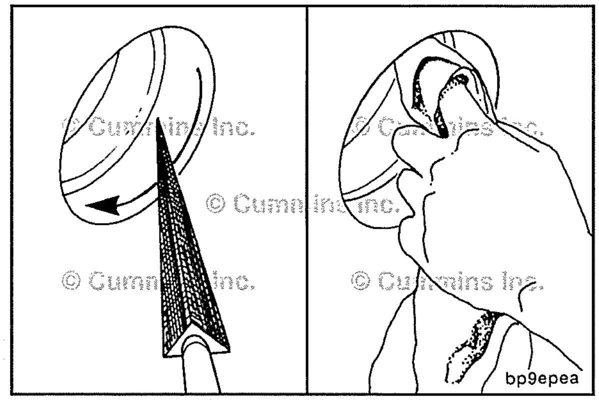
Drill a 3-mm [1/8-inch] hole in the cup plug.

Use a dent puller to remove the plug.

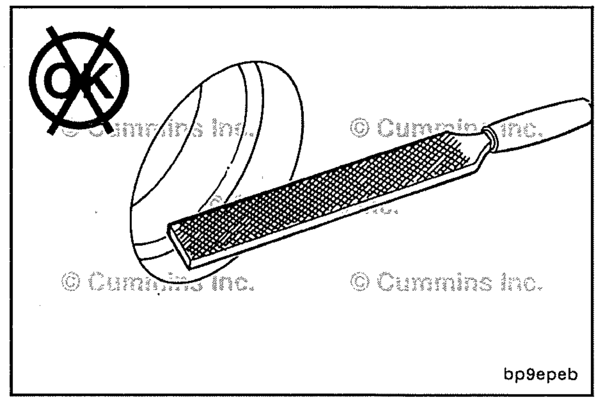
Clean and Inspect for Reuse

Lightly scrape the bore to remove any corrosion or carbon buildup.

Wipe the bore with a cloth saturated with a spray cleaner.

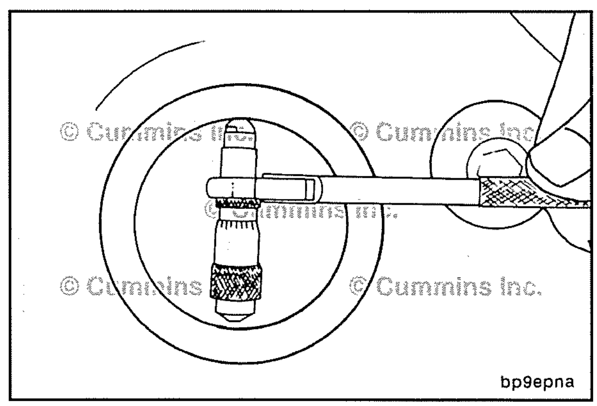


⚠CAUTION⚠
Do not use a file to remove the built up material. The cup plug bore can be damaged.

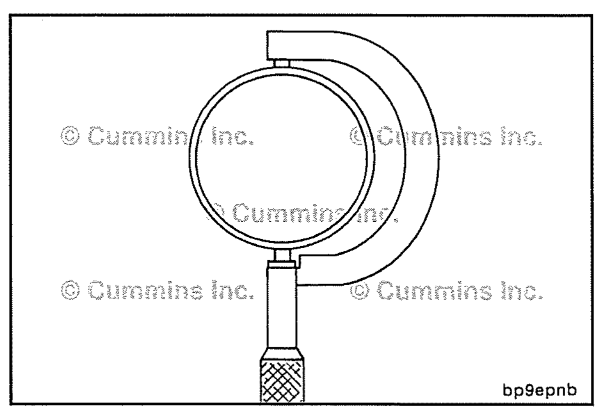


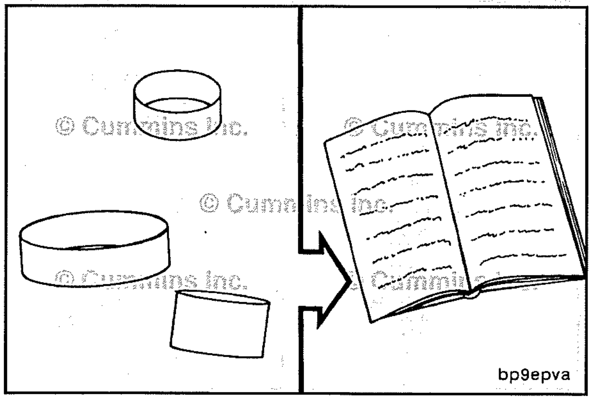
Measure the bore diameter in the vertical direction and in the horizontal direction.

Both axis measurements **must** be within 0.02 mm [0.001 in] of each other.

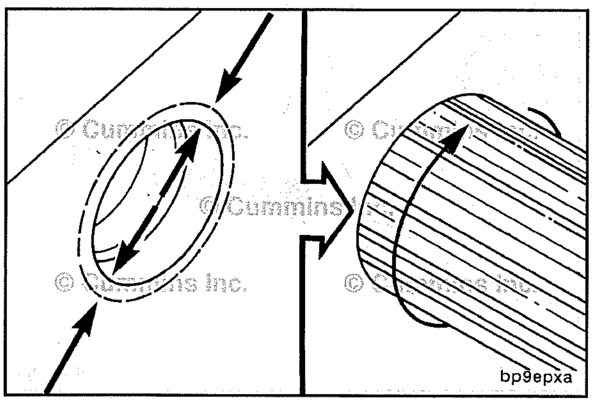


Compare the bore diameter with the recommended bore size of the cup plug being used. Use the table at the end of this procedure for specifications.

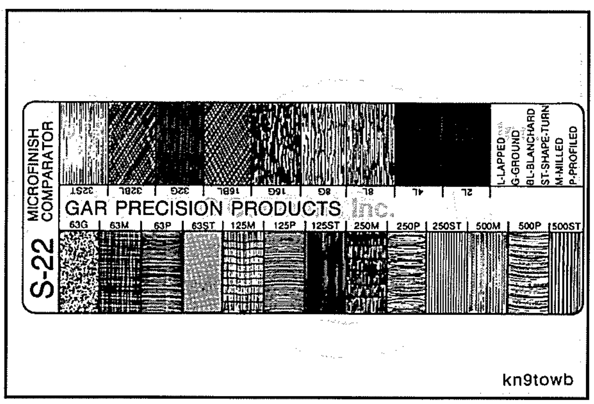




NOTE: If the correct cup plug is being used, but the bore is incorrectly sized, the bore must be repaired. The recommended repair method is to enlarge the bore for the next larger cup plug size. A listing of available cup plugs and their dimensions is provided at the end of this procedure.

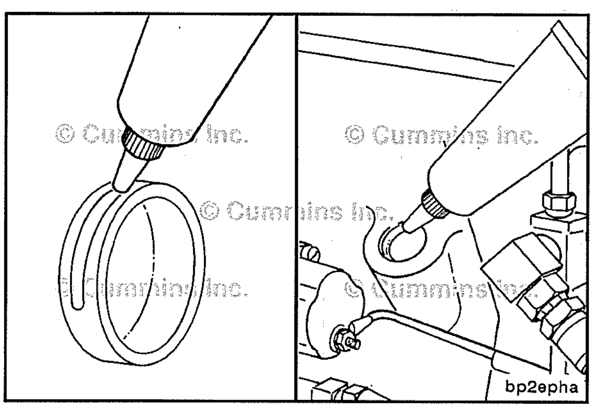


Enlargement of the cup plug bores can be accomplished by reaming or boring the faulty bore. Use the existing bore for location reference when enlarging the bore.



The surface finish of the enlarged cup plug bore is very important in making a successful repair. The surface finish of the bore **must** be a minimum of 2.03 µM [80 µ inch]. A surface finish comparator can be used.

NOTE: Units of measurement are: Micro-meter [Micro-inch].



Install

⚠CAUTION⚠

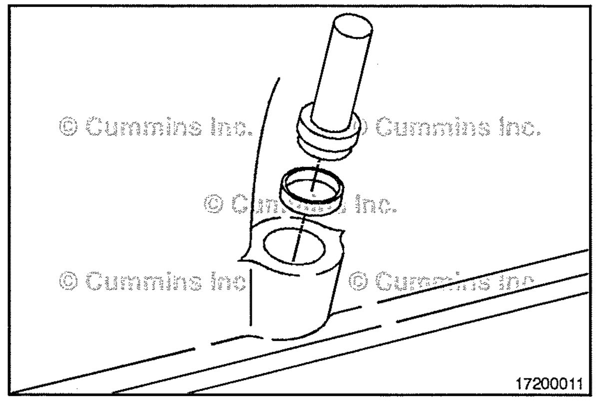
Excessive sealant can run back into the engine and cause damage to other components. Allow the sealant to dry for a minimum of two hours before operating the engine.

Apply a 2-mm [1/16-inch] bead of cup plug lock 'n seal , Part Number 3375068 or equivalent, to the outside diameter of the cup plug and the inside diameter of the cup plug installation bore.

A cup plug driver **must** be used to install the cup plug to the correct depth in the cup plug bore. Use the following cup plug drivers:

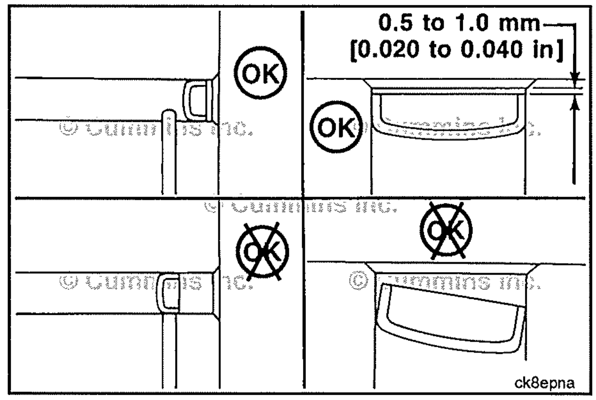
- Part Number 3822372 - 9.7 mm [0.38 in] cup plug.
- Part Number 3376816 - 25.4 mm [1.00 in] cup plug.
- Part Number 3376058 - 60.5 mm [2.38 in] cup plug.

Use cup plug driver handle, Part Number 3164085, with cup plug driver, Part Number 3376816.



The cup plug **must** be installed with the edge of the plug 0.5 to 1.0 mm [0.020 to 0.040 in] deeper than the entrance chamber of the bore.

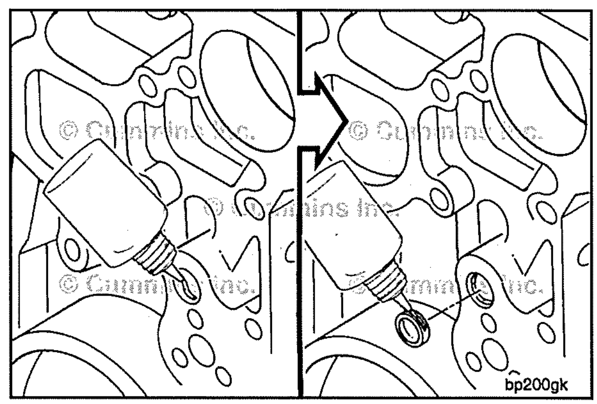
Do **not** install the plug too deep. The cross drillings in the cylinder block can be blocked shut. If the plug is **not** installed straight and flat, it **must** be replaced with a new cup plug.



⚠CAUTION⚠

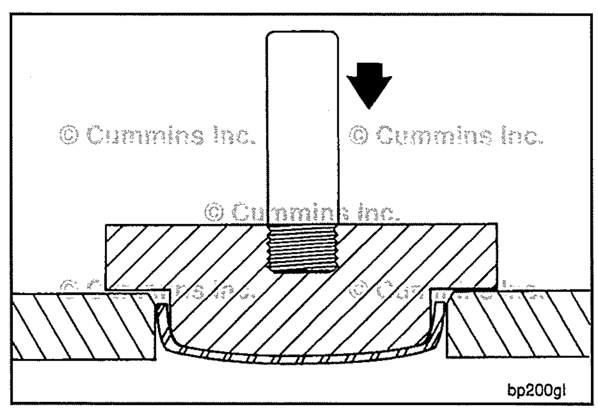
Excessive sealant application can run back into the engine and cause damage to other components. Allow the sealant to dry for a minimum of two hours before operating the engine.

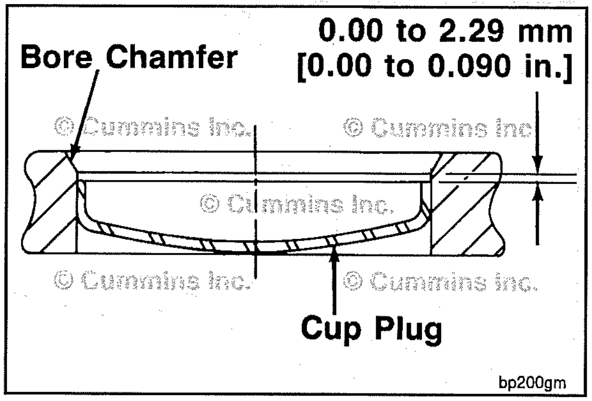
Apply a 2-mm [1/16-inch] bead of cup plug lock'n seal , Part Number 3375068 or equivalent, to the outside diameter of the cup plug and the inside diameter of the cup plug installation bore.



Install the replacement cup plug.

Use a suitable cup plug driver or mandrel to correctly position the cup plug.



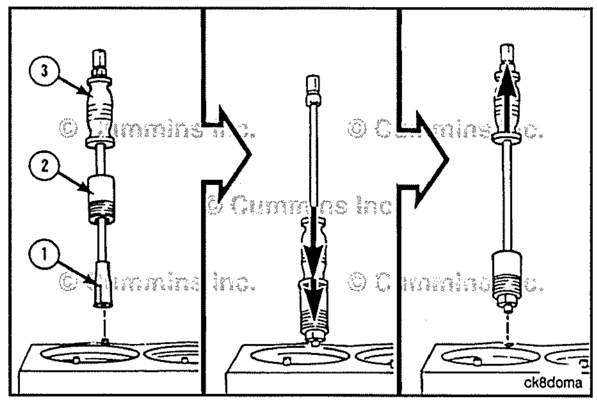


Check to make sure the cup plug is correctly installed. The top of the cup plug **must** be 0.0 to 2.29 mm [0.00 to 0.090 in] below the entrance chamfer.

Cup Plug Specifications						
	Outside Diameter		Height		Use in Bore Diameter	
Part Number	mm	inch	mm	inch	mm	inch
203933	6.55 to 6.60	0.258 to 0.260	3.18	0.125	6.40 to 6.45	0.252 to 0.254
3007632	9.78 to 9.86	0.385 to 0.388	4.78	0.188	9.63 to 9.68	0.379 to 0.381
210036	11.35 to 11.40	0.447 to 0.449	4.78	0.188	10.92 to 11.15	0.439 to 0.443
147416	12.95 to 13.00	0.510 to 0.512	6.35	0.250	12.80 to 12.85	0.504 to 0.506
213395	25.65 to 25.70	1.010 to 1.012	7.87	0.310	25.45 to 25.53	1.002 to 1.005
3007635	25.70 to 25.81	1.012 to 1.016	8.13	0.320	25.45 to 25.53	1.002 to 1.005
3004259	27.18 to 27.28	1.070 to 1.074	7.87	0.310	26.92 to 27.00	1.060 to 1.063
3032693	28.73 to 28.78	1.131 to 1.133	6.60	0.260	28.45 to 28.55	1.120 to 1.124
143066	28.83 to 28.88	1.135 to 1.137	7.87	0.310	28.65 to 28.75	1.128 to 1.132
156075	30.38 to 30.43	1.196 to 1.198	7.87	0.310	30.18 to 30.25	1.188 to 1.191
206741	60.50 to 60.60	2.382 to 2.386	9.53	0.375	60.30 to 60.35	2.374 to 2.376
3895479	51.18 to 51.28	2.015 to 2.019	9.40	0.370	50.80 to 50.88	2.000 to 2.003

Dowel Pin (017-003)

Remove



Due to the number of various aftertreatment configurations, this procedure has been written to begeneric. **Not** all illustrations within this procedure will represent the application that is being worked on.

Use a dowel pin extractor, Part Number 3163720 or equivalent, to remove the cylinder head groove pins.

Put the split collet (1) over the groove pin.

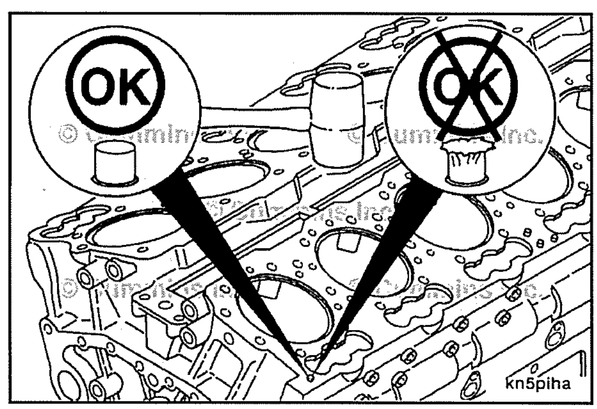
Slide the extractor collar (2) over the split collet.

Use the slide hammer (3) to push the extractor collar over the split collet tightly.

Use the slide hammer to remove the groove pin.

NOTE: If required, remove the seal rings. Tag the seal rings for future identification.

Install

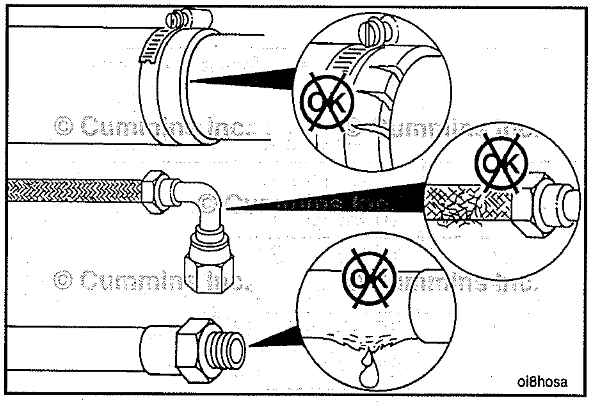


⚠CAUTION⚠

Do not use a hammer to install the groove pin(s). Damage to the groove pin(s) will result.

NOTE: Do not install the cylinder groove pins (1) in the cylinder block until the inspection and any necessary repair procedures are completed.

Use a mallet to install the groove pin(s).

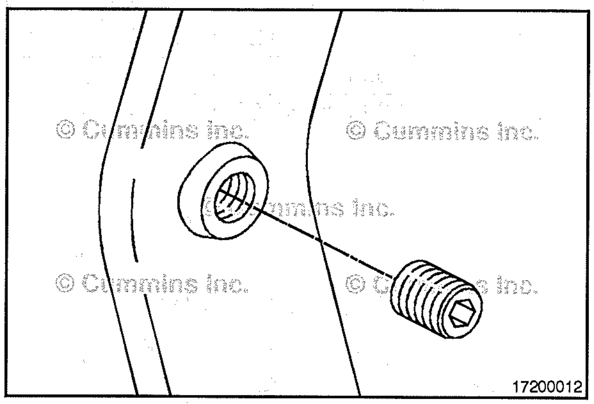


Flexible Hose (017-005)

Inspect for Reuse

Inspect all flexible hoses and their connections for leaks or deterioration.

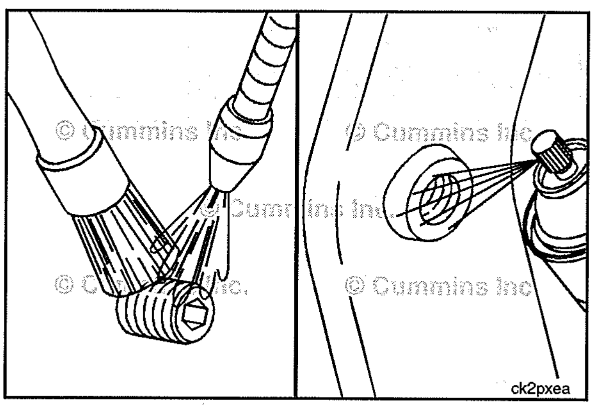
Repair or replace the hose if damaged.



Pipe Plug (017-007)

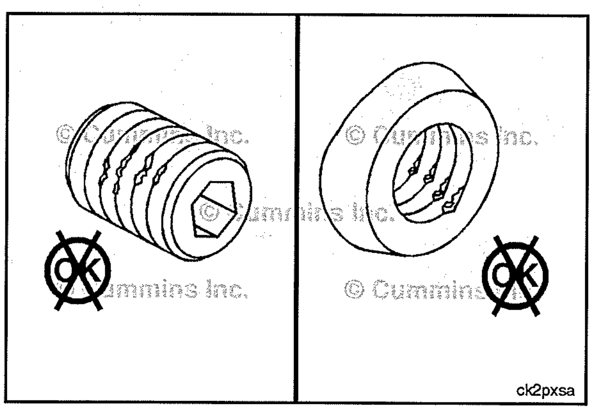
Remove

Select the appropriate size Allen wrench and remove the pipe plug.



Clean and Inspect for Reuse

Use spray cleaner, Part Number 3824510 or equivalent, to clean the threads of the pipe plugs and threaded bores.

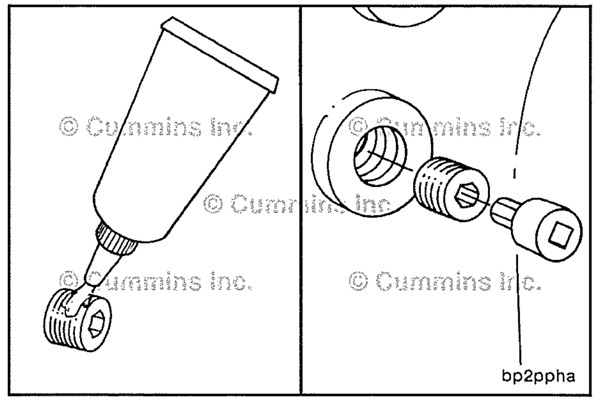


Inspect the threads of the pipe plugs for mutilation or damage.

Inspect the threaded bores for damage.

Repair the bores, if necessary. See the M11 Alternative Repair Manual, Bulletin 3810310.

Install



Apply a film of pipe plug sealant, Part Number 3375066 or equivalent, to the threads.

Install and tighten the pipe plugs.

See the following chart for torque values:

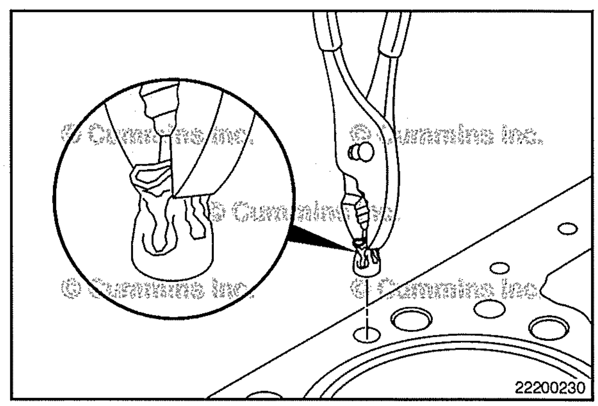
Tighten pipe plugs to the appropriate torque values.

Pipe Plug Torque Values						
Size			Torque		Torque	
Thread	Actual Thread O.D.		In Aluminum Components		In Cast Iron or Steel Components	
in.	mm	[in]	N•m	[ft-lbs]	N•m	[ft-lbs]
1/16	8.1	[0.32]	5	[45 in-lb]	15	[10]
1/8	10.4	[0.41]	15	[10]	20	[15]
1/4	13.7	[0.54]	20	[15]	25	[20]
3/8	17.3	[0.68]	25	[20]	35	[25]
1/2	21.6	[0.85]	35	[25]	55	[40]
3/4	26.7	[1.05]	45	[35]	75	[55]
1	33.5	[1.32]	60	[45]	95	[70]
1¼	42.2	[1.66]	75	[55]	115	[85]
1½	48.3	[1.90]	85	[65]	135	[100]

ck8ppoa

Ring Dowel (017-009)

Remove



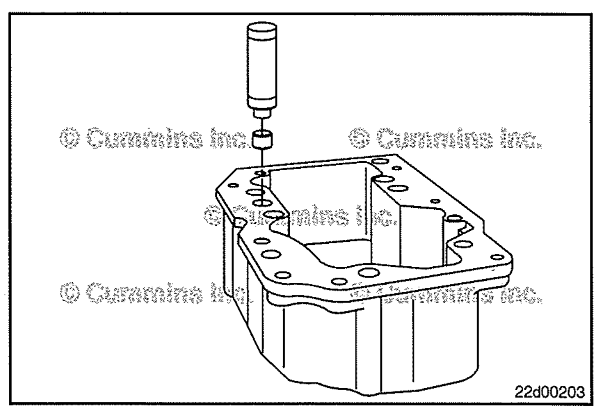
CAUTION

Do not damage the surface or the component during removal of the dowel. Protect the surface with a piece of scrap wood to leverage against.

Crush the exposed ring dowel with an appropriately sized hand tool, such as pliers and/or vice grips. Secure the dowel and remove.

Discard the ring dowel.

Install



Slide the appropriate ring dowel onto the end of the appropriate ring dowel installer.

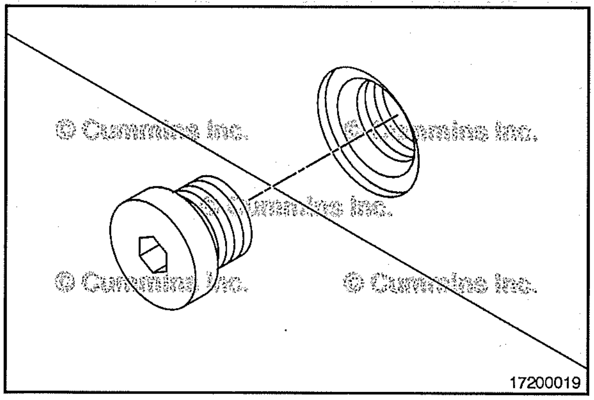
Insert the ring dowel and installer assembly into the component's dowel hole.

Lightly tap the ring dowel installer with a hammer until the installer makes contact with the component.

Remove the ring dowel installer.

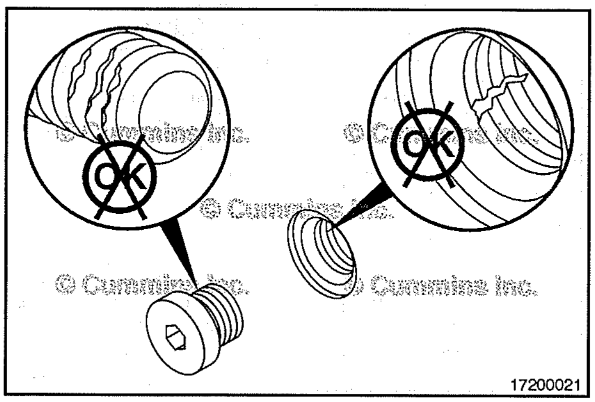
Straight Thread Plug (017-011)

Remove



Select the appropriate size allen wrench or socket and remove the plug.

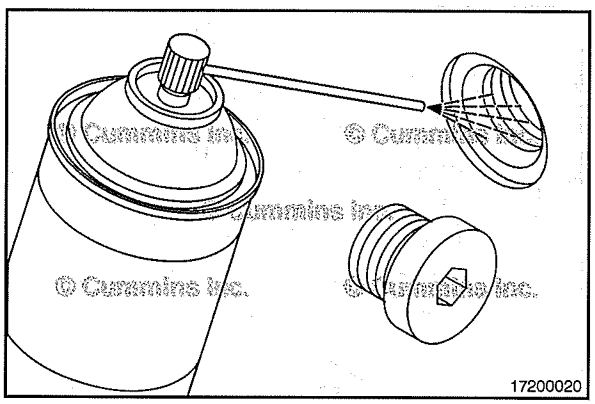
Clean and Inspect for Reuse



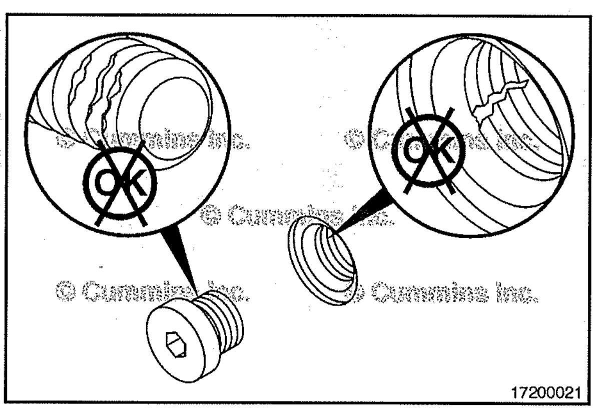
Inspect the threads of the pipe plugs for mutilation or other damage.

Inspect the threaded bores for damage.

Repair the bores, if necessary.



Use spray cleaner, Part Number 3824510 or equivalent, to clean the threads of the straight thread plugs and threaded bores.

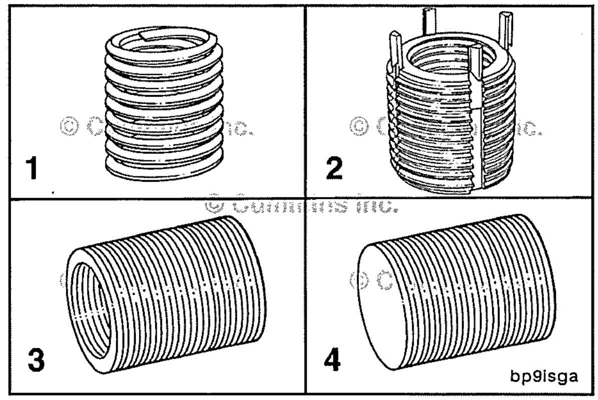


Inspect the threads of the pipe plugs for mutilation or damage.

Inspect the threaded bores for other damage.

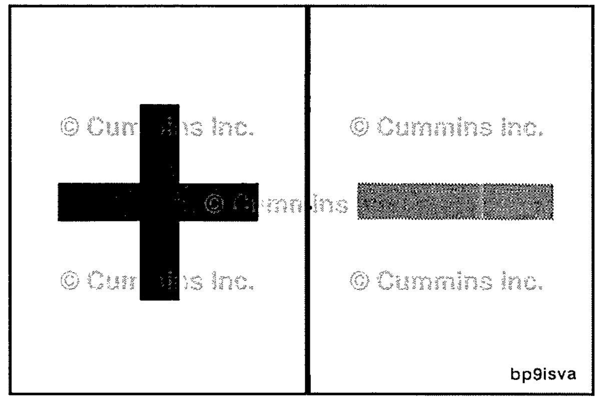
If the threaded bores are damaged, repair the threads according to the Repair section in this procedure.

Repair



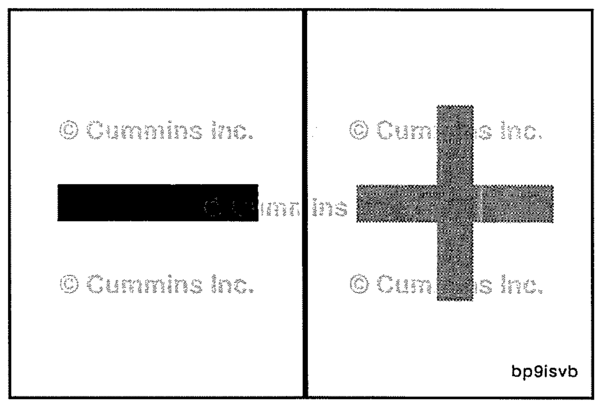
Four different types of thread inserts can be used to repair damaged capscrew threads:

1 Coiled thread inserts
2 Keylock thread inserts
3 Open end thread inserts
4 Closed end (blind) thread inserts.



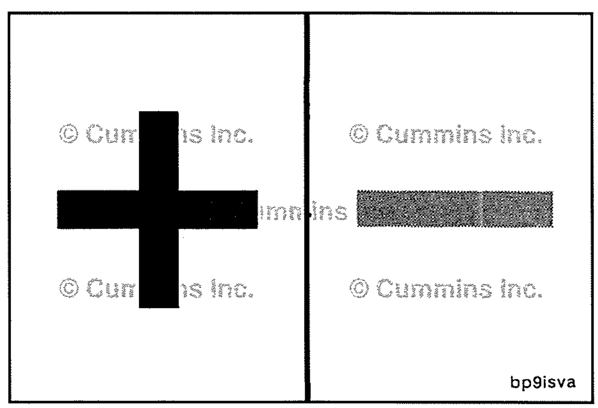
Coiled thread repair inserts have the following advantages:

- Can be installed in locations that have minimal thickness around the threaded hole
- Made of materials that resist and prevent galvanic action
- Sealants are **not** required when installing repair inserts
- Equivalent to or exceeds the strength of the original threads
- Finish machining is **not** required.



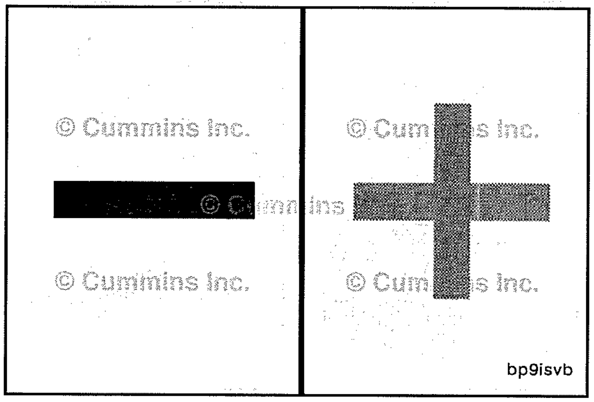
Coiled thread repair inserts have the following disadvantages:

- Special sized tap drills or reamers are required
- Special taps are required
- Special installation tools are required
- The repair insert can **not** be reused if it "backs out" after installation
- The coiled thread insert has no bottom and provides no sealing capabilities.



Keylock thread inserts have the following advantages:

- Standard, commercially available, drills and taps are used during installation
- Relatively inexpensive and available from several sources
- Can be removed and replaced without requiring modification or rework to the component.



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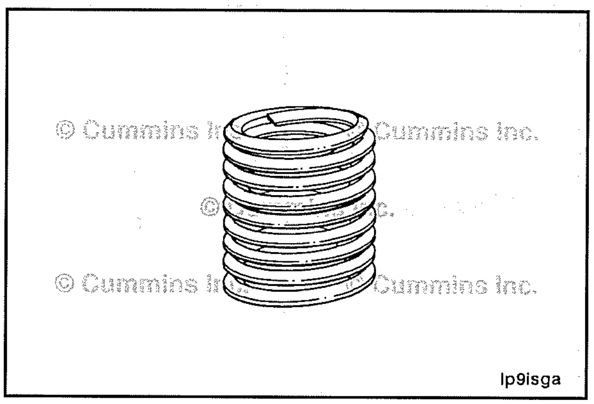
Keylock thread inserts have the following disadvantages:

- Generally apply to repair of components that have thicker wall sections
- Installation requires a locking key driver.

NOTE: Inserts can be used in cast iron, steel, copper, brass, bronze, aluminum, magnesium, plastic, and wood.

For special installations, call or write the following manufacturers.

Perma-Thread™	**Heli-Coil™**	**Coil Thread**
Microdot Inserts1025 N. Armanda Street Anaheim, CA 92806(714) 870-6650	Heli-Coil™ ProductsShelter Rock LaneDanbury, CT 06810(203) 743-7651	Tridair Industries 3000 West Lomita Blvd. Torrance, CA 90505(213) 530-2220



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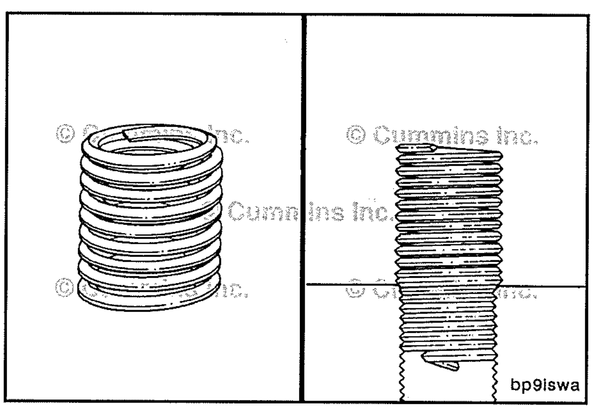
NOTE: This part of the procedure is for repairing coiled thread inserts.

This repair procedure provides useful information and installation instructions for coiled thread inserts. Coiled thread inserts are a precision wound wire insert for repairing failed or mutilated internal threads.



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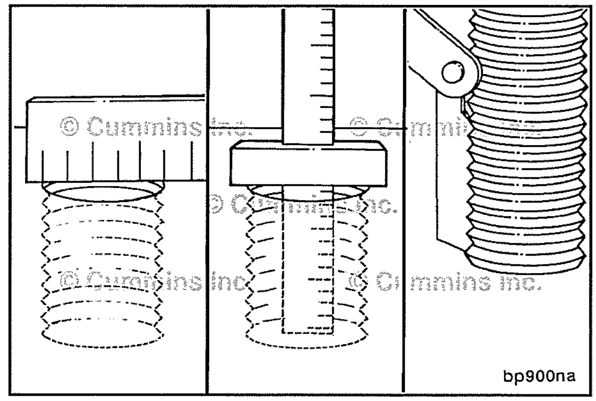
These coils in their free state are designed to be larger in diameter than the tapped hole. After installation, the insert conforms to the outer wall of the tapped hole. This compressed fit holds the insert in place.

NOTE: Inserts are normally made of stainless steel wire. However, other materials are available to meet special installation requirements.

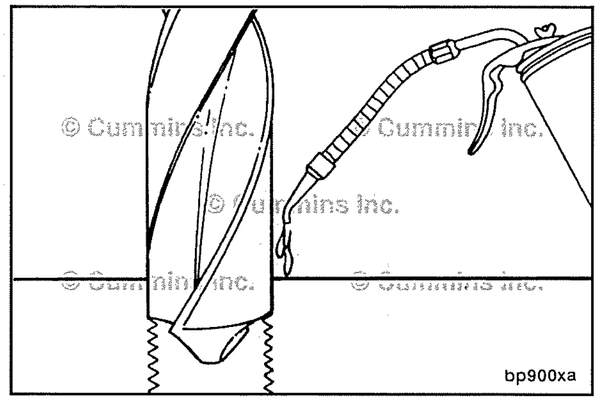
Determine the diameter, depth, and pitch of the original threaded hole.



⚠WARNING⚠

To reduce the possibility of personal injury, always wear protective goggles when drilling metal.

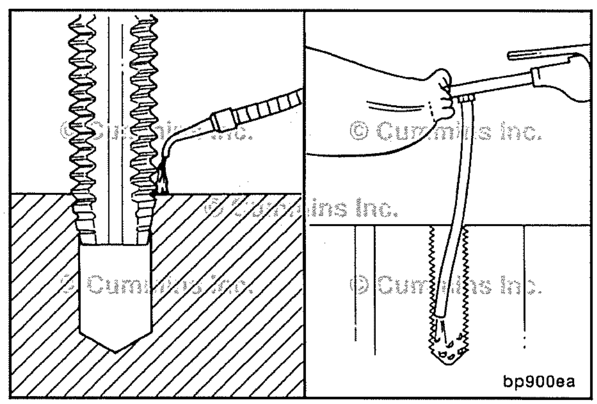
Use cutting oil while drilling the capscrew hole to the specified diameter. Use the charts in this procedure for drill size diameter specifications. Drill to the bottom of blind capscrew holes.



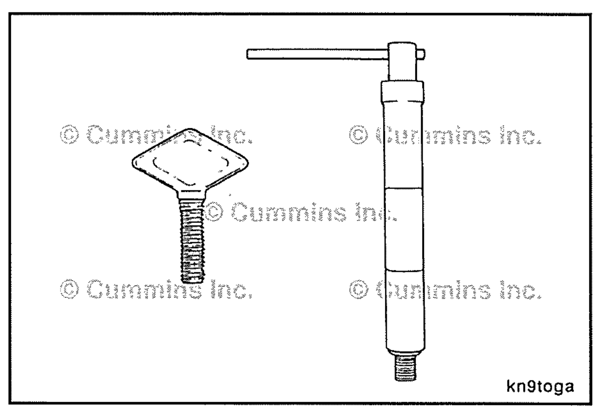
Use the special tap specified in the chart, according to the thread size needed, to cut the threads in the capscrew hole.

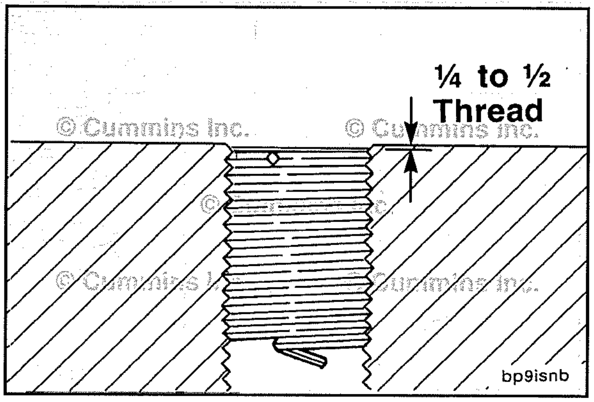
NOTE: Use cutting oil when tapping the capscrew hole. Clean the capscrew hole before installing the repair insert.

Use chip removing unit, Part Number 3164019, to remove machining chips from the capscrew hole.

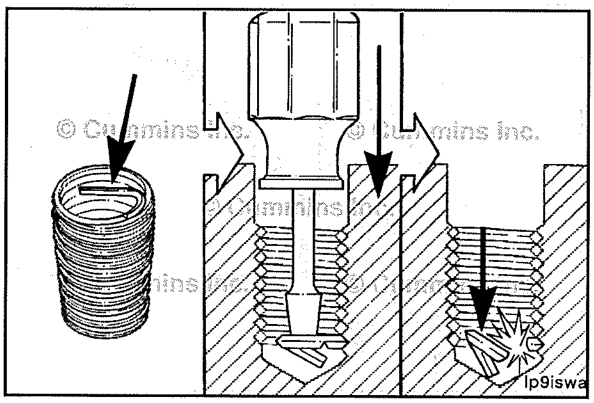


Select the type of installation tool required for your specific thread insert and space limitations.

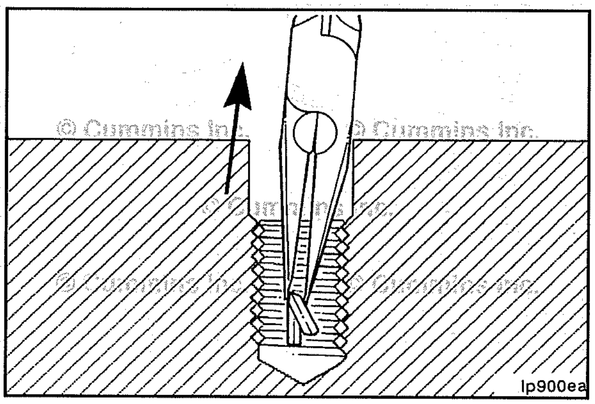




Install the repair insert into the prepared hole. The top of the insert **must** be 1/4 to 1/2 of a thread below the surface of the part.



Break the installation tang off of the thread repair insert. Position a punch or screwdriver near the free end of the installation tang. Strike the tool to break off the tang.



Remove the installation tang from the repaired hole.

Coiled Thread Insert Part Numbers - Metric Threads			
Thread Size	**Thread Length - mm**	**Heli-Coil™ Part Number**	**Perma Thread™ Part Number**
M6 X 1.00	9	1084-6CN-0070	206M-8C-0090
M6 X 1.00	12	1084-6CN-0120	206M-6C-0120
M6 X 1.25	12	1084-8CN-0120	206M-8C-0120
M6 X 1.25	16	1084-8CN-0160	206M-8C-0160
M10 X 1.50	15	1084-10CN-0150	206M-10C-0150
M10 X 1.50	20	1084-10CN-0200	206M-10C-0200
M12 X 1.75	18	1084-12CN-0180	206M-12C-0180
M12 X 1.75	24	1084-12CN-0240	206M-12C-0240
M14 X 2.00	21	1084-14CN-0210	206M-14C-0210
M14 X 2.00	28	1084-14CN-0280	206M-14C-0280
M16 X 2.00	24	1084-16CN-0240	206M-16C-0240
M16 X 2.00	38	1084-16CN-0320	206M-16C-0320

Drill Sizes				
Thread Size	**Suggested Drill Size - Metric (mm)**		**Suggested Drill Size - U.S. Customary [Inch]**	
	Aluminum	**Steel**	**Aluminum**	**Steel**
M6 X 1.00	6.25	6.30	D [0.2460]	1/4 [0.2500]
M8 X 1.25	8.30	8.40	21/64 [0.3281]	Q [0.3320]
M10 X 1.50	10.5	10.5	Z [0.4130]	Z [0.4130]
M12 X 1.75	12.5	12.5	31/64 [0.4844]	1/2 [0.500]
M14 X 2.00	14.5	14.5	37/64 [0.5781]	37/64 [0.5781]
M16 X 2.00	16.5	16.5	21/32 [0.6562]	21/32 [0.6562]

Tap Part Numbers				
Thread Size	**Heli-Coil™ Plug Tap Part Number**	**Heli-Coil™ Bottoming Tap Part Number**	**Perma-Thread™ Plug Tap Part Number**	**Perma-Thread™ Bottoming Tap Part Number**
M6 X 1.00	2087-6	2093-6	5043-060CP5	5043-060CB5
M8 X 1.25	2087-8	2093-8	5043-080CP5	5043-080CB5
M10 X 1.50	2087-10	2093-10	5043-100CP5	5043-100CB5
M12 X 1.75	2087-12	2093-12	5043-120CP5	5043-120CB5
M14 X 2.00	2087-14	2093-14	5043-140CP5	5043-140CB5
M16 X 2.00	2087-16	2093-16	5043-160CP5	5043-160CB5

Coiled Thread Insert Part Numbers - Unified Threads					
Thread Size and Pitch	**Thread Length-Inch**	**Cummins® Part Number**	**Heli-Coil™ Part Number**	**Perma-Thread™ Part Number**	**Coil Thread Part Number**
1/4-20	0.500	113759	1185-4CN-0500	208C4-0500	TNC-4C-0500
5/16-18	0.625	68372	1185-5CN-0625	208C5-0625	TNC-5C-0625
5/16-24	0.625	69003	1191-5CN-0625	208F5-0625	TNF-5C-0625
3/8-16	0.563	67184-A	1185-6CN-0563	208C6-0750	TNC-6C-0562
3/8-16	0.750	67184-B	1185-6CN-0750	208C6-0750	TNC-6C-0750
3/8-16	0.938	67184-C	1185-6CN-0938	208C6-0938	TNC-6C-0938
3/8-16	1.125	67184-D	1185-6CN-1125	208C6-1125	TNC-6C-1125
3/8-24	0.375	672125-A	1191-6CN-0375	208F6-0375	TNF-6C-0375
3/8-24	0.563	672125-B	1191-6CN-0563	208F6-0562	TNF-6C-0562
3/8-24	0.750	672125-C	1191-6CN-0750	208F6-0750	TNF-6C-0750
3/8-24	0.938	672125-D	1191-6CN-0938	208F6-0938	TNF-6C-0938

Coiled Thread Insert Part Numbers - Unified Threads					
Thread Size and Pitch	**Thread Length-Inch**	**Cummins® Part Number**	**Heli-Coil™ Part Number**	**Perma-Thread™ Part Number**	**Coil Thread Part Number**
3/8-24	1.125	672125-E	1191-6CN-1125	208F6-1125	TNF-6C-1125
7/16-14	0.656	67234-A	1185-7CN-0656	208C7-0656	TNC-7C-0656
7/16-14	0.875	67234-B	1185-7CN-0875	208C7-0875	TNC-7C-0875
7/16-14	1.094	67234-C	1185-7CN-1094	208C7-1094	TNC-C7-1094
7/16-14	1.312	67234-D	1185-7CN-1312	208C7-1312	TNC-7C-1312
1/2-13	0.750	67183-A	1185-8CN-0750	208C8-0750	TNC-8C-0750
1/2-13	1.000	67183-B	1185-8CN-1000	208-C8-1000	TNC-8C-1000
1/2-13	1.250	37183-C	1185-8CN-1250	208C8-1250	TNC-8C-1250
1/2-13	1.500	67183-D	1185-8CN-1500	208C8-1500	TNC-8C-1500
9/16-18	1.125	69070	1191-9CN-1125	208F9-1125	TNF-9C-1125
5/8-11	0.875	101541	1185-10CN-0875	208C10-0875	
5/8-11	1.250	101540	1185-10CN-1250	208C10-1250	TNC-10C-0938
5/8-18	0.938	163398	1191-10CN-0938	208F10-0938	TNF-10C-0938
3/4-10	1.125	101542	1185-12CN-1125	208C12-1125	TNC-12C-1125
3/4-16	1.500	132672	1191-12CN-1500	208C12-1500	TNF-12C-1500
7/8-14	0.875	100292	1191-14CN-0875	208F14-0875	TNF-14C-0875
7/8-14	1.312	100854	1191-14CN-1312	208F14-1312	TNF-14C-1312
1-8	0.680	200845	389-16CN-0680	1328-16-0680	
1-1/8-7	2.250	102588	1185-18CN-2250	208C18-2250	TNC-18C-2250

Drill Size and "Plug" Tap Part Numbers - Unified Threads					
Nominal Thread Size and Pitch	**Tap Drill Size - Inch** **Aluminum**	**Cast Iron**	**Heli-Coil™ Part Number**	**Coil Thread Part Number**	**Perma-Thread™ Part Number**
1/4-20	H [0.2660]	H [0.2660]	4CPA H3	CTC-4SRP-H3	1043-4CP2-H3
5/16-18	Q [0.3320]	Q [0.3320]	5CPA H4	CTC-5SRP-H4	1043-5CP2-H4
5/16-24	21/64 [0.3281]	21/64 [0.3281]	5FPA H2	CTF-5SRP-H3	1043-5FP2-H3
3/8-16	X [0.3970]	X [0.3970]	6CPA H4	CTC-6SRP-H4	1043-6CP2-H4
3/8-24	25/64 [0.3906]	25/64 [0.3906]	6FPA H3	CTF-6SRP-H3	1043-6FP2-H3
7/16-14	29/64 [0.4531]	29/64 [0.4531]	7CPA H4	CTC-7SRP-H4	1043-7CP2-H4
1/2-13	33/64 [0.5156]	29/64 [0.5312]	8CPA H4	CTC-8SRP-H4	1043-8CP2-H4
9/16-18	37/64 [0.5781]	37/64 [0.5781]	18193-9 H4	CTF-9SRP-H4	1043-9FP2-H4
5/8-11	21/32 [0.6562]	21/32 [0.6562]	18187-10 H4	CTC-10SRP-H4	1043-10CP2-H4
5/8-18	41/64 [0.7656]	41/64 [0.7656]	18193-10 H4	CTC-10SRP-H4	1043-10CP2-H4
3/4-10	25/32 [0.7812]	25/32 [0.7812]	18187-12 H5	CTC-12SRP-H5	1043-12CP2-H5
3/4-16	49/64 [0.7656]	49/64 [0.7656]	18193-12 h4	CTF-12SRP-H4	1043-12FP2-H4
7/8-14	57/64 [0.8906]	49/64 [0.8906]	18193-14 H4	CTF-14SRP-H4	1043-14FP2-H4
1-8	1-1/32 [1.0312]	1-1/32 [1.0312]	18187-16 H6	CTC-16SRP-H6	1043-16CP2-H6
1-1/8-7	1-11/64 [1.1719]	1-11/64 [1.1719]	18187-18 H6	CTC-18SRP-H6*	1043-18CP2-H6*

* These taps are for aluminum and magnesium metals **only**.

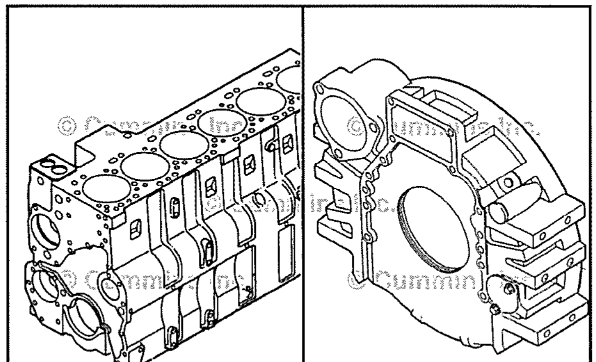
Note: All taps are class 2B unless otherwise specified.

Drill Size and Bottom Tap Part Numbers - Unified Threads					
Nominal Thread Size and Pitch	**Tap Drill Size - Inch** **Aluminum**	**Cast Iron**	**Heli-Coil™ Part Number**	**Coil Thread Part Number**	**Perma-Thread™ Part Number**
1/4-20	H [0.2660]	H [0.2660]	4CBA H3	CTC-4SRB-H3	1043-4CB2-H3
5/16-18	Q [0.3320]	Q [0.3320]	5CBA H4	CTC-5SRB-H4	1043-5CB2-H4

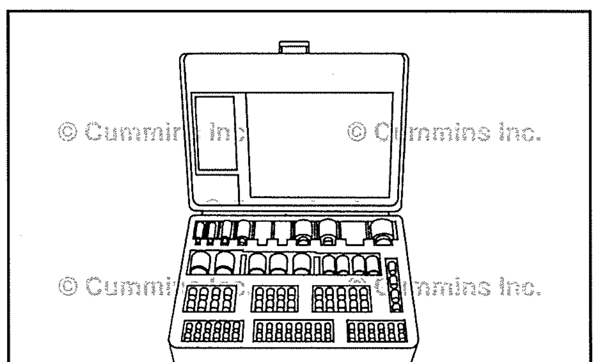
Drill Size and Bottom Tap Part Numbers - Unified Threads					
Nominal Thread Size and Pitch	**Tap Drill Size - Inch** **Aluminum**	**Cast Iron**	**Heli-Coil™ Part Number**	**Coil Thread Part Number**	**Perma-Thread™ Part Number**
5/16-24	21/64 [0.3281]	21/64 [0.3281]	5FBA H2	CTF-5SRB-H3	1043-5FB2-H3
3/8-16	X [0.3970]	X [0.3970]	6CBA H4	CTC-6SRB-H4	1043-6CB2-H4
3/8-24	25/64 [0.3906]	25/64 [0.3906]	6FBA H3	CTF-6SRB-H3	1043-6FB2-H3
7/16-14	29/64 [0.4531]	29/64 [0.4531]	7CBA H4	CTC-7SRB-H4	1043-7CB2-H4
1/2-13	33/64 [0.5156]	29/64 [0.5312]	8CBA H4	CTC-8SRB-H4	1043-8CB2-H4
9/16-18	37/64 [0.5781]	37/64 [0.5781]	20193-9 H4	CTF-9SRB-H4	1043-9FB2-H4
5/8-11	21/32 [0.6562]	21/32 [0.6562]	20187-10 H4	CTC-10SRB-H4	1043-10CB2-H4
5/8-18	41/64 [0.7656]	41/64 [0.7656]	20193-10 H4	CTC-10SRB-H4	1043-10CB2-H4
3/4-10	25/32 [0.7812]	25/32 [0.7812]	20187-12 H5	CTC-12SRB-H5	1043-12CB2-H5
3/4-16	49/64 [0.7656]	49/64 [0.7656]	20193-12 h4	CTF-12SRB-H4	1043-12FB2-H4
7/8-14	57/64 [0.8906]	49/64 [0.8906]	20193-14 H4	CTF-14SRB-H4	1043-14FB2-H4
1-8	1-1/32 [1.0312]	1-1/32 [1.0312]	20187-16 H6	CTC-16SRB-H6	1043-16CB2-H6
1-1/8-7	1-11/64 [1.1719]	1-11/64 [1.1719]	20187-18 H6	CTC-18SRB-H6*	1043-18CB2-H6*
* These taps are for aluminum and magnesium metals **only**. **Note:** All taps are class 2B unless otherwise specified.					

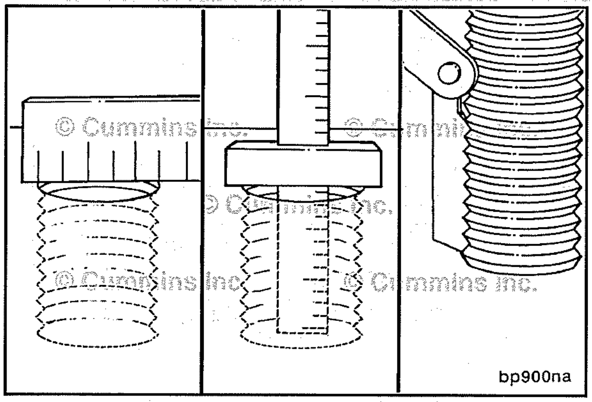
NOTE: This section of the procedure provides guidelines for using keylock inserts.

Keylock inserts can be used to repair threads in cast iron, steel, and aluminum components.

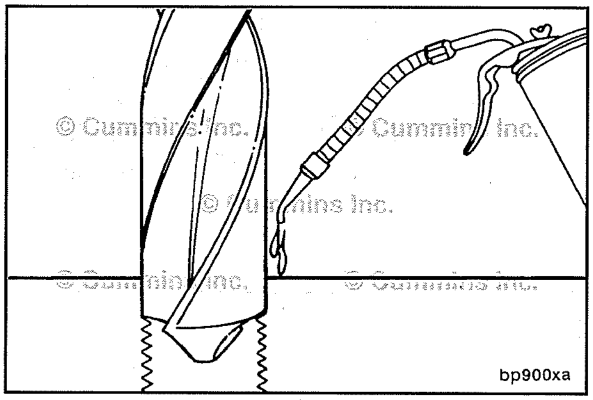

ck9isva

Thread repair kit, Part Number 3375021, contains keylock inserts. The inserts are internally and externally threaded metallic cylinders which have captive locking keys. The keys prevent the insert from rotating after it has been installed.


bp9toga



Determine the diameter, depth, and pitch of the original threaded hole.

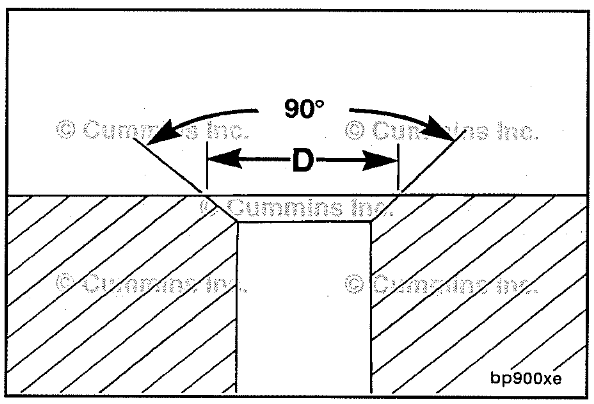


WARNING

To reduce the possibility of personal injury, always wear protective goggles when drilling metal.

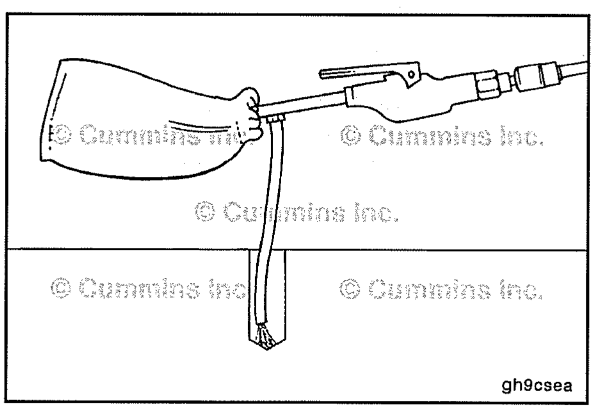
Use cutting oil while drilling the capscrew hole to the specified diameter. Use the charts in this procedure for drill size diameter specifications. Drill to the bottom of blind capscrew holes.

NOTE: The drill must be in proper alignment when drilling the capscrew hole.



Countersink the hole to the diameter specified on the chart. The correct angle is 82 to 100 degrees.

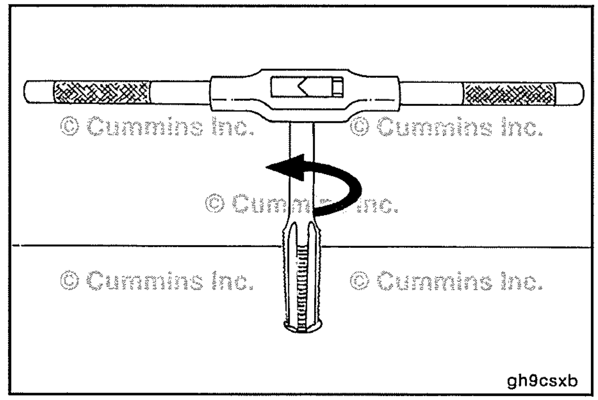
NOTE: Use cutting oil when countersinking the capscrew hole.



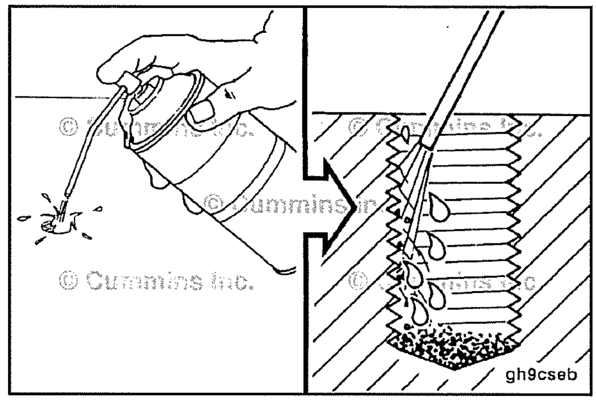
Use chip removal unit, Part Number 3164019, to remove any debris from the hole.

Use cutting oil to tap the hole to the correct diameter, pitch, and depth.

Tap size and depth information is included at the end of this procedure.



Use a spray cleaner to clean the oil from the capscrew hole and flush the newly cut threads.

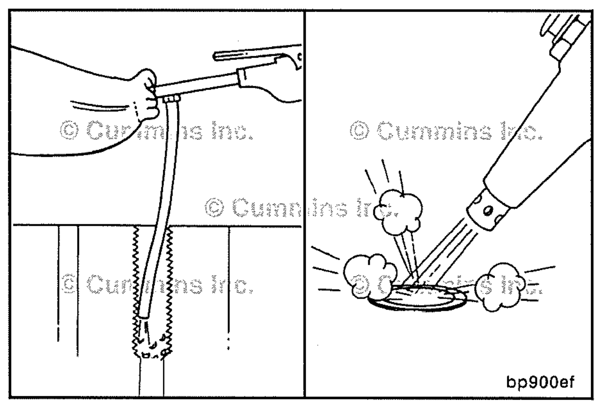


⚠ WARNING ⚠

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

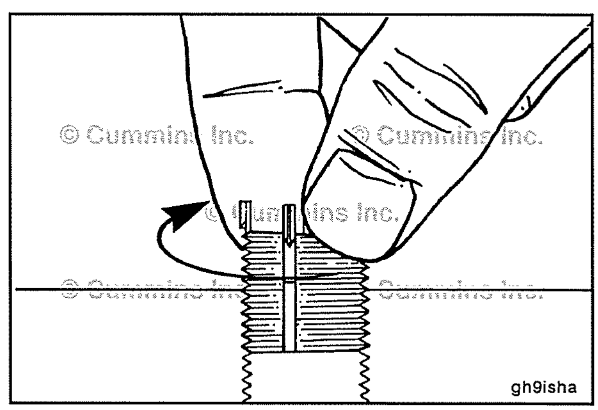
Use chip removal unit, Part Number 3164019, to remove any debris from the hole.

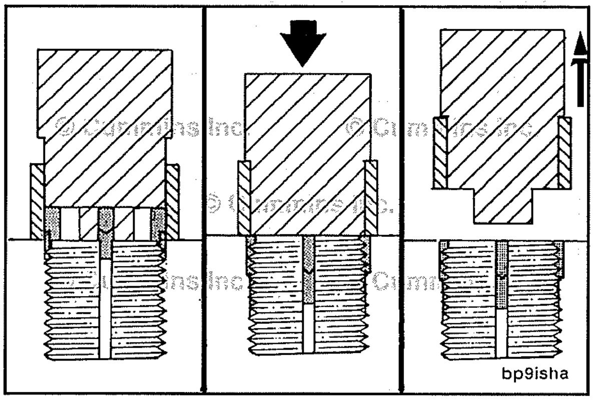
Dry the threads with compressed air.



Install the insert into the prepared hole.

Turn the insert **clockwise** until the insert stops at the specified depth.





Put the staking tool over the insert. Slide the sleeve of the tool over the keys.

Use a hammer to strike the installation tool until the keys are driven down to their full depth.

Remove the tool.

The repair is now complete.

Keylock Thread Inserts - Unified Threads							
Cummins® Part Number	**Internal Thread Size Class 2B**	**Tap Drill Size - Inch**	**Tap Size - Inch Class 2B**	**Installation Tool Part Number**	**Minimum Tap Depth - Inch**	**Countersink Diameter - Inch**	**Overall Length - Inch**
3375141	1/4-20	0.332	3/8-16	3375142	0.43	0.385	0.37
3375022	5/16-18	0.397	7/16-14	3375023	0.50	0.447	0.43
3375430	5/16-18 (Heavy Duty)	0.453	1/2-13	3375026	0.56	0.510	0.43
3375024	3/8-16	0.453	1/2-13	3375026	0.56	0.510	0.50
3375025	3/8-24	0.453	1/2-13	3375026	0.56	0.510	0.50
3375027	7/16-14	0.516	9/16-12	3375029	0.62	0.572	0.56
3375028	7/16-20	0.516	9/16-12	3375029	0.62	0.572	0.56
3375030	1/2-13	0.578	5/8-11	3375032	0.68	0.635	0.62
3375031	1/2-20	0.578	5/8-11	3375032	0.68	0.635	0.62
3375143	5/8-11	0.766	13/16-16	3375034	0.87	0.822	0.81
3375033	5/8-18	0.766	13/16-16	3375034	0.87	0.822	0.81
3375035	3/4-16	1.062	1-1/8-12	3375036	1.18	1.145	1.12
3375037	1-18	1.312	1-3/8-12	3375038	1.56	1.395	1.37

Keylock Thread Inserts - Tridair Keenserts™ - Unified Threads							
Part Number	**Internal Thread Size Class 2B**	**External Thread Size Class 2A**	**Length Inch**	**Tap Drill Diameter**	**Countersink Diameter**	**Tap Size Class 2 B**	**Insert Tool Part Number**
RKKA 1/4-20	1/4-20	3/8-16	0.37	"Q"	0.38	3/8-16	TRKA 1/4
RKKA 5/16-18	5/16-18	7/16-14	0.43	"X"	0.44	7/16-14	TRKA 5/16
RKK 5/16-18 (Heavy Duty)	5/16-18	1/2-13	0.43	29/64	0.51	1/2-13	TRK 5/16
RKKA 3/8-16	3/8-16	1/2-13	0.50	29/64	0.51	1/2-13	TRKA 3/8
RKKA 3/8-24	3/8-24	1/2-13	0.50	29/64	0.51	1/2-13	TRKA 3/8
RKKA 7/16-14	7/16-14	9/16-12	0.56	33/64	0.57	9/16-12	TRKA 7/16
RKKA 7/16-20	7/16-20	9/16-12	0.56	33/64	0.57	9/16-12	TRKA 7/16
RKKA 1/2-13	1/2-13	5/8-11	0.62	37/64	0.63	5/8-11	TRKA 1/2
RKKA 1/2-20	1/2-20	5/8-11	0.62	37/64	0.63	5/8-11	TRKA 1/2
RKK 5/8-11	5/8-11	7/8-14	0.87	53/64	0.88	7/8-14	TRK 5/8
RKK 5/8-18	5/8-18	7/8-14	0.87	53/64	0.88	7/8-14	TRK 5/8
RKK 3/4-10	3/4-10	1-1/8-12	1.12	1-1/16	1.14	1-1/8-12	TRK 3/4
RKK 3/4-16	3/4-16	1-1/8-12	1.12	1-1/16	1.14	1-1/8-12	TRK 3/4

Keylock Thread Inserts - Tridair Keenserts™ - Metric Threads							
Part Number	**Internal Thread Size**	**External Thread Size**	**Length - mm**	**Tap Drill Diameter**	**Countersink Diameter**	**Tap Size**	**Insert Tool Part Number**
KNM 6x1F	M6 x 1.0	M10 x 1.25	10	8.8	10.25	M10 x 1.25	TRKM 6
KNM 8x1.25F	M8 x 1.25	M12 x 1.25	12	10.8	12.25	M12 x 1.25	TRKM 8
KNM 10x1.5F	M10 x 1.50	M14 x 1.5	14	12.8	14.25	M14 x 1.5	TRKM 10
KNM 12x1.75F	M12 x 1.75	M16 x 1.5	16	14.75	16.25	M16 x 1.5	TRKM 12

Keylock Thread Inserts - Tridair Keenserts™ - Metric Threads							
Part Number	**Internal Thread Size**	**External Thread Size**	**Length - mm**	**Tap Drill Diameter**	**Countersink Diameter**	**Tap Size**	**Insert Tool Part Number**
KNHM 14x2F	M14 x 2.0	M20 x 1.5	20	18.75	20.25	M20 x 1.5	TRKHM 14

Keylock Thread Inserts - Microdot K-Serts - Unified Threads							
Part Number	**Internal Thread Size Class 2B**	**External Thread Size Class 2A**	**Length - inch**	**Tap Crill Diameter**	**Countersink Diameter**	**Tap Size Class 2 B**	**Insert Tool Part Number**
K51240-420	1/4-20	3/8-16	0.37	0.331-0.336	0.39	3/8-16	KT151240-4
K51240-518	5/16-18	7/16-14	0.43	0.376-0.401	0.45	7/16-14	KT151240-5
K51241-518 (Heavy Duty)	5/16-18	1/2-13	0.43	29/64	0.51	1/2-13	KT151241-5
K51240-616	3/8-16	1/2-13	0.50	29/64	0.51	1/2-13	KT151240-6
K51240-6	3/8-24	1/2-13	0.50	29/64	0.51	1/2-13	KT151240-6
K51240-714	7/16-14	9/16-12	0.56	33/64	0.57	9/16-12	KT51240-7
K51240-7	7/16-20	9/16-12	0.56	33/64	0.57	9/16-12	KT51240-7
K51240-813	1/2-13	5/8-11	0.62	37/64	0.64	5/8-11	KT51240-8
K51240-8	1/2-20	5/8-11	0.62	37/64	0.64	5/8-11	KT51240-8
K51241-1011	5/8-11	7/8-14	0.87	53/64	0.89	7/8-14	KT51241-10
K51241-10	5/8-18	7/8-14	0.87	53/64	0.89	7/8-14	KT51241-10
K51241-1210	3/4-10	1-1/8-12	1.12	1-1/16	1.15	1-18-12	KT51241-12
K51241-12	3/4-16	1-1/8-12	1.12	1-1/16	1.15	1-1/8-12	KT51241-12

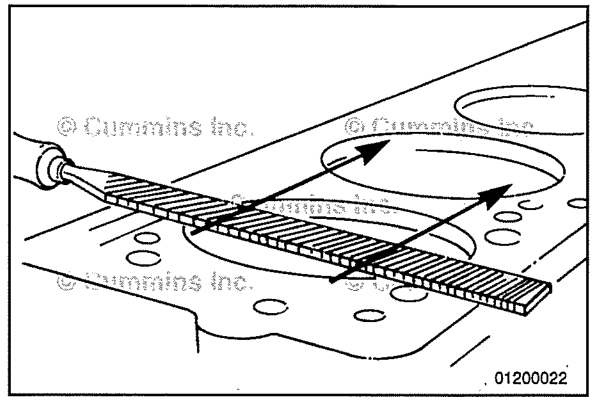
Keylock Thread Inserts - Microdot K-serts - Metric Threads							
Part Number	**Internal Thread Size**	**External Thread Size**	**Length - mm**	**Tap Drill Diameter**	**Countersink Diameter**	**Tap Size**	**Insert Tool Part Number**
KM9900-060	M6 x 1.00	M10 x 1.25	10.0	8.8	10.25	M10 x 1.25	KTM9000-060
KM9900-080	M8 x 1.25	M12 x 1.25	12.0	10.8	12.25	M12 x 1.25	KTM9000-080
KM9900-100	M10 x 1.50	M14 x 1.50	14.0	12.8	14.25	M14 x 1.50	KTM9000-100
KM9900-120	M12 x 1.75	M16 x 1.50	16.0	14.75	16.25	M16 x 1.50	KTM9000-120
KHM9900-140	M14 x 2.00	M20 x 1.50	20.0	18.75	20.25	M20 x 1.50	KHTM9000-140
KHM9900-160	M16 x 2.00	M22 x 1.50	22.0	20.50	22.25	M22 x 1.50	KHTM9000-160

NOTE: This section of the procedure is for Open End Thread Repair Inserts.

This procedure describes the method recommended for repairing damaged metric threads. Installing metric open end thread repair inserts is an approved method for warranty repairs and can be performed without removing the engine from the chassis. Use care to prevent contaminants from entering the engine during this process.

Inspect the area around the threaded hole that is to be repaired.

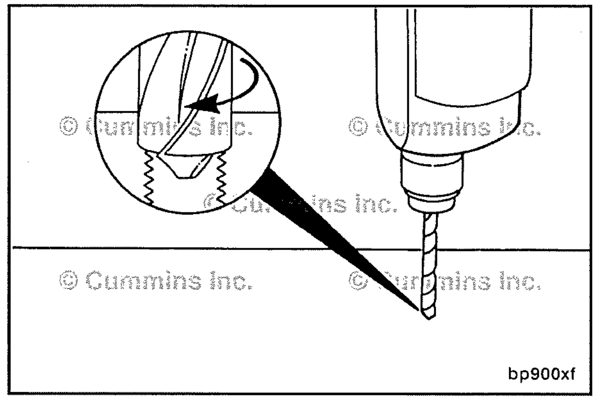
Remove any burrs from the surface. A flat mill file is very effective for this process. Burr removal is necessary so an accurate fixture location can be obtained.



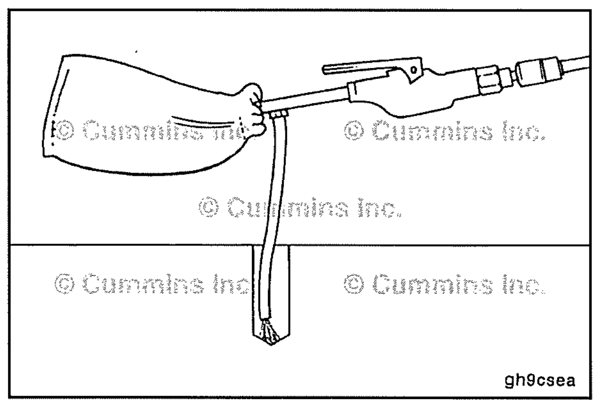
WARNING

To reduce the possibility of personal injury, always wear protective goggles when drilling metal.

Use cutting oil when drilling the damaged threads to the specified diameter and depth dimensions for the specified repair insert. A listing of installation requirements is included in this procedure.

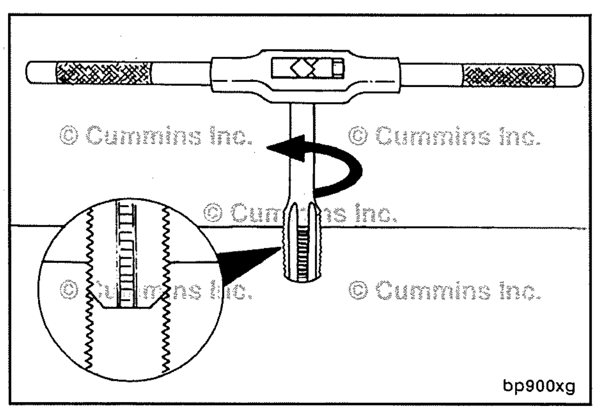


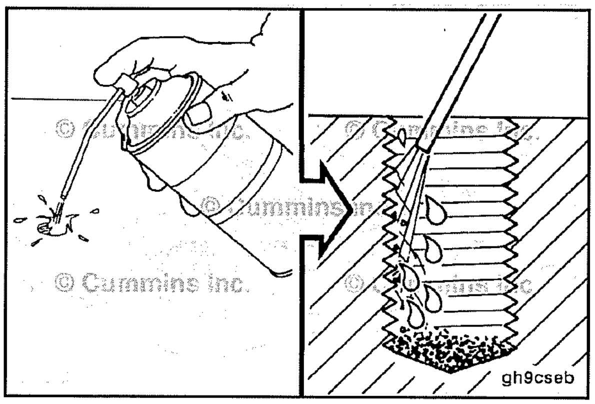
Use chip removal unit, Part Number 3164019, to remove any debris from the hole.



Use cutting oil. Tap the hole for the repair insert. The correct thread depth will allow the insert to be installed 0.0 to 0.25 mm [0.00 to 0.010 in] below the surface of the component.

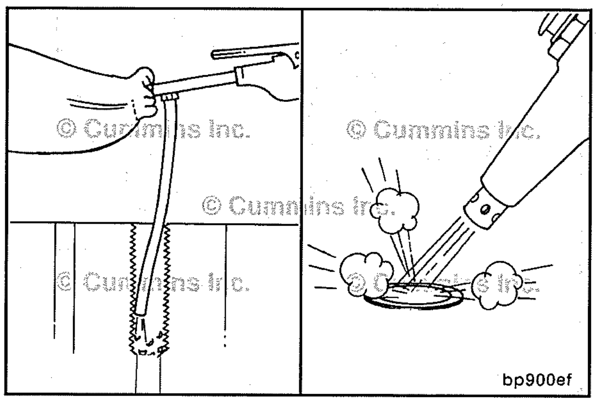
Measure the insert and compare the measurement to the data sheet contained in this procedure for insert length specifications.





Use a spray cleaner to clean the oil from the capscrew hole.

Flush the newly cut threads.

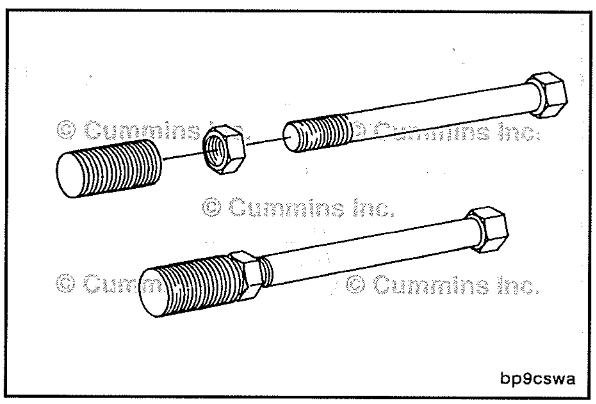


⚠WARNING⚠

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

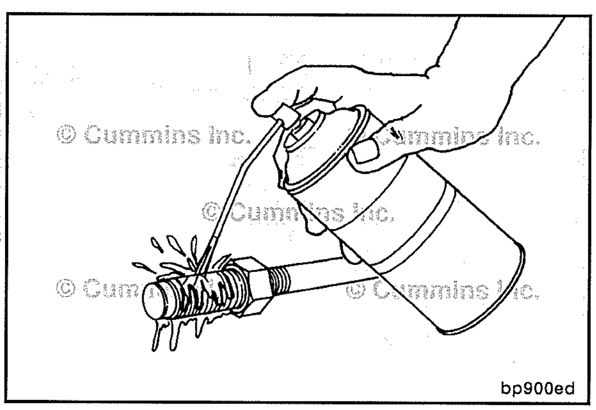
Use chip removal unit, Part Number 3164019, to remove any debris from the hole.

Dry the threads with compressed air.



Obtain a capscrew and nut with the same size threads as the insert inside diameter.

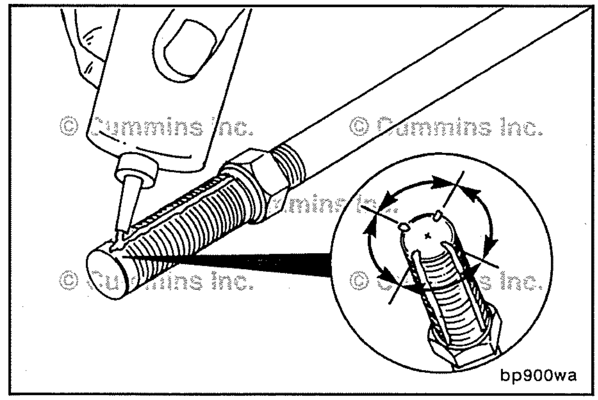
Install the nut and insert on the capscrew.



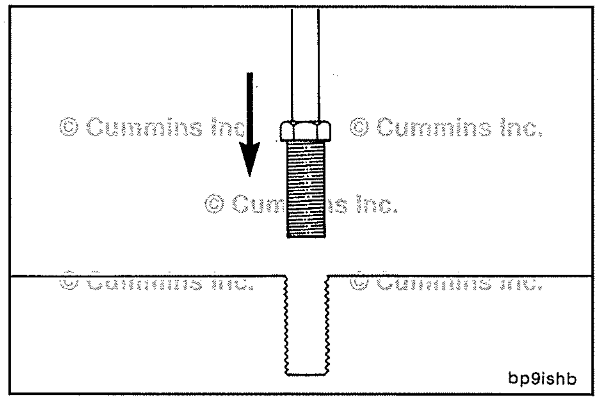
Use a spray cleaner to remove the preservative coating from the outside diameter of the insert.

Apply four beads of sealant, Part Number 3375068, to the outside diameter of the insert.

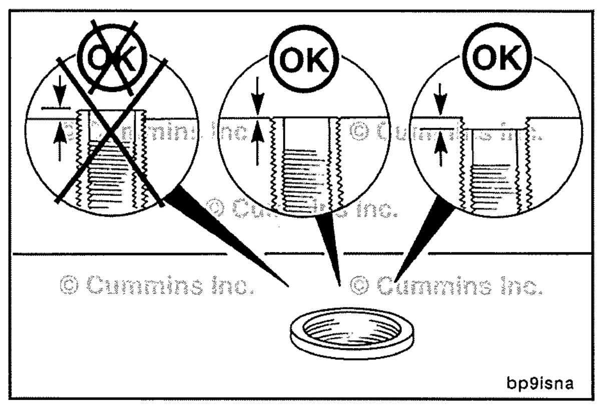
NOTE: The beads of sealant must be about 0.8 mm [1/32 in] wide and spaced 90 degrees from each other.



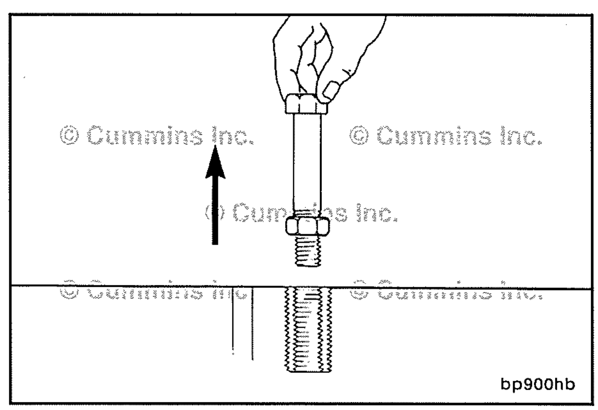
Install the repair insert.

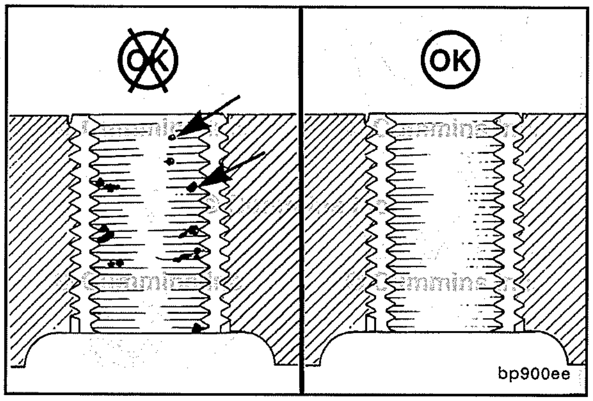


The insert **must** be 0.0 to 0.25 mm [0.00 to 0.010 in] below the surface.

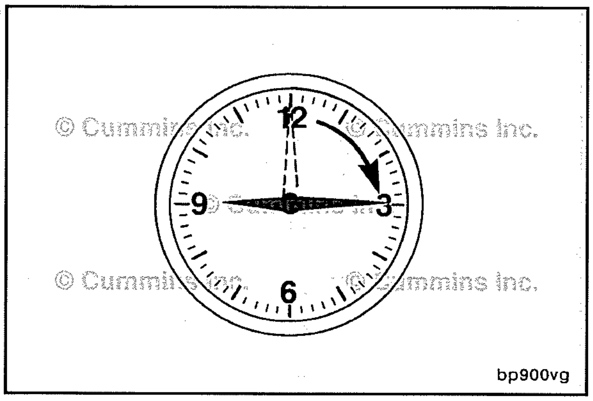


Loosen the nut and remove the capscrew.





Make sure the inside portion of the repair insert is clean. Remove any file shavings or debris.



Allow the sealant to cure for 15 minutes before use.

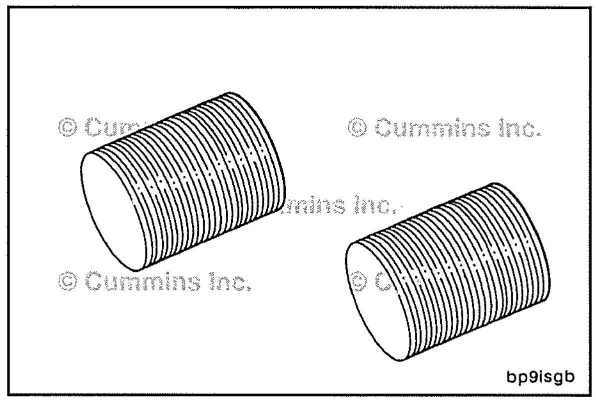
Reference Data and Functional Checklist				
Cummins® Part Number	Internal Thread (Size it repairs)	Overall Length - mm	Tap Drill Diameter - mm	External Thread (Tap Size)
3376701	M6 x 1.00-6H	12.0	8.8	M10 x 1.25-6g
3376702	M8 x 1.25-6H	12.0	10.8	M12 x 1.25-6g
3376703	M8 x 1.25-6H	17.0	10.8	M12 x 1.25-6g
3376704	M8 x 1.25-6H	20.0	10.8	M12 x 1.25-6g
3376705	M10 x 1.50-6H	08.0	12.8	M14 x 1.50-6g
3376706	M10 x 1.50-6H	12.5	12.8	M14 x 1.50-6g
3376707	M10 x 1.50-6H	14.0	12.8	M14 x 1.50-6g
3376709	M10 x 1.50-6H	18.0	12.8	M14 x 1.50-6g
3376710	M10 x 1.50-6H	20.0	12.8	M14 x 1.50-6g
3376711	M10 x 1.50-6H	24.0	12.8	M14 x 1.50-6g
3376712	M12 x 1.25-6H	08.0	14.75	M16 x 1.50-6g
3376713	M12 x 1.75-6H	08.0	14.75	M16 x 1.50-6g
3376714	M12 x 1.75-6H	21.0	14.75	M16 x 1.50-6g
3376715	M14 x 2.00-6H	30.0	16.5	M18 x 1.50-6g
3376716	M16 x 2.00-6H	30.0	18.0	M20 x 2.00-06g

NOTE: This part of this procedure applies to Closed End "Blind" Inserts.

This part of the procedure provides the instructions for installing closed end "blind" inserts.

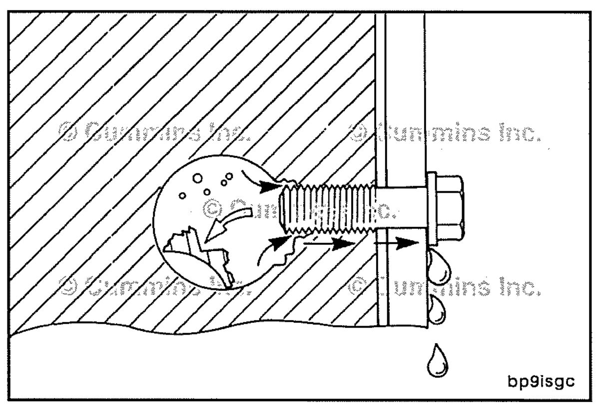
The charts contained in this procedure list the two types of blind inserts.

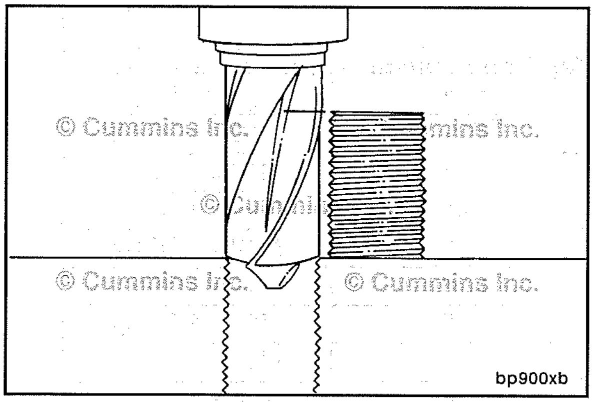
- SAE internal and external threads
- Metric internal with SAE external threads.



Closed end inserts are generally used in cases where the bottom or side of a hole has been pierced. They can be used to repair any kind of hole or thread, if desired.

NOTE: Closed end inserts can not be used to repair top deck cracks that run into cylinder head capscrew holes.

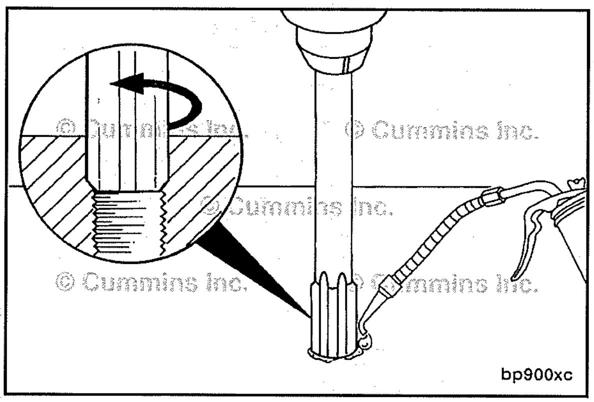




Obtain the required reamer or drill size for the hole to be repaired. Use the charts contained in this procedure for size specifications. Install it in the drill.

Set the drill depth by placing the insert to be installed between the top of the hole and the drill chuck.

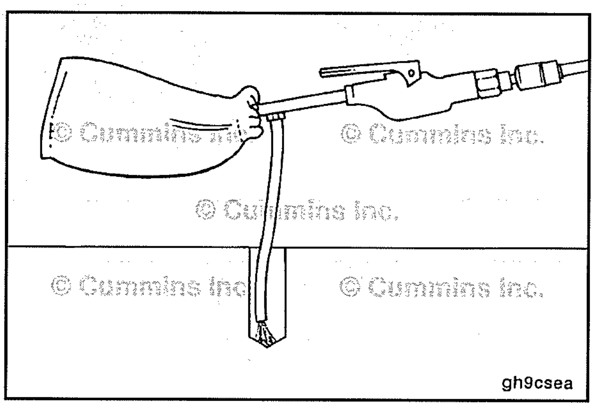
NOTE: If the drill is too long, make a mark on the drill bit to indicate the correct depth.



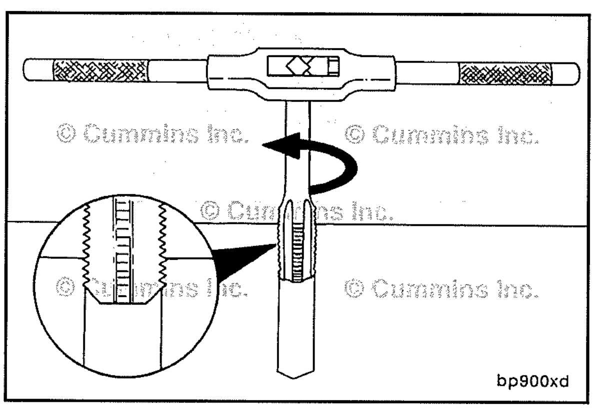
WARNING
To reduce the possibility of personal injury, always wear protective goggles when drilling metal.

Use cutting oil. Drill or ream the hole to the proper depth.

NOTE: In some cases when using a drill, the proper depth will pierce the bottom of the hole.



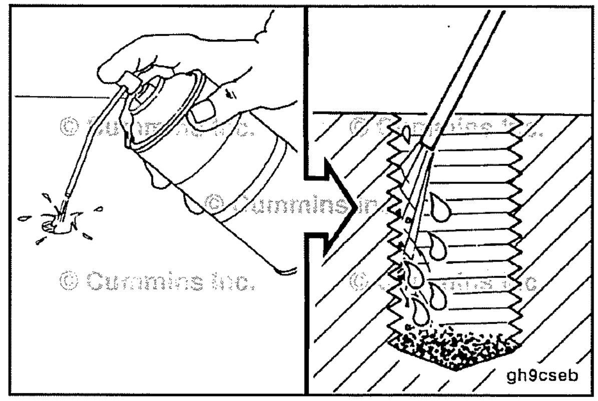
Use chip removing unit, Part Number 3164019, to remove machining chips from the capscrew hole.



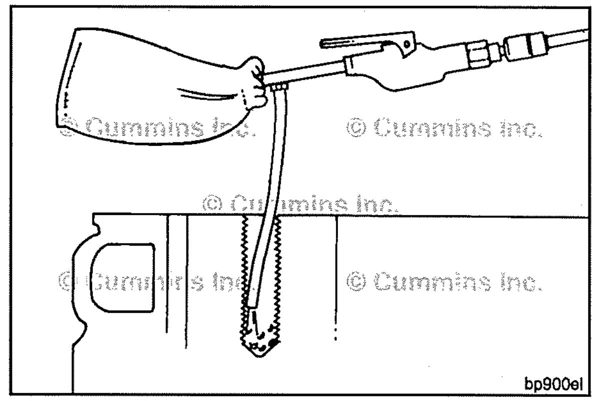
Use cutting oil. Tap the hole to the required depth. Use the charts contained in this procedure for tap sizes.

NOTE: The correct depth will allow the insert to be installed flush, to slightly below the surface.

Use a spray cleaner to remove the oil film and clean the newly cut threads.



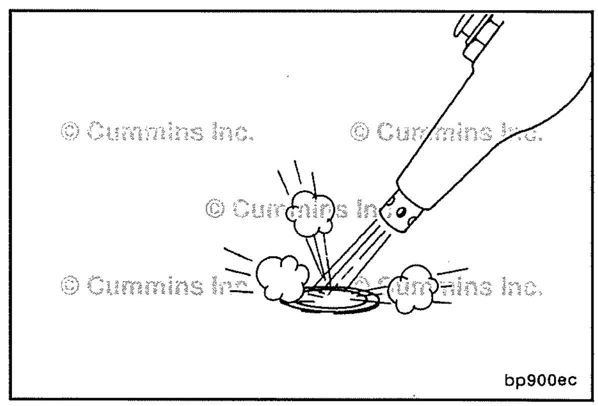
Use chip removal unit, Part Number 3164019, to remove any debris from the hole.



WARNING

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

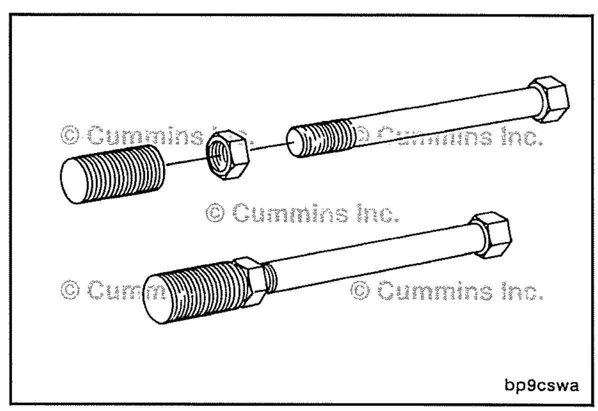
Use compressed air to dry the threads.

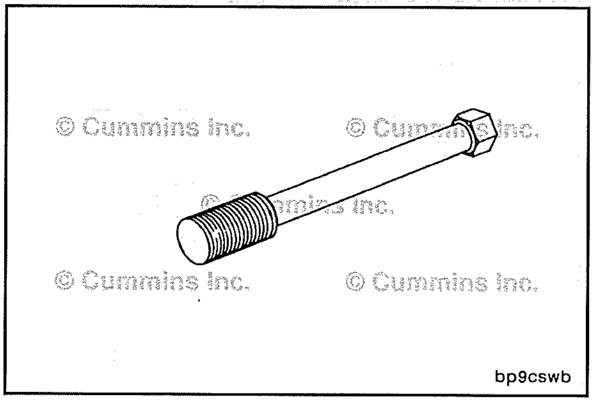


Obtain a capscrew and nut with the same size threads as the insert inside diameter.

Install the nut first, then the insert on the capscrew.

NOTE: The nut should have a straight shoulder which, when installed against the insert, will allow the insert to be installed slightly below the surface.

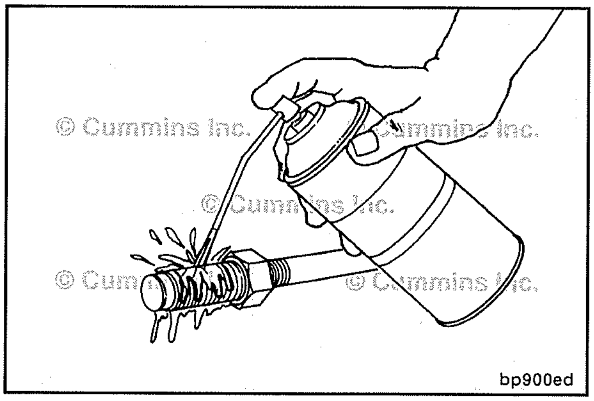




bp9cswb

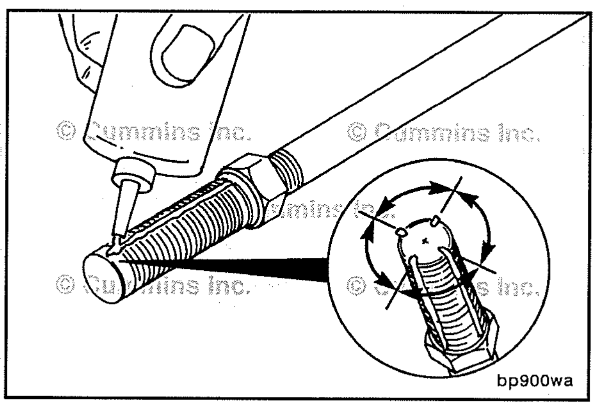
If a nut is **not** available, it is acceptable to bottom the capscrew out in the insert for installation.

NOTE: This type installation will require time for the sealant to set up before removing the capscrew from the thread insert.



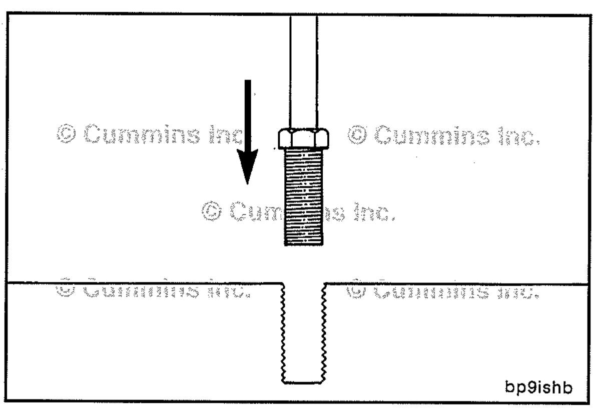
bp900ed

Use a spray cleaner to remove the preservative coating from the outside diameter of the insert.



bp900wa

Apply four beads of sealant, Part Number 3375068, to the outside diameter of the insert. The beads of sealant **must** be about 0.8 mm [1/32 inch] wide and spaced 90 degrees from each other.

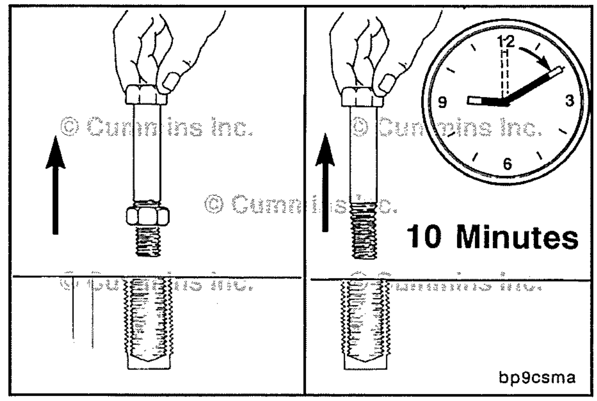


bp9ishb

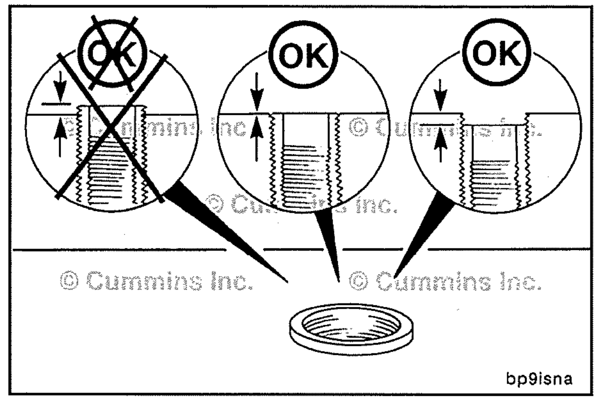
Install the repair insert.

Loosen the nut and remove the capscrew.

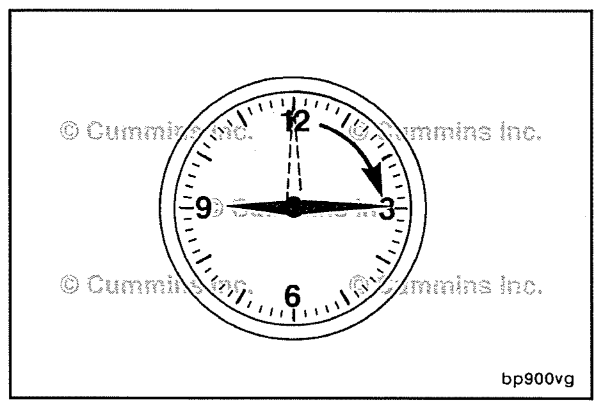
NOTE: If a capscrew without a nut was used, allow 10 minutes for the sealant to cure before removing the capscrew.



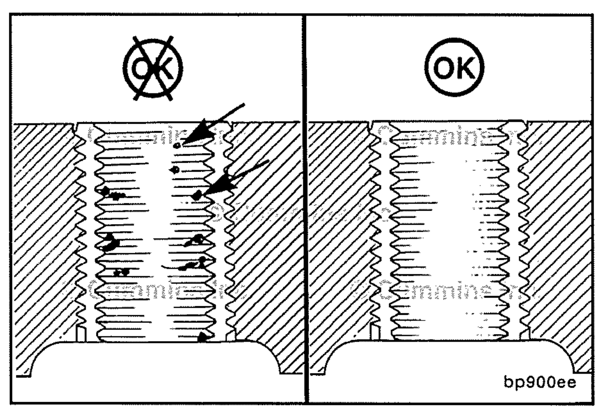
The insert should be flush to slightly below the surface.



Allow the sealant to cure for 15 minutes before use.

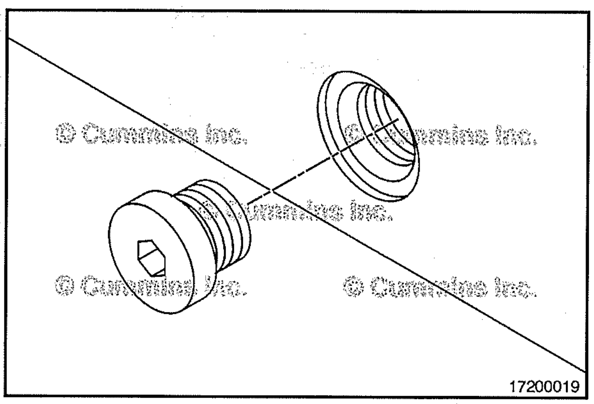


Clean the insert threads to remove any debris.



Closed End Inserts - SAE Internal and External Threads				
Cummins® Part Number	Internal Thread (Size it repairs) Class 2B	External Threads (Tap Size) Class 2B	Tap Drill (Reamer) Diameter - Inch	Nominal Overall Length - Inch
3376437	1/4-20 UNC	3/8-16 UNC	0.332	0.750
3376438	5/16-18 UNC	7/16-14 UNC	0.397	0.930
3376439	3/8-16 UNC	1/2-13 UNC	0.453	1.130
3376440	3/8-24 UNF	1/2-13 UNC	0.453	1.070
3376441	7/16-14 UNC	9/16-12 UNC	0.516	1.150
3376442	7/16-20 UNF	9/16-12 UNC	0.516	1.210
3376443	1/2-13 UNC	5/8-11 UNC	0.578	1.510
3376446	1/2-20 UNF	5/8-11 UNC	0.578	1.190
3376444	5/8-11 UNC	13/16-16 UNC	0.766	1.640
3376445	5/8-18 UNF	13/16-16 UNC	0.766	1.360
3376447	9/16-18 UNF	11/16-11 UNC	0.641	1.180

Closed End Inserts - Metric Internal Threads, SAE External Threads (3822709 KIT)				
Cummins® Part Number	Internal Thread (Size it repairs)	External Threads (Tap Size) Class 2B	Tap Drill (Reamer) Daimeter - Inch	Nominal Overall Length - Inch
3822698	M 6X 1.0-6H	3/8-16 UNC	0.3125	0.75
3822699	M 8X 1.25-6H	1/2-13 UNC	0.421	0.94
3822700	M 10X 1.50-6H	9/16-12 UNC	0.484	1.12
3822701	M 12X 1.25-6H	5/8-18 UNF	0.578	1.37
3822702	M 12X 1.50-6H	5/8-18 UNF	0.578	1.37
3822703	M 12X 1.75-6H	5/8-18 UNF	0.578	1.37
3822704	M 14X 2.00-6H	3/4-16 UNF	0.687	1.50
3822705	M 16X 1.50-6H	7/8-14 UNF	0.812	1.75
3822706	M 16X 2.00-6H	7/8-14 UNF	0.812	1.75



Install

Install a new o-ring on the plug. Lubricate the o-ring with clean 15W-40 oil.

Install and tighten the plugs.

Use to the following chart for torque values.

Tighten straight thread plugs to the appropriate torque value.

Straight Thread O-Ring Plugs

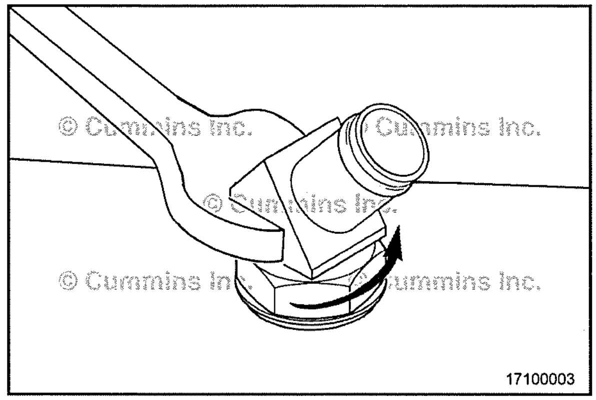
Thread Size Inches	Torque - lbf			
	N•m	In-lb	N•m	ft-lb
1/4	4	35		
3/8	6	50		
1/2	8	70		
9/16	12	105		
5/8	16	145		
3/4			20	15
7/8			35	20
1			40	30
1-1/16			45	35
1-3/16			55	40

oi203vg

Straight Thread Fittings (017-016)

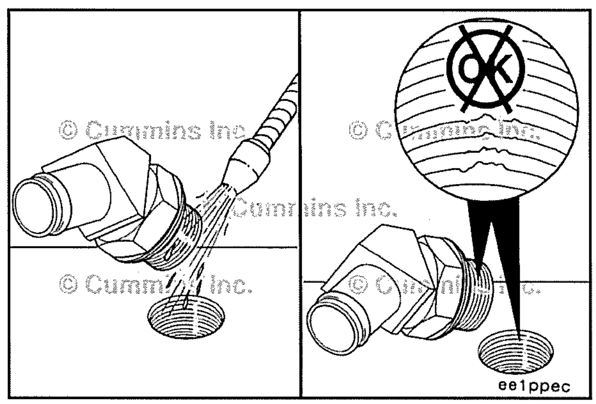
Remove

Remove the straight thread fitting.


17100003

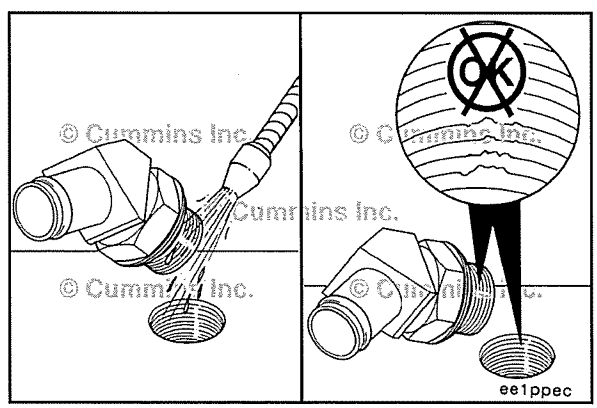
Clean and Inspect for Reuse

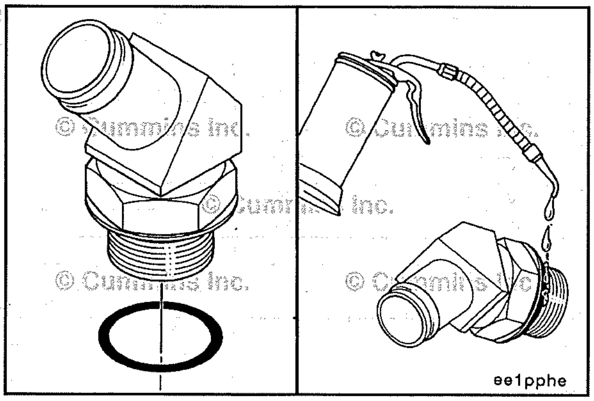
Use cleaner, Part Number 3824510 or equivalent, to clean the threads of the straight thread fittings and threaded bores.


ee1ppec

Inspect the threads of the fittings for mutilation or other damage.

Inspect the threaded bores for damage.


ee1ppec

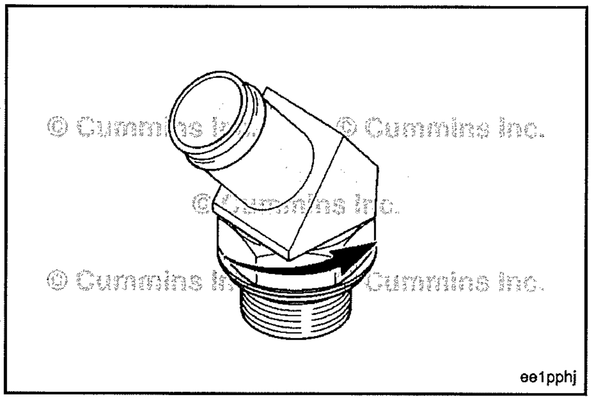


Install

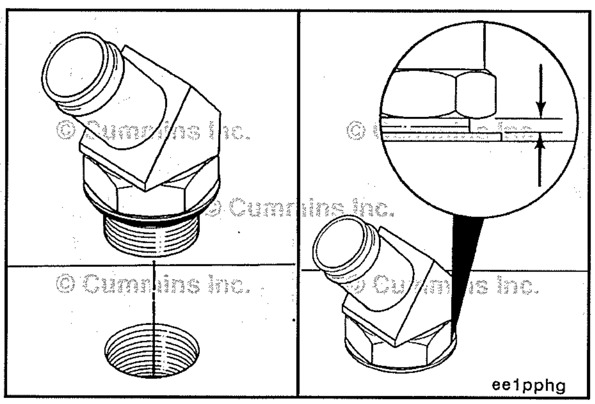
Adjustable style fittings in straight thread bosses or holes apply to all fittings (elbows, connectors, tees, check valves, etc.) that have straight threads, an o-ring, a backup washer, and a locknut.

Install a new o-ring onto the fitting.

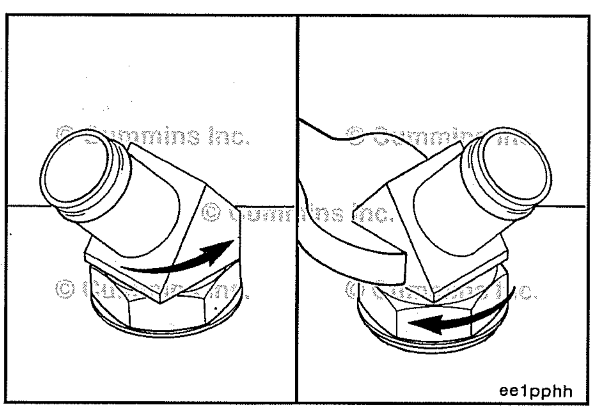
Lubricate the o-ring.



Raise the locknut, to permit the backup washer to be installed in the extreme upper end of the groove.



Install the fitting into the straight thread boss or hole to full depth, where the metal backup washer contacts the face of the boss or hole.

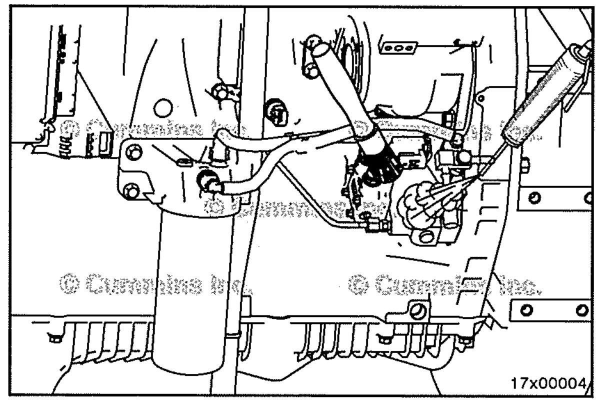


Position the fitting by turning it out **counterclockwise** up to a maximum of one turn.

Holding the pad of the fitting with a wrench, tighten the locknut and washer against the face of the boss or hole to the specified torque value. See equipment manufacturer service information for torque specifications.

Banjo Connector (017-019)

Preparatory Steps



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

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

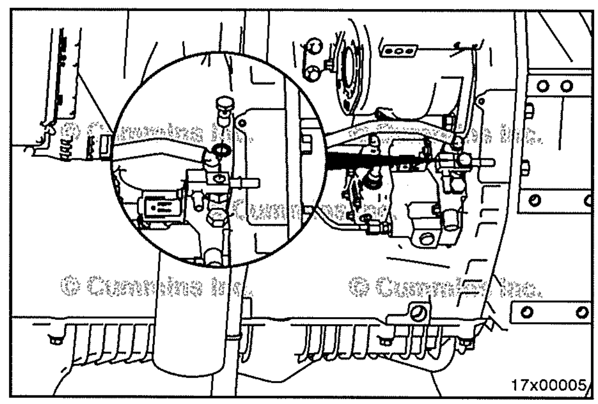
WARNING
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

CAUTION
Use a cleaning solvent that will not harm aluminum.

- Use a brush and solvent to clean the fitting, connectors, and surrounding area.
- Dry with compressed air.

Remove

Remove the banjo connector and sealing washers.



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

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

WARNING

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

CAUTION

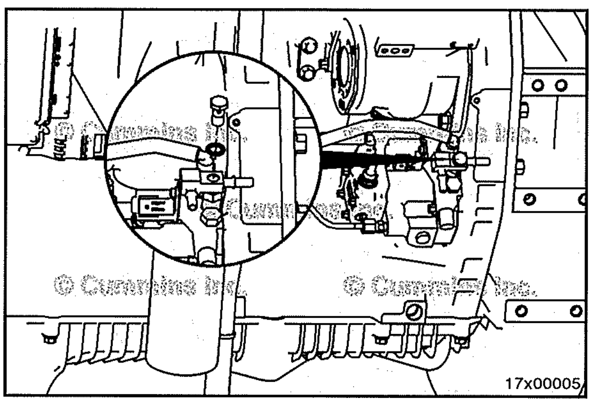
Use a cleaning solvent that will not harm aluminum.

Flush the connector with solvent.

Inspect the banjo connectors for damage to the threads.

Inspect the sealing surfaces for damage.

Inspect for blockage by debris.



Install

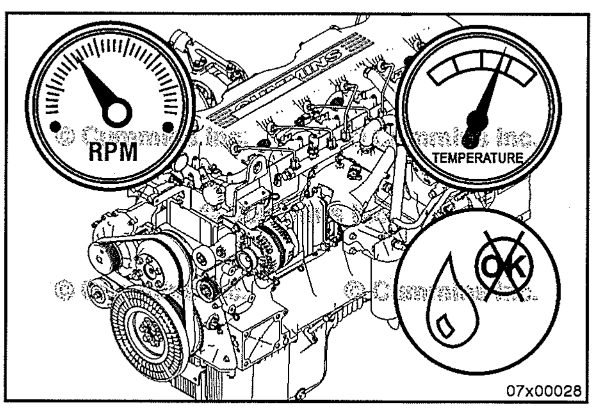
CAUTION

Hold banjo fittings while tightening the banjo bolt to prevent fitting rotation. Allowing the banjo fitting to rotate may damage the fuel line.

Install the banjo connector with two new sealing washers.

One sealing washer **must** be between the connector and fitting, and one sealing washer **must** be between the fitting and the housing.

See the appropriate service procedure for torque values.



Finishing Steps

- Operate the engine and check for leaks.

Section 19 - Electronic Controls - Group 19

Section Contents

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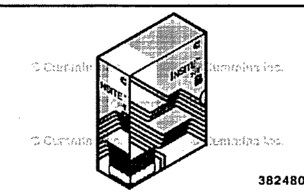
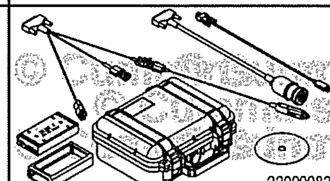
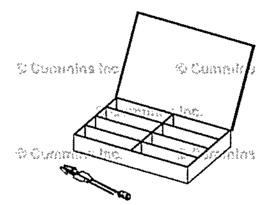
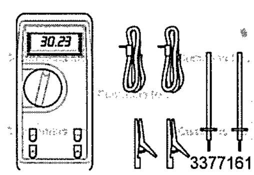
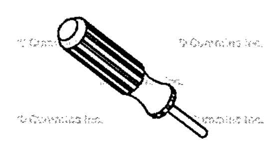
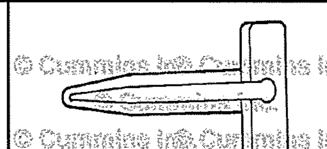
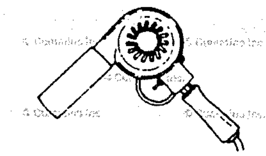
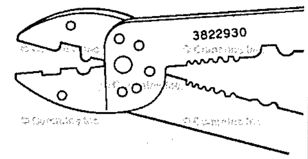
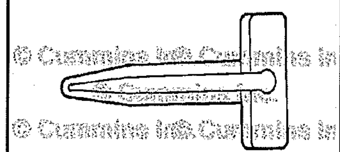
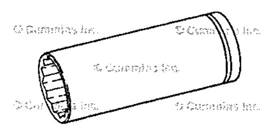
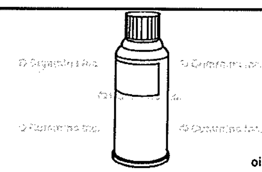
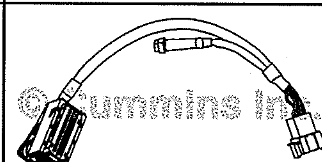
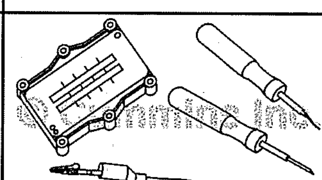
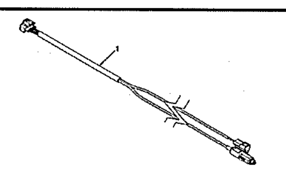
Service Tools

Electronic Engine Controls

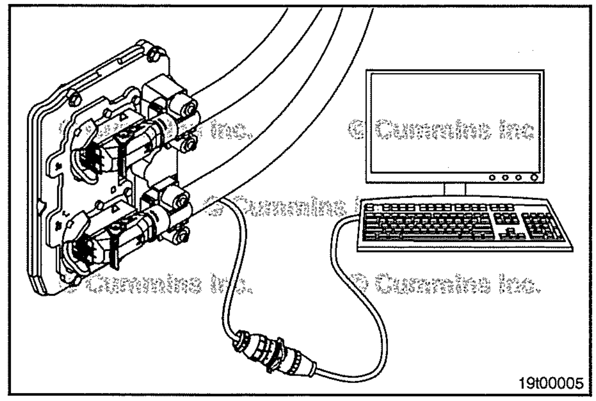
The following special tools are recommended to perform procedures in this section. The use of these tools is shown in the appropriate procedure. These tools can be purchased from a local Cummins® Authorized Repair Location.

Tool No.	Tool Description	Tool Illustration
3886388	**INSITE™ Electronic Service Tool Software Kit** Used to troubleshoot, program, and adjust engines with electronic controlled fuel systems. Refer to a Cummins® Authorized Repair Location for the latest revision.	 3824801
2892092	**Data Link Adapter Kit** INLINE™ 6 adapter and associated cables are used to connect a computer to an engine data link.	 22000083
4919115	**Electrical Test Lead Kit** Contains various test leads for testing electrical circuits. Reference Service Tool Instruction, Bulletion 3400282, for kit contents.	 19p00106
3164488	**Multimeter** Used to measure electrical circuits; voltage (volts), resistance (ohms), and current (amps).	 3377161
3822608	**Weather-Pack™ Terminal Removal Tool** Used to repair Weather-Pack™ connectors.	 3822608
3822760	**Deutsch™ Terminal Removal Tool (Blue)** Used to repair Deutsch™ connectors.	 3822760

Tool No.	Tool Description	Tool Illustration
3822860	**Heat Gun** Used to repair connector wires.	
3822930	**Wire Crimping Pliers** Used when repairing connector wires.	 3822930
3824816	**Deutsch™ Terminal Removal Tool (Yellow).** Used to repair Deutsch™ 9-pin connectors.	 3822760
3823843	**Deep Well Socket (1-1/4 inch)** Used to remove and install sensors and actuators.	 3823843
3824510	**Electrical Contact Cleaner** Used to clean electrical contacts and connectors.	 oi8togt
2892289	**Benchtop Calibration Cable** Used with parent cable, Part Number 3163151, power adapter, Part Number 3824102, and the INLINE™ 6 adapter, Part Number 2892092.	 22t00002
2892512	**Wiring Repair Kit** This kit contains various connectors and tools used to repair wiring harnesses.	 22t00003
5298821	**NOx Sensor Service Tool:** The harness allows the inlet and/or outlet NOx sensor to be isolated from the engine wiring harness and/or the OEM wiring harness for testing.	

Barometric Air Pressure Sensor (019-004)

Initial Check



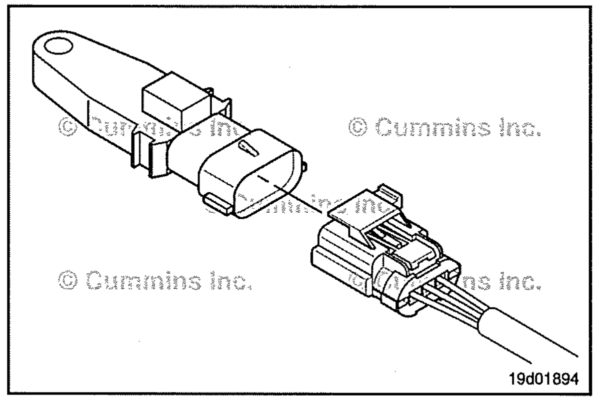
Connect INSITE™ electronic service tool to the vehicle data link.

Turn the keyswitch to the ON position.

Monitor the barometric air pressure.

If the barometric air pressure is less than or equal to 523 mm Hg [20.6 in Hg] and the present elevation is less than 3.048 km [10,000 ft], replace the barometric air pressure sensor.

Remove



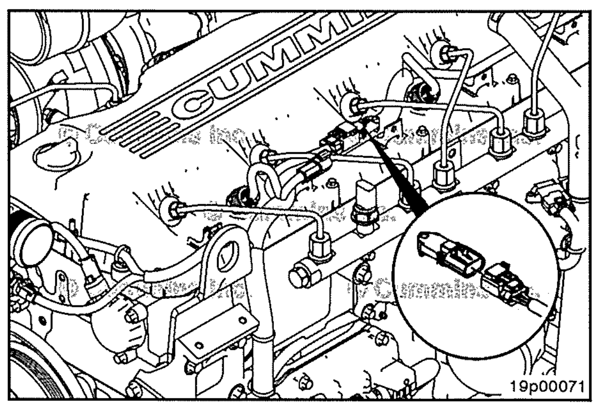
The barometric air pressure sensor is located on the engine wiring harness, near the ECM.

Slide the locking tab sideways.

Push down on the button toward the rear of the connector and disconnect from the sensor.

The sensor is attached to the engine wiring harness. It is **not** mounted on the engine with capscrews.

Install



Install a new sensor on the engine.

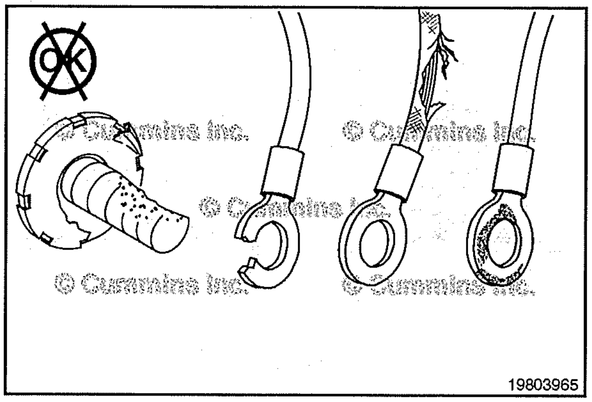
Push the connectors together until they lock.

Slide the locking tab to the lock position.

Use a wire tie to secure the sensor to the wiring harness. When possible, use the original factory sensor cradle to mount the sensor.

Secure the sensor so that:

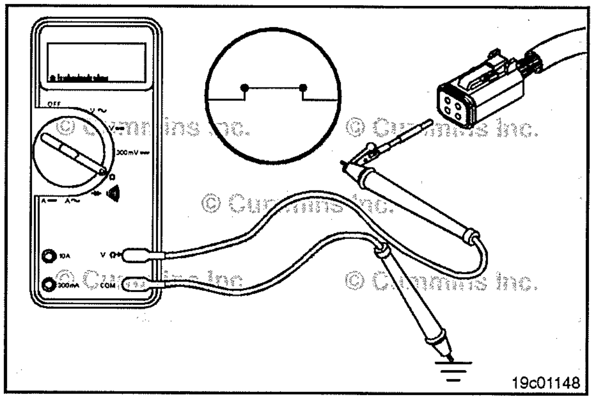
- The connector is held securely to the harness and is **not** allowed to vibrate loose.
- The wire tie is **not** placed over the wires entering the rear of the connector; doing so can put excessive stress on the wires, seals, and wire crimps, which can cause damage.
- The sensing port, on the underside of the sensor, has adequate access to environmental conditions and is protected from events that could damage or plug the sensing port or sensing element. Damaging events include, but are **not** limited to, direct water spray, paint, harsh chemicals, and debris.
- The final placement of the sensor and wires are clear of moving parts and **not** in direct contact with surfaces that can abrade the wires.



Battery Ground Circuit (019-008)

Resistance Check

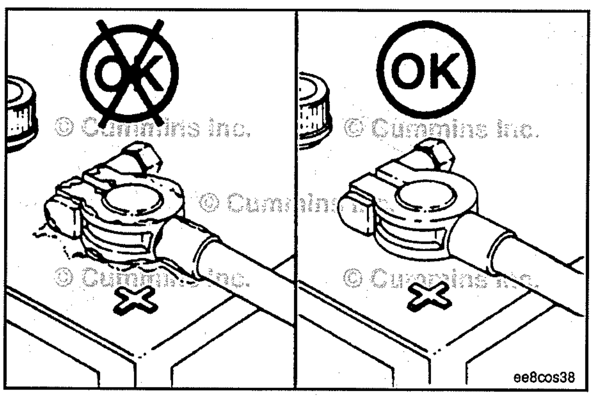
Check the Original Equipment Manufacturer harness ground connection for loose, corroded, or broken connections.



CAUTION

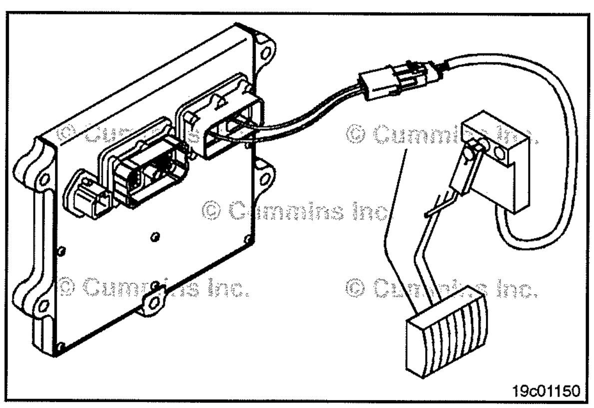
The leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

Measure the resistance between the battery supply negative (-) pin of the Original Equipment Manufacturer harness control module connector(s) and engine block ground or chassis ground for each control module. Reference the wiring diagram for connector pin identification. The resistance **must** be 10 ohms or less.



If the resistance value is **not** correct, check the batteries, cables, and cable connections.

Repair or replace the parts as required.



Clutch Pedal Position Switch (019-009)

General Information

The clutch pedal position switch circuit is used to disable the PTO and cruise control features.

The circuit consists of an open control switch, a clutch pedal position switch signal wire, and a switch return. When the clutch pedal position switch is installed and adjusted, the contact points are held closed. When the clutch pedal is depressed, the clutch pedal position switch is in its normally open position. This will disable the PTO or cruise control operation.

Resistance Check

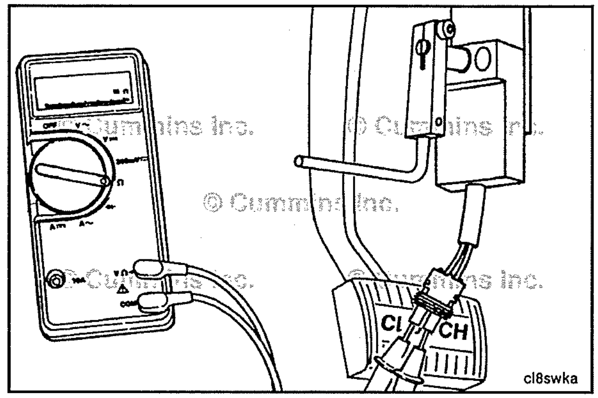
If an electronic service tool is available, monitor the clutch switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Find the clutch pedal position switch. The location will depend on the OEM installation procedures.

Disconnect the wiring harness attached to the switch terminals.

Adjust the multimeter to measure resistance.

Touch the probes of a multimeter to the two terminals in the connector of the clutch pedal position switch.

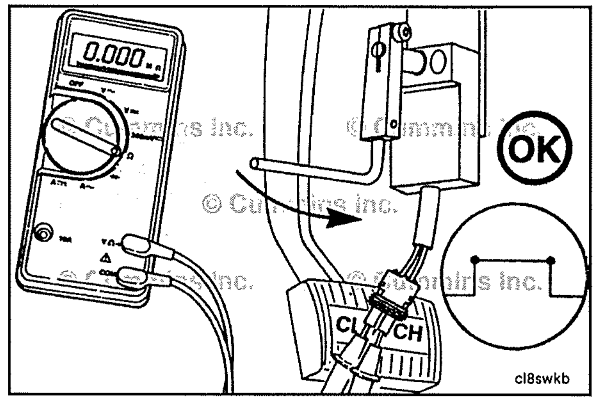


Release the clutch pedal. The multimeter **must** show a closed circuit (10 ohms or less).

If the switch is **not** closed when the clutch is fully engaged, adjust the clutch switch trip lever. If the switch is **not** closed after adjusting the trip lever, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

Depress the clutch pedal. The clutch pedal position switch **must** open. The multimeter **must** show an open circuit (100k ohms or more).

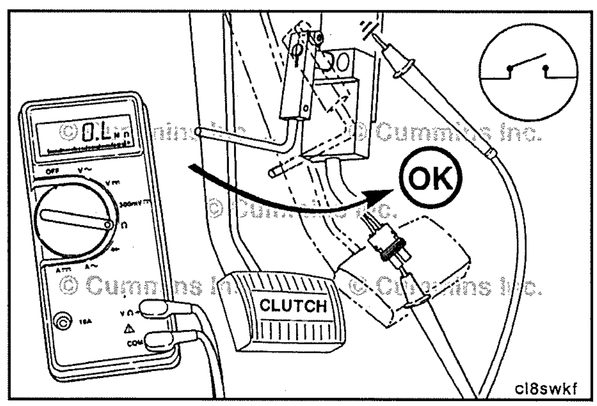
If the switch is **not** open when the clutch is fully engaged, adjust the clutch switch trip lever. If the switch is **not** open after adjusting the trip lever, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.



Check for Short Circuit to Ground

Remove one multimeter probe from the clutch pedal position switch connector and touch the probe to the chassis ground. The multimeter **must** show an open circuit (100k ohms or more) when the clutch pedal is released. If the circuit is closed, replace the clutch pedal position switch.

Refer to the OEM troubleshooting and repair manual.



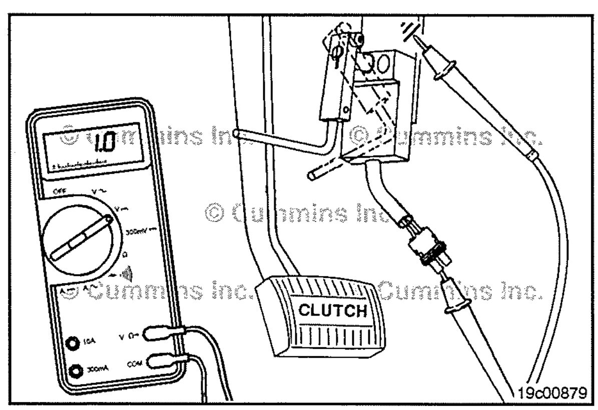
Check for Short Circuit to External Voltage Source

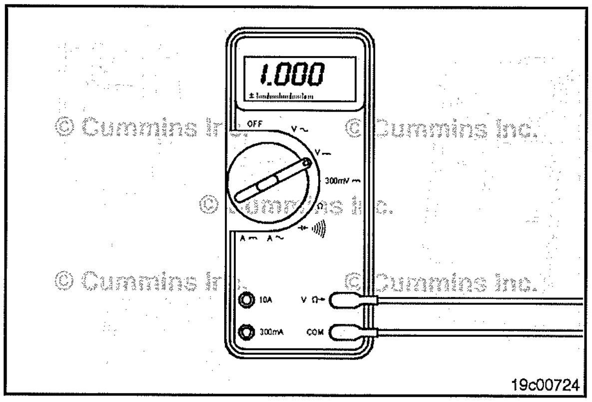
Turn the keyswitch to the ON position.

Adjust the multimeter to measure VDC.

Insert one of the multimeter probes into the clutch pedal position switch connector.

Touch the other multimeter probe to the engine block ground and measure the voltage. The voltage **must** be 1.5 VDC or less with the clutch pedal released and depressed.



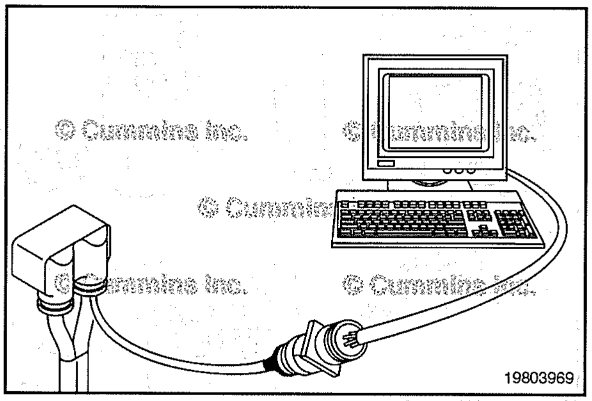


If the voltage value is more than 1.5 VDC, there is a short circuit to an external voltage source.

NOTE: An external voltage source is any wire in the OEM harness wiring that carries the voltage.

Remove the external voltage source.

If the clutch pedal position switch passed all previous checks, connect the switch to the wiring harness. The clutch pedal position switch circuit **must** be checked.



Clutch Pedal Position Switch Circuit (019-010)

Resistance Check

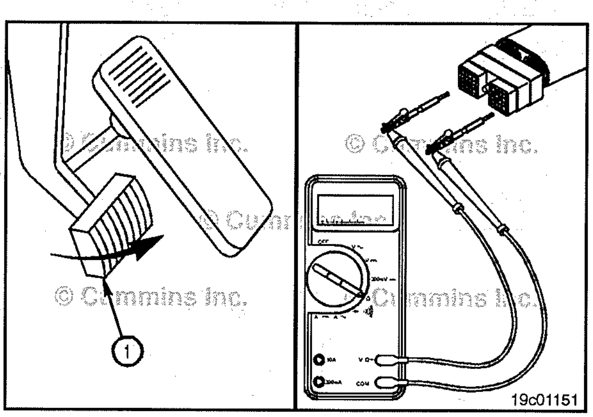
⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If electronic service tool is available, monitor the clutch pedal position switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Insert a test lead into the clutch pedal position switch return pin depending on the OEM application of the OEM connector. Insert the other test lead into the clutch pedal position switch signal pin of the OEM connector.

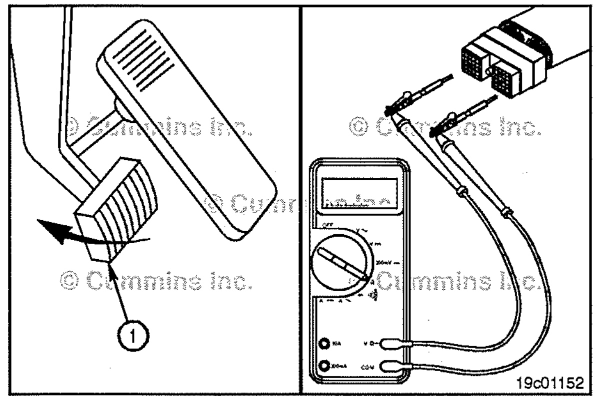


Connect the alligator clips to the two probes of the multimeter. Adjust the multimeter to measure resistance.

The multimeter **must** show a closed circuit (10 ohms or less) when the clutch pedal (1) is released.

Depress the clutch pedal (1). The multimeter **must** show an open circuit (100k ohms or more). If the resistance values are **not** correct, the clutch pedal position switch signal wire and the return wire **must** be checked for an open circuit, provided the clutch pedal position switch was previously checked.

If the values are correct, the circuit **must** still be checked for a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.

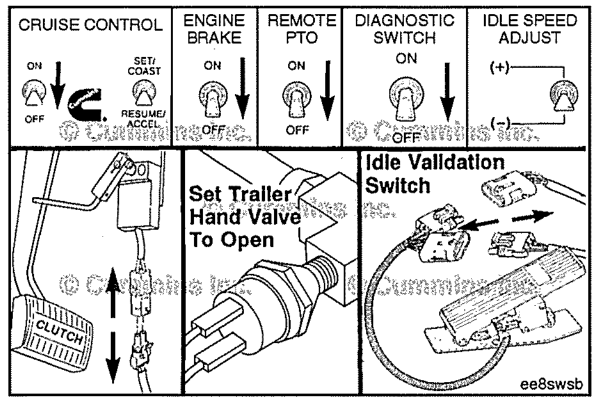


Check for Short Circuit to Ground

To isolate the clutch pedal position switch circuit when checking for a short circuit to ground, turn all cab panel switches to the OFF or neutral position.

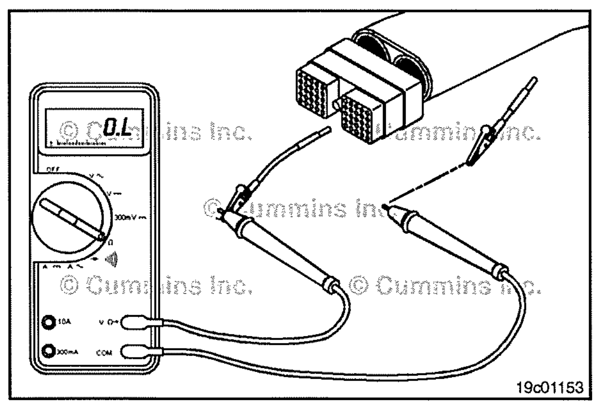
Set the service brake using the trailer brake hand valve.

Disconnect the clutch pedal position switch, the idle validation switch, and the throttle pedal.



Remove the test lead from the switch return pin.

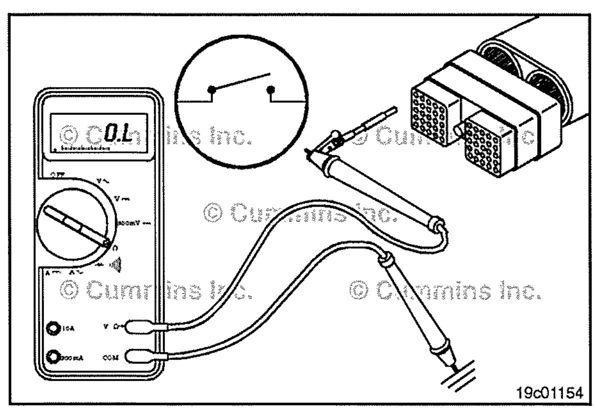
Disconnect the multimeter probe from the alligator clip.

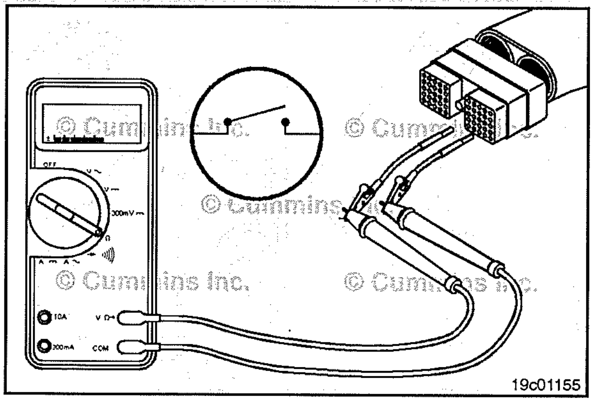


Touch the other multimeter probe to the engine block ground. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the clutch pedal position switch circuit.

Repair or replace the wire connected to the clutch pedal position switch signal pin in the OEM harness according to the vehicle manufacturer's procedures.

Connect all components when the repair is complete.




19c01155

Check for Short Circuit from Pin to Pin

Isolate the clutch pedal position switch circuit as described in previous step. Set all cab panel switches to the OFF or neutral position, and disconnect the clutch pedal position switch and the throttle pedal.

Adjust the multimeter to measure resistance. Then insert one test lead into the clutch pedal position switch signal pin of the OEM harness connector. Insert the other test lead into the clutch pedal position switch return pin. Connect the alligator clips to the multimeter probes.

Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

With the first test lead still touching the clutch pedal position switch signal pin, remove the test lead from the clutch pedal position switch return pin and touch it to all other pins, one at a time. The multimeter **must** show an open circuit (100k ohms or more) at all pins.

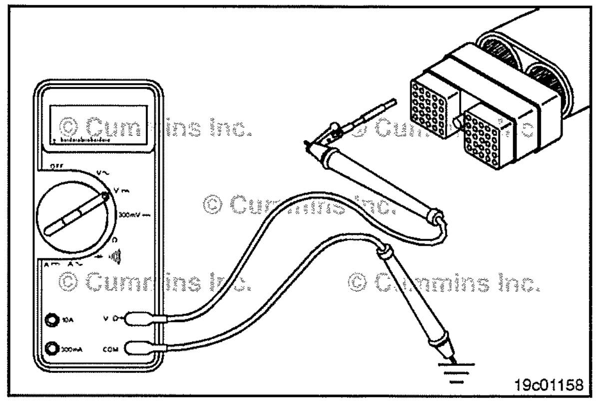
If the circuit is **not** open, there is a short circuit between the wire connected to the clutch pedal position switch signal pin and any pin that shows a closed circuit. Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

Remove the test lead from the clutch pedal position switch signal pin and touch it to the clutch pedal position switch return pin. Touch the other test lead to all other pins, one at a time. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more), except for the clutch pedal position switch return pin.

If the circuit is **not** open, there is a short circuit between the wire connected to the clutch pedal position switch return wire and any pin that measured a closed circuit. Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

Check for Short Circuit to External Voltage Source

Isolate the clutch pedal position switch circuit as described in the previous steps. Set the cab panel switches to the OFF or neutral position, and disconnect the clutch pedal position switch and the throttle pedal. Turn the keyswitch to the ON position. Adjust the multimeter to measure VDC.



Insert test lead connected to the positive multimeter probe into the clutch pedal position switch signal pin. Disconnect the negative multimeter probe from the test lead and touch it to the engine block ground. Measure the voltage. The voltage **must** be 1.5 VDC or less.

NOTE: An external voltage source is any wire in the OEM wiring that carries voltage.

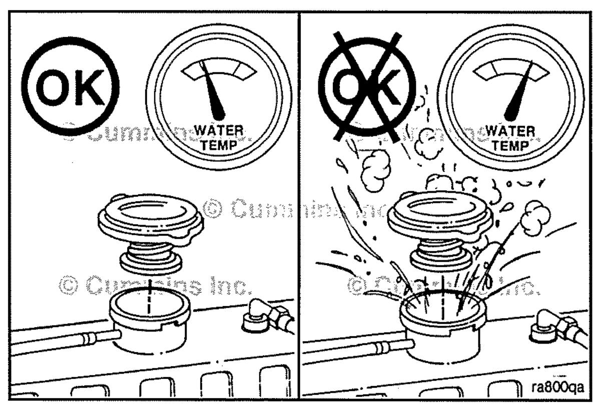
If the voltage value is more than 1.5 VDC, there is a short circuit between the wire connected to the clutch pedal position switch signal pin and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.

Remove the test lead from clutch pedal position switch signal pin and insert it into the clutch pedal position switch return pin. With the multimeter probe still touching the engine block ground, measure the voltage. The voltage **must** be 1.5 VDC or less. If the voltage value is **not** correct, there is a short circuit between the wire connected to the clutch pedal position switch return and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.

Connect all components after completing the repairs.

Engine Coolant Level Sensor (019-017)

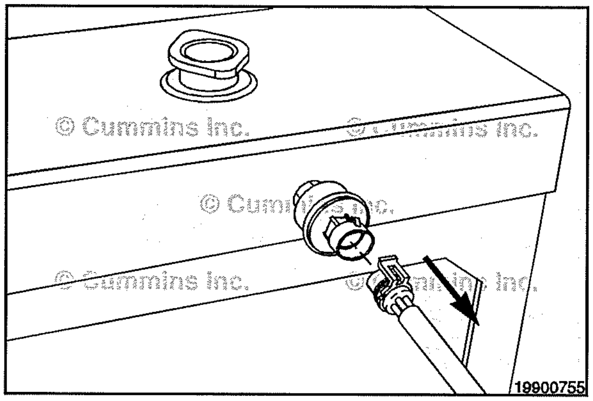
Preparatory Steps



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

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

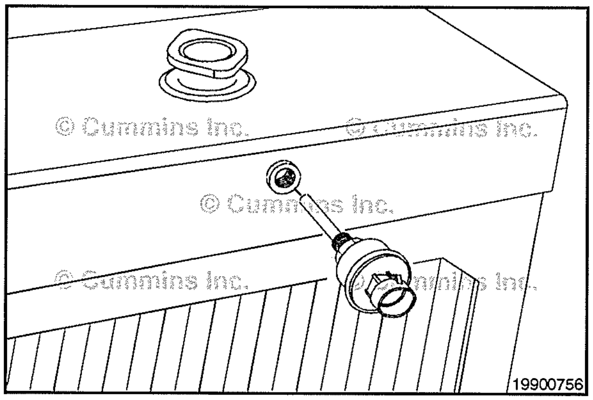
- Remove the radiator cap.
- Drain enough coolant from the cooling system to empty the radiator top tank. Refer to Procedure 008-018 in Section 8.



Remove

Lift up on the locking tab and pull the electrical connectors apart.

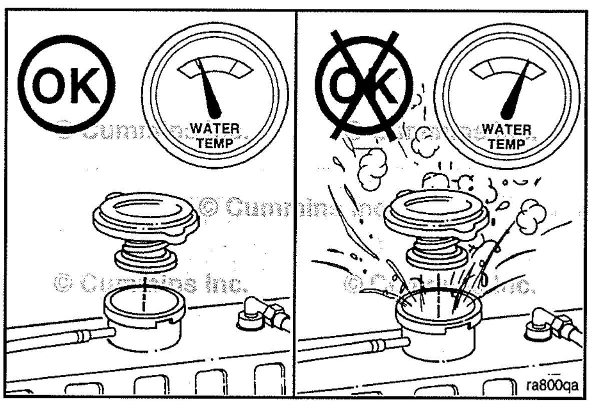
Remove the sensor.



Install

Install and tighten the new sensor according to the vehicle manufacturer's instructions.

Push the electrical connectors together until they lock.

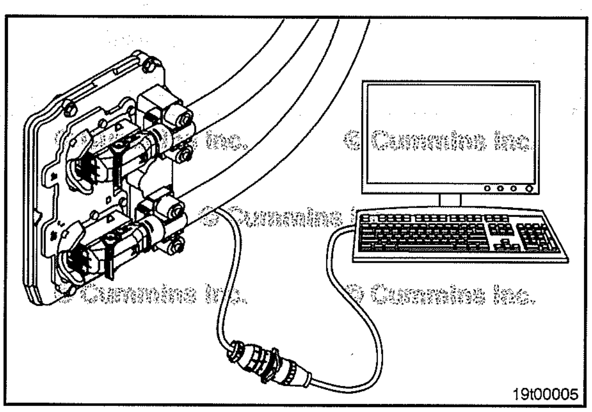


Finishing Steps

WARNING

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

- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Install the radiator cap.
- Operate the engine to normal operating temperature and check for leaks and proper operation.



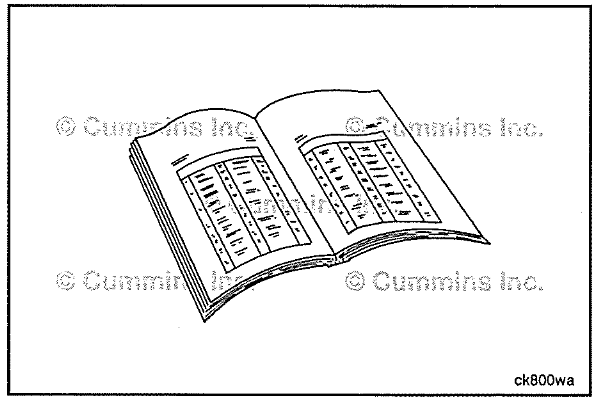
Engine Coolant Temperature Sensor (019-019)

Initial Check

Connect INSITE™ electronic service tool.

Verify that the coolant temperature reading on INSITE™ electronic service tool and the gauge reading are the same.

Preparatory Steps



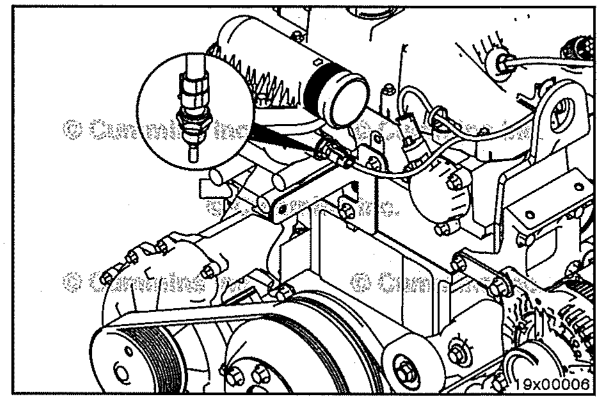
⚠WARNING⚠
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

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

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

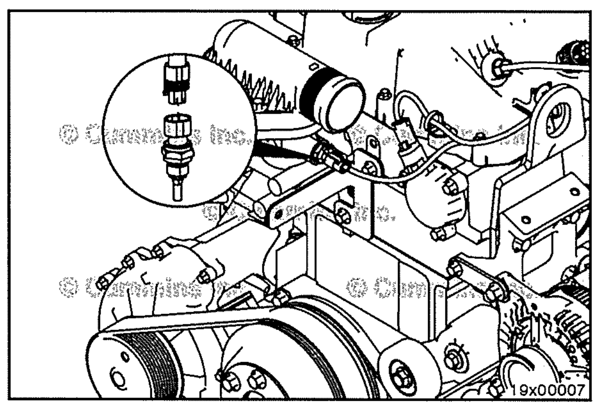
Remove

The coolant temperature sensor is located on the thermostat housing.



Lift up on the locking tab and pull the electrical connectors apart.

Remove the sensor.



Install

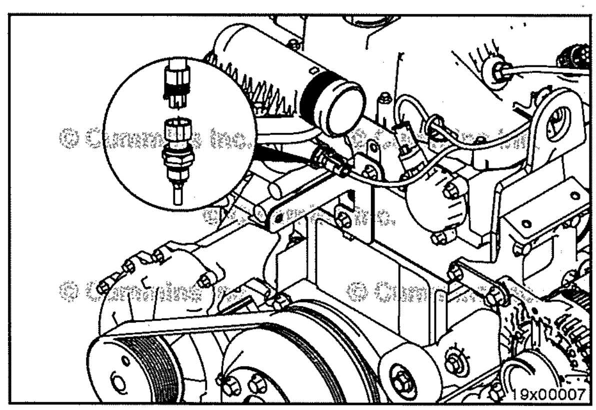
Make sure the new sensor has an o-ring installed.

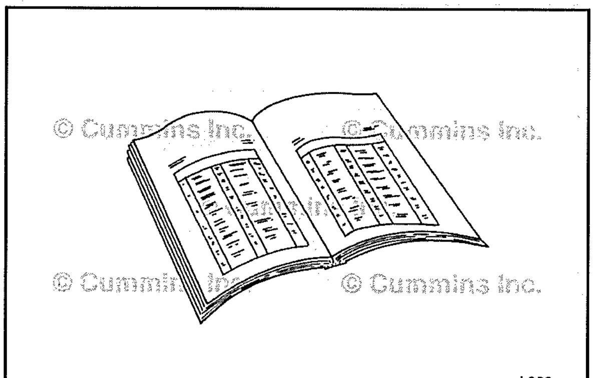
Lubricate the o-ring with clean engine oil.

Install the new sensor into the engine. Tighten the sensor.

Torque Value: 20 N•m [177 in-lb]

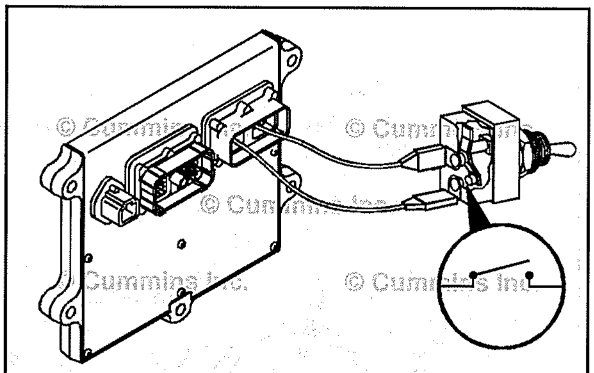
Push the connectors together until they lock.




ck800wa

Finishing Steps

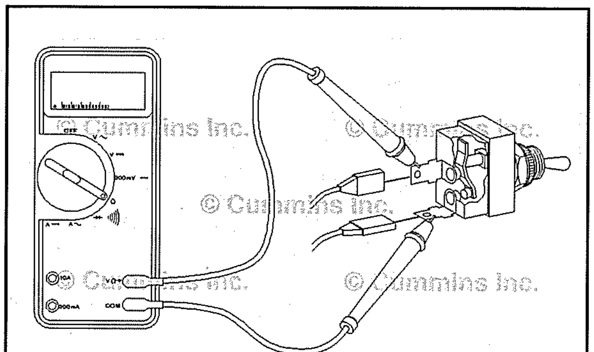
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Operate the engine and check for leaks.
- Use INSITE™ electronic service tool to monitor the engine coolant temperature sensor for proper operation.


19c01162

Cruise Control or PTO ON/OFF Switch (019-021)

General Information

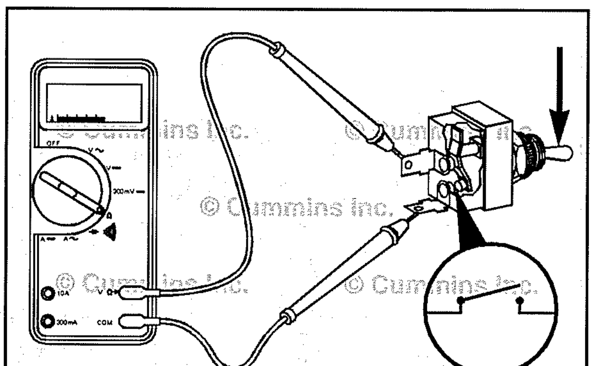
The ON/OFF toggle switch is used to activate or disable the cruise control operation and PTO operation. The cruise control/PTO ON/OFF switch circuit consists of the cruise control ON/OFF switch signal, the switch return, and the OEM cab-mounted toggle switch.


19900590

Resistance Check

If an electronic service tool is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate the desired ON/OFF toggle switch. Remove and tag the two connectors from the terminals on the switch. Touch the multimeter probes to the terminals on the switch.


19c01163

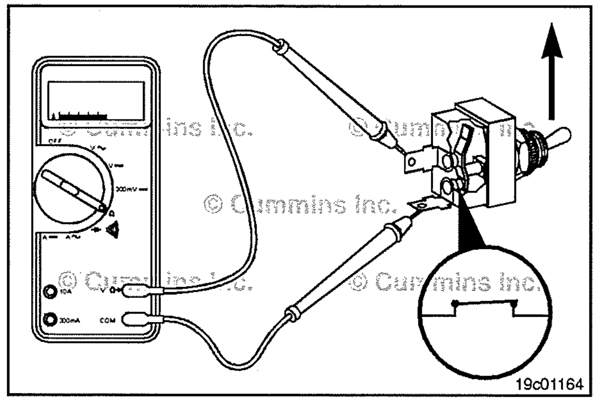
Move the switch to the OFF position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

Move the switch to the ON position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).

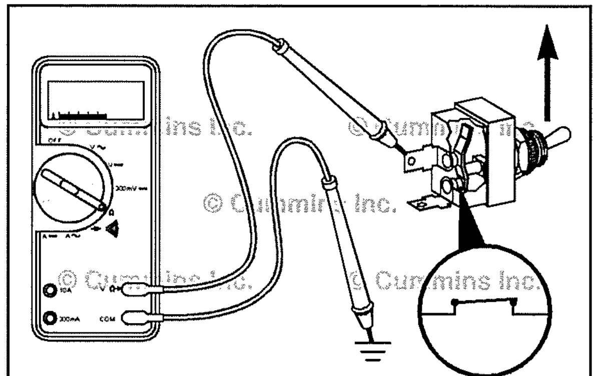
If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.


19c01164

Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.


19c01165

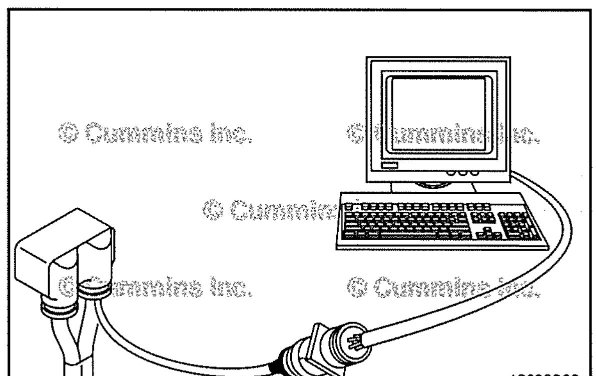
Cruise Control or PTO ON/OFF Switch Circuit (019-022)

Resistance Check

CAUTION

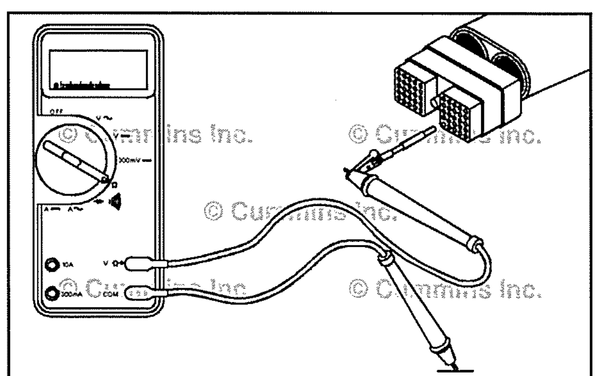
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

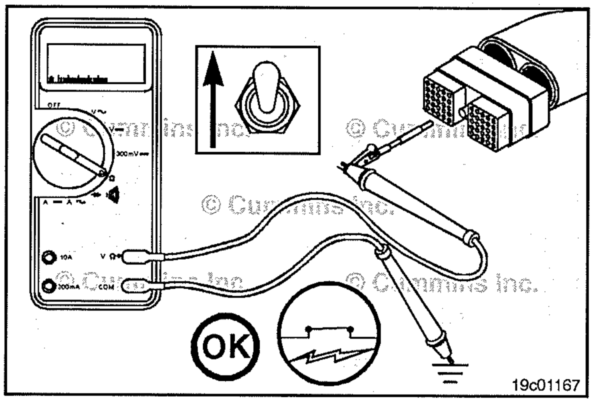
If electronic service tool is available, monitor the switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.


19803969

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Insert the test lead into the cruise control ON/OFF switch signal pin of the original equipment manufacturer (OEM) harness connector and attach it to the multimeter probe. Touch the other probe to the engine block ground.

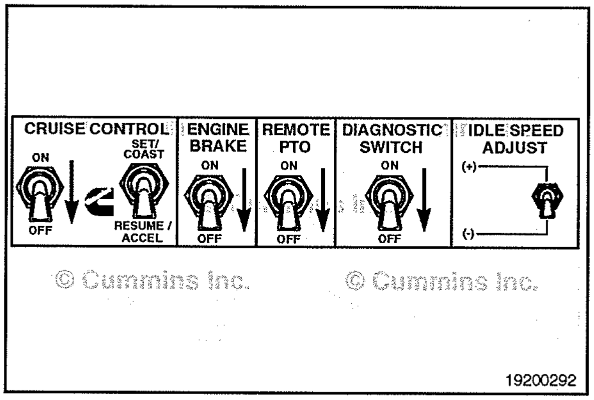

19c01166



19c01167

Move the ON/OFF switch to the ON position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the cruise control ON/OFF switch input for an open circuit. Refer to the OEM troubleshooting and repair manual.

If the resistance is within specification, the cruise control ON/OFF switch input **must** be checked for a short circuit to ground, a short circuit from terminal to terminal, and a short circuit to an external voltage source.



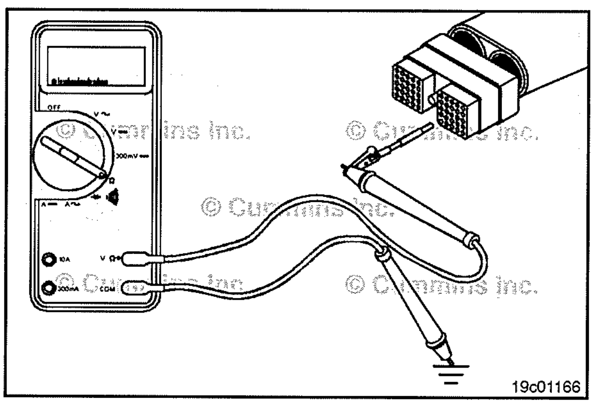
19200292

Check for Short Circuit to Ground

To isolate the cruise control circuit when checking for a short circuit, disconnect the OEM harness connector from the ECM and the OEM harness from the cruise control switch.

Disconnect the clutch pedal position switch, idle validation on/off switch, and the accelerator pedal position switch. Set all cab panel switches to the OFF or neutral position.

Set the service brake using the trailer brake hand valve.



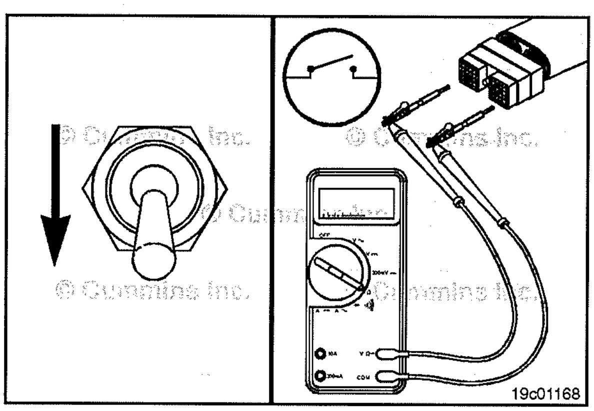
19c01166

Adjust the multimeter to measure resistance. Insert a test lead into the cruise control ON/OFF switch input of the OEM harness connector and attach it to a multimeter probe. Remove the other multimeter probe from the alligator clip and touch it to the engine block ground.

Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the cruise control circuit, provided that the switch has been previously checked.

Repair or replace the wire connected to the cruise control ON/OFF switch input in the OEM harness according to the vehicle manufacturer's procedures.



19c01168

Check for Short Circuit from Pin to Pin

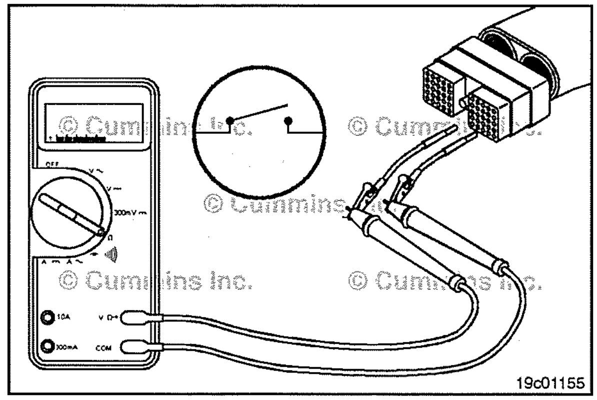
Check for a short circuit from pin-to-pin. Isolate the cruise control circuit by setting the switches as in the previous section. Set the cruise control/PTO ON/OFF switch to the OFF position. Insert the lead into the cruise control ON/OFF switch input. Connect the alligator clip to the multimeter. With the other lead inserted into the switch return wire(s), measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the cruise control ON/OFF switch input and check all other pins. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the cruise control ON/OFF switch input circuit and any pin that shows a closed circuit, provided the switch has previously been checked.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

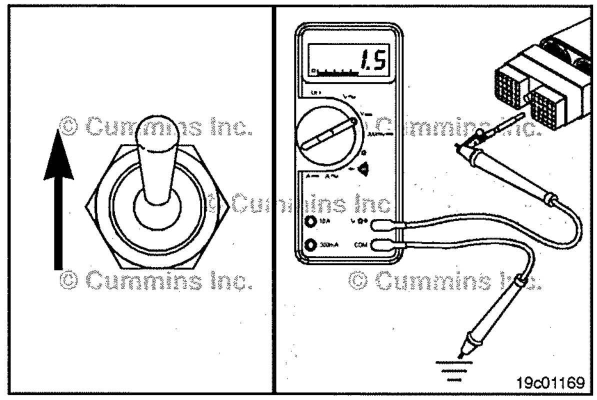


Check for Short Circuit to External Voltage Source

Turn the vehicle keyswitch to the ON position. Set the cruise control/PTO ON/OFF switch to ON. Adjust the multimeter to measure VDC. Insert a test lead into the cruise control ON/OFF switch input and attach it to a multimeter probe. Disconnect the other multimeter probe from the other lead and touch it to the engine block ground. Measure the voltage. The voltage **must** be 1.5 VDC or less.

If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the cruise control/PTO ON/OFF switch circuit and a wire carrying power in the OEM harness. Remove the voltage source or repair the wiring in the OEM harness according to the vehicle manufacturer's procedures. Connect all components after completing the repair.

NOTE: If the cruise control/PTO ON/OFF switch circuit was approved in all of the previous tests, it is functioning correctly.



Cruise Control or PTO Set/Resume Select Switch (019-023)

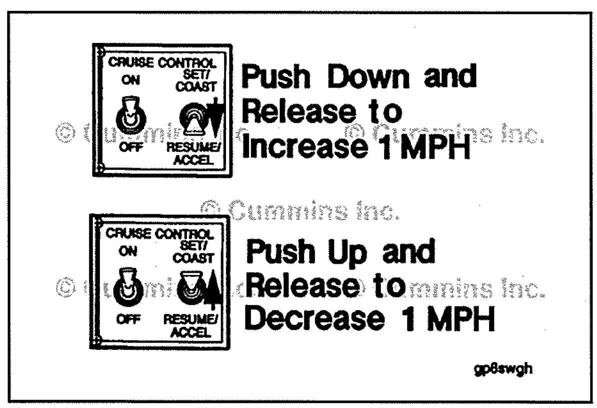
General Information

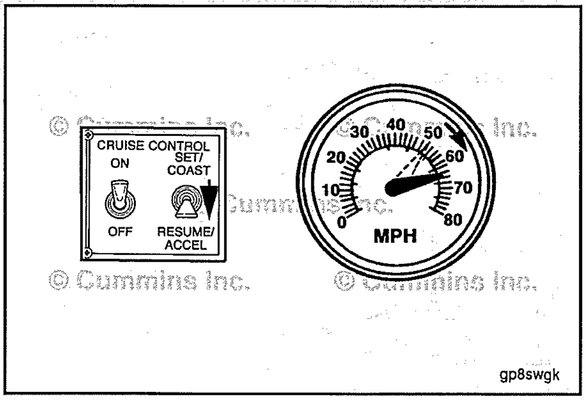
The cruise control/PTO set/resume select switch has two positions: SET/COAST and RESUME/ACCEL.

The switch can be used for: Cruise Control SET/COAST and RESUME/ACCEL, PTO INCREASE/DECREASE, IDLE INCREASE/DECREASE, ROAD SPEED GOVERNOR INCREASE/DECREASE, DIAGNOSTIC FAULT CODE INCREASE/DECREASE. For additional information, see Section F.

The operator can set the vehicle cruising speed when the switch is in the SET/COAST position. The SET/COAST position can also be used to reduce the vehicle cruising speed. Hold the switch in the SET/COAST position and the vehicle will coast down to a lower speed. When the select switch is released, the cruising speed will be reset.

NOTE: Some OEM's have switches labeled SET/ACCEL and RESUME/COAST.

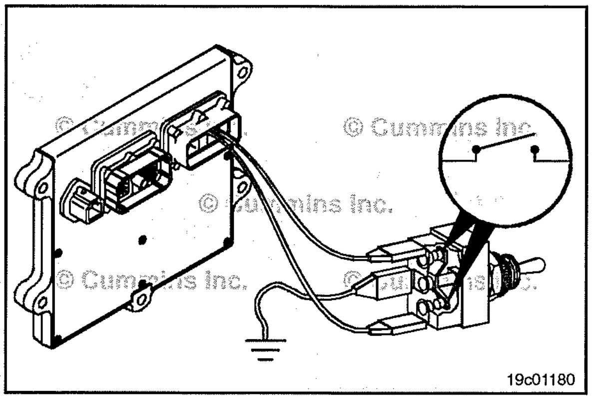




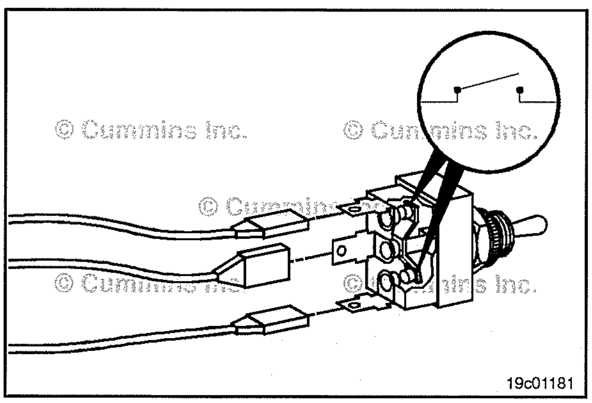
gp8swgk

The operator can resume cruise control, after clutching or braking, by moving the switch to RESUME/ACCEL. The vehicle speed will return to the last set mph.

The RESUME/ACCEL position can also be used to increase the vehicle cruising speed. Hold the select switch in the RESUME/ACCEL position and the vehicle will increase in speed. When the switch is released, the cruising speed will be reset.


19c01180

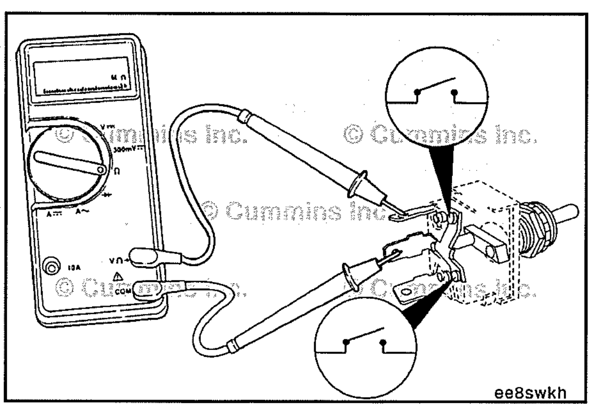
The cruise control/PTO set/resume switch circuit consists of the switch return, the cruise control/PTO resume/accel switch signal, cruise control/PTO set/coast switch signal and the vehicle mounted switch.


19c01181

Resistance Check

If an electronic service tool is available, monitor the cruise control/PTO set/resume select switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Label the wires with the location on the switch or the wire number. Remove the three electrical connectors from the switch.

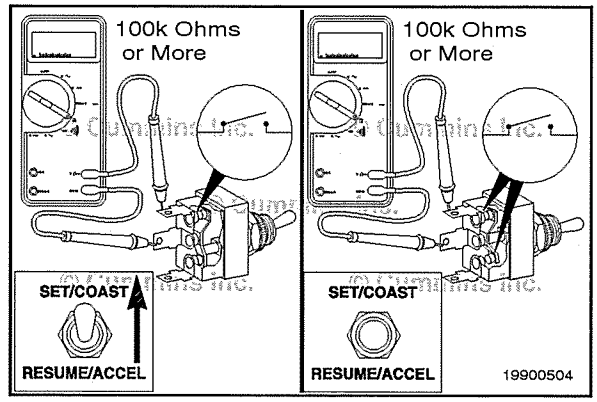

ee8swkh

Adjust the multimeter to measure resistance.

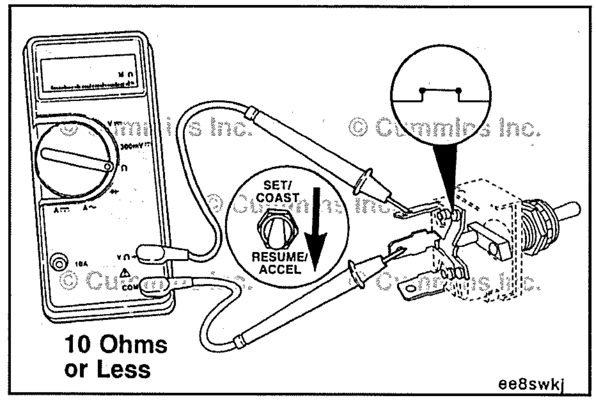
Touch one multimeter probe to the center terminal of the switch. Touch the other multimeter probe to the RESUME/ ACCEL terminal of the switch.

Hold the switch in the SET/COAST position. The multimeter **must** show an open circuit (100k ohms or more) when the switch is held in the SET/COAST position and after it is released. If the circuit is **not** open, the switch has failed.

Refer to the OEM troubleshooting and repair manual for replacement procedures.



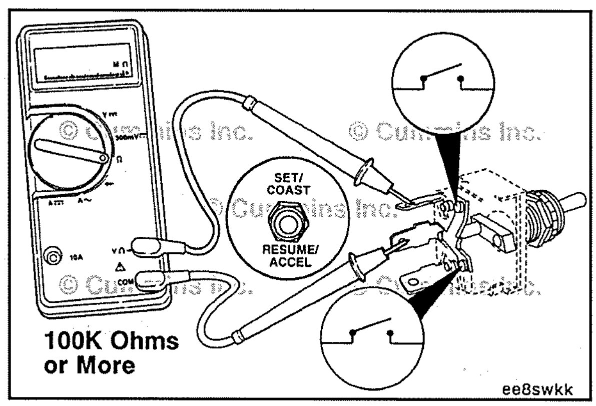
Hold the switch in the RESUME/ACCEL position. The multimeter **must** show a closed circuit (10 ohms or less) when the switch is held in the RESUME/ACCEL position.



When the switch is released, the multimeter **must** show an open circuit (100k ohms or more). If the multimeter does **not** show the correct values in either test, the switch has failed.

Refer to the OEM troubleshooting and repair manual for replacement procedures.

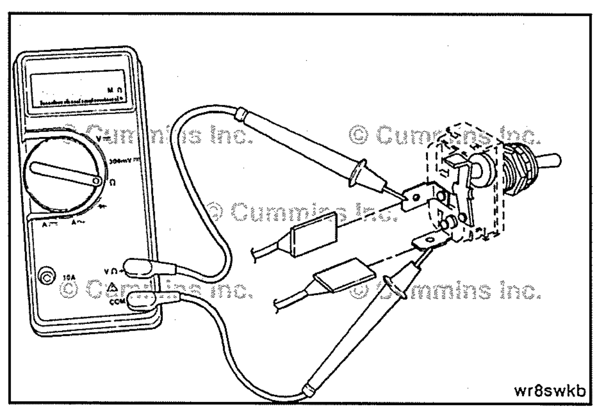
If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

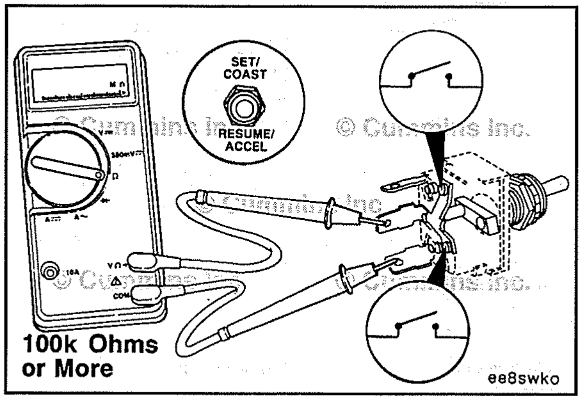


Touch one multimeter probe to the center terminal of the switch. Touch the other multimeter probe to the SET/ COAST terminal of the switch.

Hold the switch in the SET/COAST position.

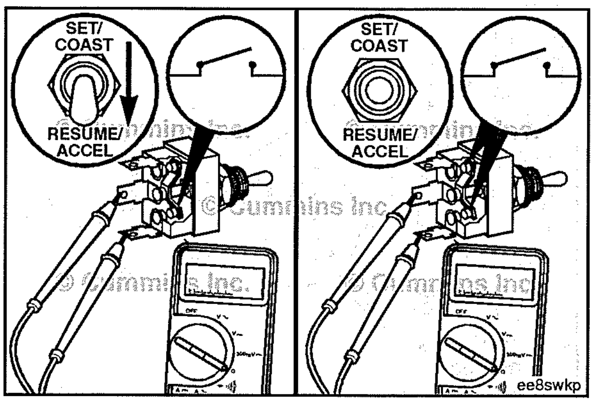
The multimeter **must** show a closed circuit (10 ohms or less) while the switch is held to the SET/COAST position.





When the switch is released, the multimeter **must** show an open circuit (100k ohms or more). If the multimeter does **not** show the correct values in either test, the switch has failed.

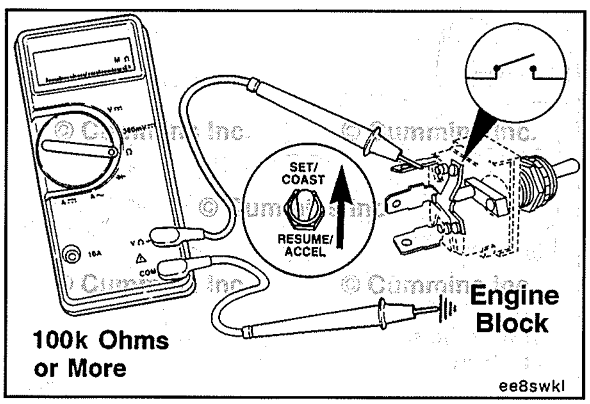
Refer to the OEM troubleshooting and repair manual for replacement procedures.



Move the switch to the RESUME/ACCEL position.

The multimeter **must** show an open circuit (100k ohms or more) when the switch is held in the RESUME/ACCEL position and when it is released. If the circuit is **not** open, the switch has failed.

Refer to the OEM troubleshooting and repair manual for replacement procedures.

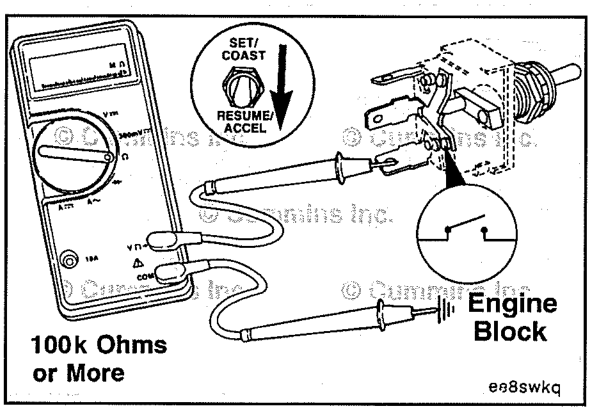


Check for Short Circuit to Ground

Adjust the multimeter to measure resistance.

Touch one multimeter probe to the RESUME/ACCEL terminal of the switch. Touch the other multimeter probe to the chassis ground. Move the switch to the SET/ COAST position then to the RESUME/ACCEL position. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more) when the switch is in all positions. If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.



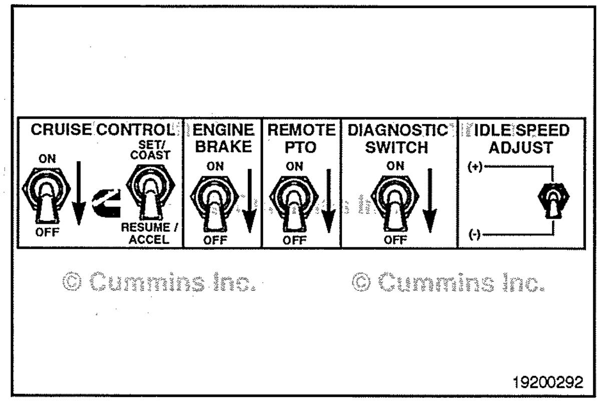
Touch one multimeter probe to the SET/COAST terminal of the switch. Touch the other multimeter probe to chassis ground. Move the switch to the RESUME/ACCEL position, then to the SET/COAST position. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more) when the switch is in all positions. If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.

Cruise Control or PTO Set/Resume Select Switch Circuit (019-024)

General Information

In addition to cruise control functions, the cruise control select switch also provides for increasing/decreasing idle speed, PTO speed, fault code flashout, and road speed governor limit.

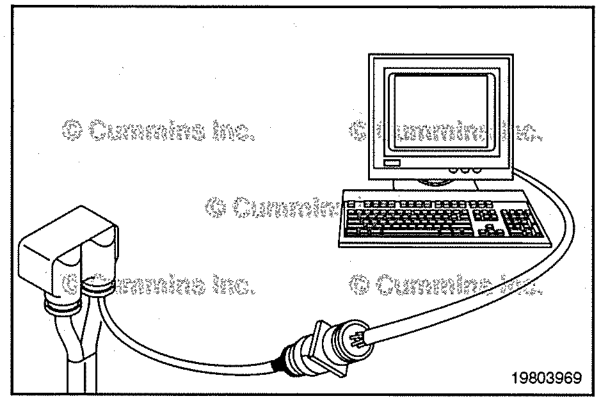


Resistance Check

⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

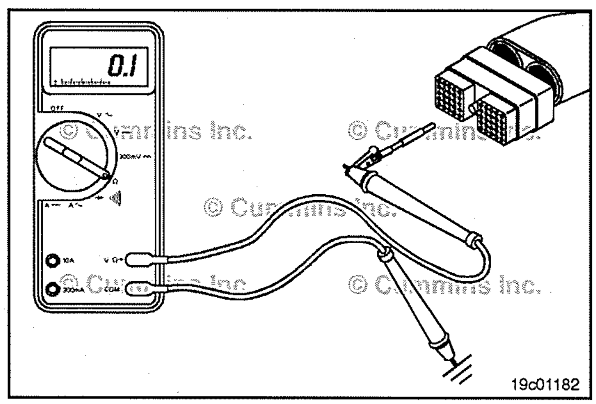
If electronic service tool is available, monitor the cruise control/PTO set/resume select switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

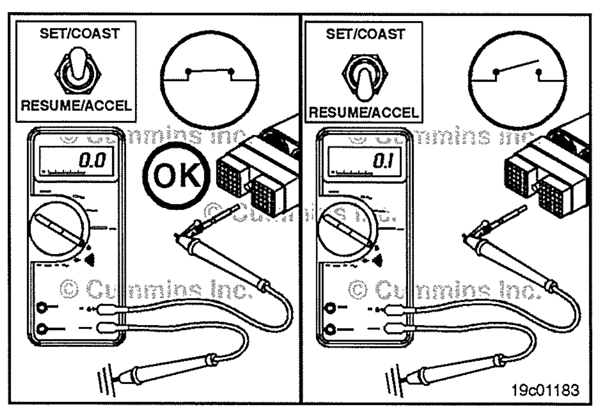
Insert a test lead into the cruise control/PTO set/coast switch signal of the OEM harness connector and connect the alligator clip to the multimeter probe.

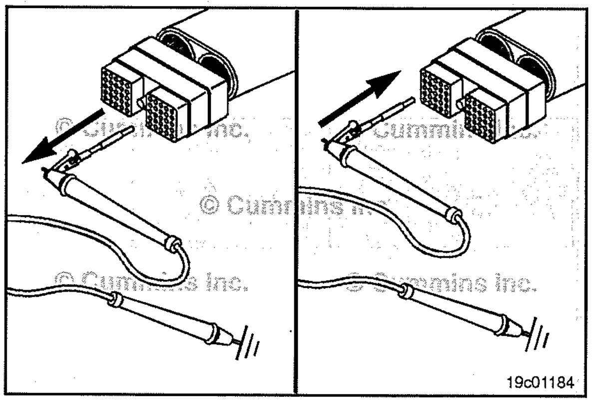
Touch the other probe to engine block ground.



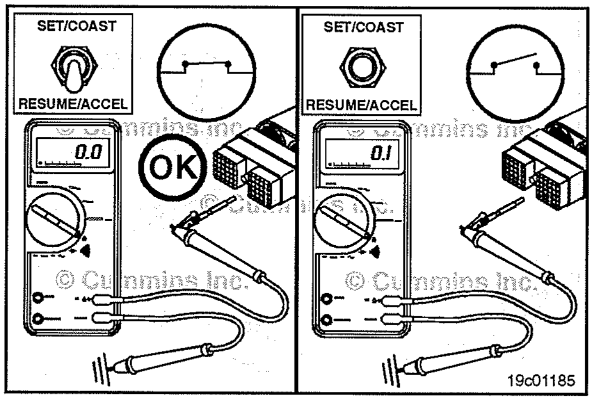
Hold the cruise control select switch in the SET/COAST position. The multimeter **must** show a closed circuit (10 ohms or less) while holding the switch in the SET/COAST position and return to an open circuit (100k ohms or more) when the switch is released. The circuit **must** remain an open circuit (100k ohms or more) when the switch is in the RESUME/ACCEL position.

If the resistance values are **not** correct, make sure the cruise control/PTO set/coast input and the cruise control/PTO resume/accel input wires are properly installed on the cruise control select switch. If both control wires are correctly installed, inspect the cruise control/PTO set/coast input and the cruise control/PTO resume/accel wires for an open circuit, provided the cruise control select switch has been previously checked.



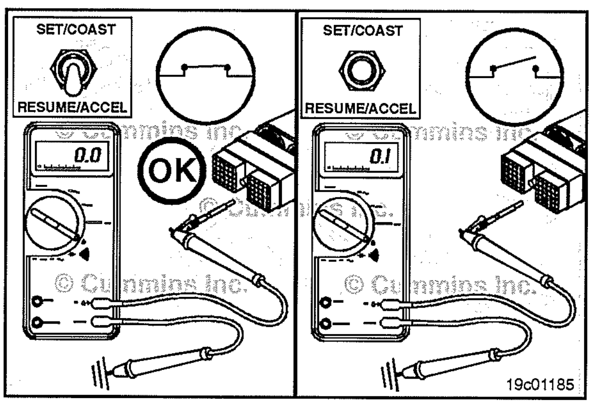


Remove the lead from the cruise control/PTO set/coast switch signal and insert it into the cruise control/PTO resume/accel switch signal.



Hold the cruise control select switch in the RESUME/ ACCEL position. The multimeter **must** show a closed circuit (10 ohms or less) when the switch is in the RESUME/ACCEL position and an open circuit (100k ohms or more) when the switch is released.

The circuit **must** remain an open circuit (100k ohms or more) when the switch is held in the SET/COAST position.

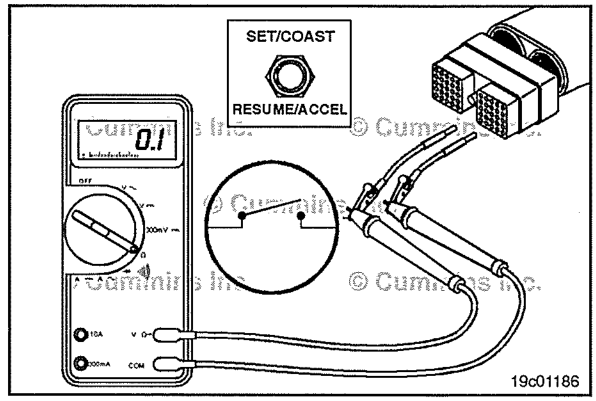


If the resistance values are **not** correct, make sure the cruise control/PTO resume/accel wire is properly installed on the cruise control select switch. If the cruise control/ PTO resume/accel wire is properly installed on the cruise control select switch, inspect the cruise control/PTO resume/accel signal for an open circuit, provided the cruise control select switch has been previously checked.

If the resistance values are correct in the previous checks, the cruise control/PTO set/coast signal and cruise control/ PTO resume/accel signal **must** still be checked for a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.

Check for Short Circuit from Pin to Pin

Isolate the cruise control/PTO set/resume select switch circuit as described in the previous section. Insert a test lead into the cruise control/PTO set/coast switch signal pin of the OEM harness connector. Insert the other lead into the first pin in the connector. Connect the alligator clips to the multimeter probes. Measure the resistance.



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The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the first pin in the connector and check all other pins. The multimeter **must** show an open circuit (100k ohms or more).

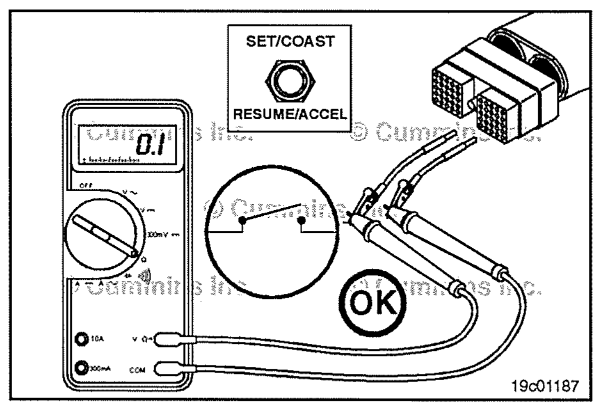
If the circuit is **not** open, there is a short circuit from the wire connected to the cruise control/PTO set/coast switch signal pin and any pin that measured less than 100k ohms.

Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.

Remove the lead from the cruise control/PTO set/coast signal pin and insert it into the cruise control/PTO resume/accel switch signal pin. Insert the other lead into the first pin in the connector.

Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the first pin in the connector and measure the resistance to all other pins. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit between the wire connected to the cruise control/PTO resume/accel switch signal pin and any pin that measured less than 100k ohms.



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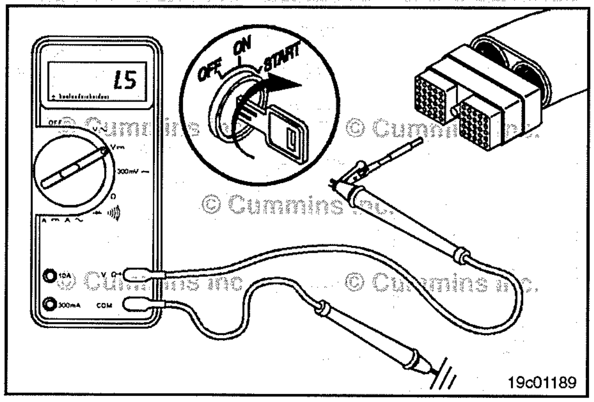
Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to External Voltage Source

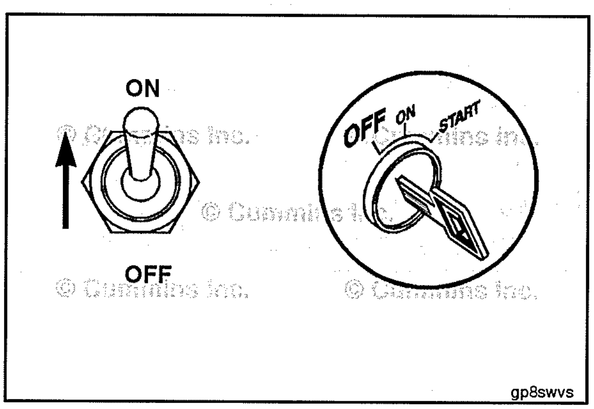
Isolate the cruise control/PTO resume/accel switch circuit as described in the previous section. Turn the vehicle keyswitch to the ON position. Adjust the multimeter to measure VDC. Insert a test lead into the cruise control/PTO resume/accel switch signal of the OEM harness connector. Connect the test lead alligator clip to the positive (+) multimeter probe. Touch the negative (-) multimeter probe to the engine block ground and measure the voltage. The multimeter **must** show less than 1.5 VDC.

If the voltage value is **not** correct, there is an external voltage source short circuit to the cruise control/PTO set/coast switch signal in the OEM harness. Remove the voltage source. Repair or replace the wire in the OEM harness. Refer to Procedure 019-071.

Remove the lead from the cruise control/PTO set/coast switch input pin and insert it into the cruise control/PTO resume/accel switch input pin. Touch the negative multimeter probe to the engine block ground and measure the voltage. The multimeter **must** show less than 1.5 VDC.

If the voltage value is **not** correct, there is an external voltage source short circuit to the cruise control/PTO resume/accel switch input pin in the OEM harness. Remove the voltage source. Repair or replace the wire in the OEM harness. Refer to Procedure 019-071.

Connect all components after completing the repair.

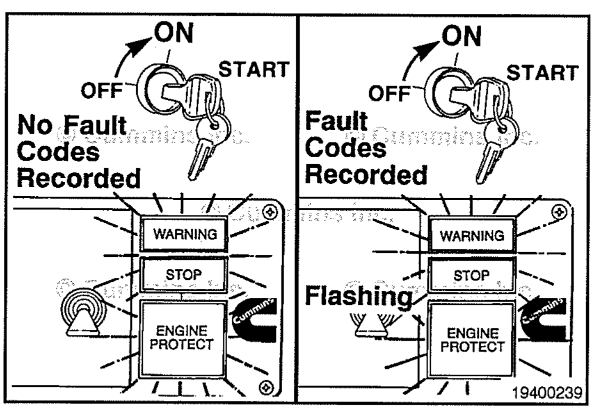


Diagnostic Test Mode Switch (019-027)

General Information

The diagnostic ON/OFF switch circuit signals the system that the operator is requesting to read any active fault code recorded in the ECM.

NOTE: Some OEM's use a shorting plug rather than a switch.



When the ECM receives the signal from the diagnostic ON/OFF switch, the yellow and red warning lights will come on and start flashing if any active fault code is recorded in the ECM. If both warning lights remain on and do **not** flash, there are no active fault codes present.

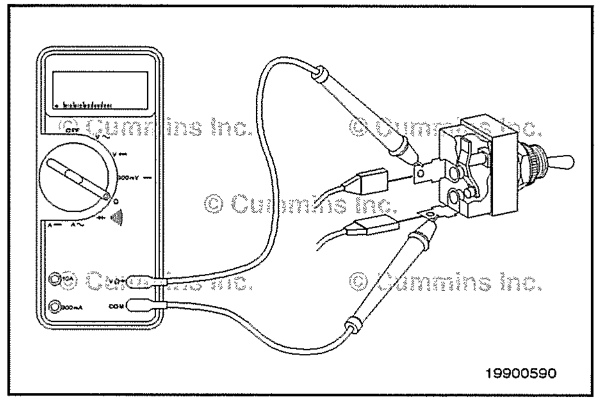
NOTE: The equipment **must** be stationary. If road speed is detected, the flashing sequence will **not** occur.

Resistance Check

If an electronic service tool is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate the desired ON/OFF toggle switch. Remove and tag the two connectors from the terminals on the switch.

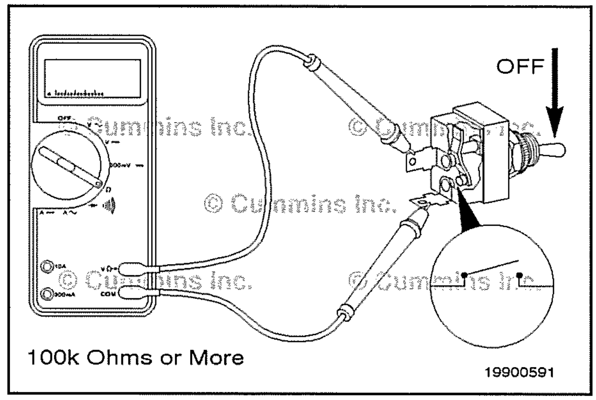
Touch the multimeter probes to the terminals on the switch.



Move the switch to the OFF position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed.

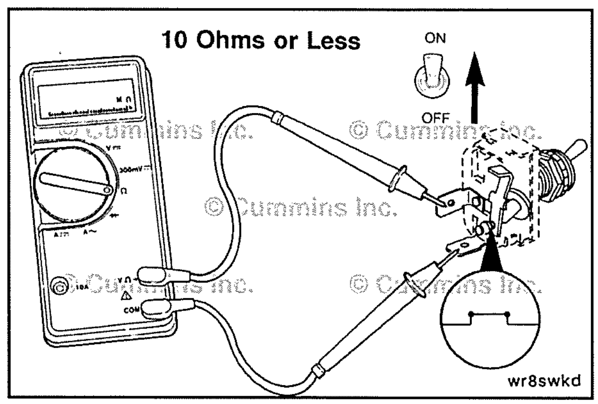
Refer to the OEM troubleshooting and repair manual for the replacement procedures.



Move the switch to the ON position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed.

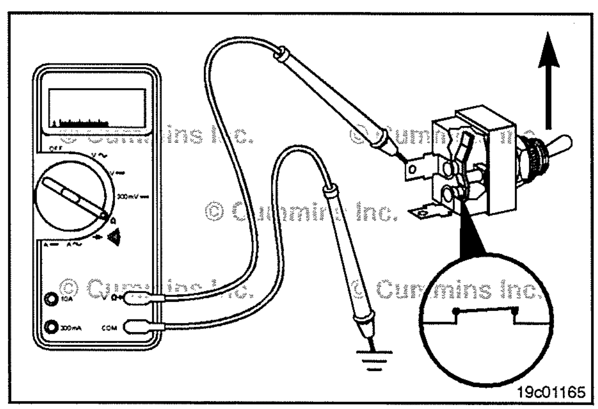
Refer to the OEM troubleshooting and repair manual for the replacement procedures.

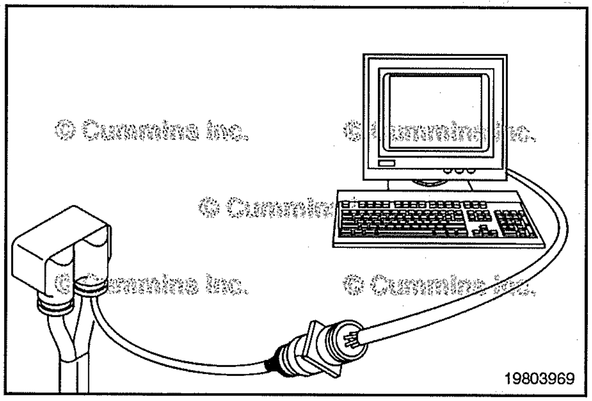
If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.



Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.





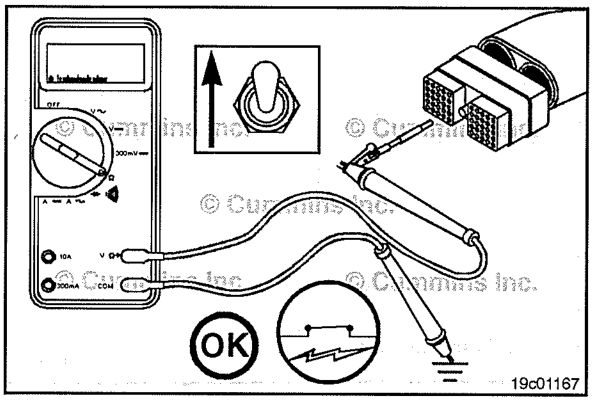
Diagnostic Test Mode Switch Circuit (019-028)

Resistance Check

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If electronic service tool is available, monitor the switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Insert the test lead into the diagnostic test mode switch signal pin in the OEM harness connector and connect it to the multimeter probe.

Touch the other probe to the engine block or chassis ground.

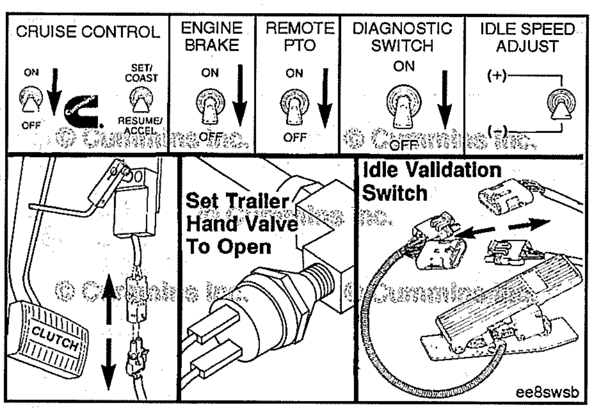
Move the ON/OFF switch to the ON position.

If the OEM wired the switch return to chassis ground, the multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the diagnostic test mode switch signal wire for an open circuit.

If the OEM wired the switch return to the OEM wire harness, the multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, inspect the diagnostic test mode switch signal wire for a closed circuit.

Refer to the OEM troubleshooting and repair manual.

If the resistance is within specification, the diagnostic test mode switch signal wire **must** be checked for a short circuit to ground, a short circuit from terminal to terminal, and a short circuit to an external voltage source.



Check for Short Circuit to Ground

To isolate the diagnostic test mode switch signal circuit when checking for an electrical short, turn all cab panel switches to the OFF or neutral position.

Set the service brake using the trailer brake hand valve.

Disconnect the clutch pedal position switch.

Disconnect the idle validation switch.

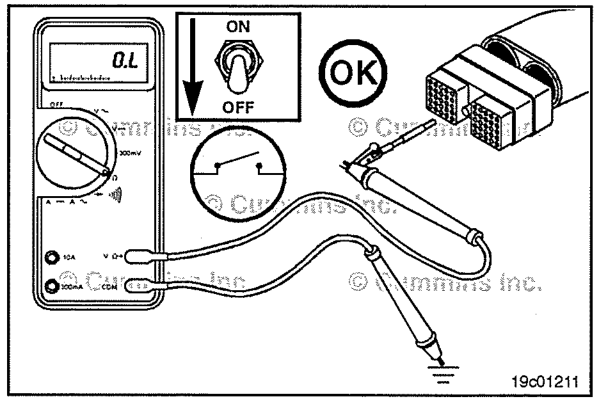
NOTE: Some equipment may vary, depending on OEM application.

Disconnect the OEM harness connector from the electronic control unit. Set the diagnostic test mode switch to the OFF position.

Insert one of the test leads into the diagnostic test mode switch signal pin of the OEM harness connector and connect it to a multimeter probe.

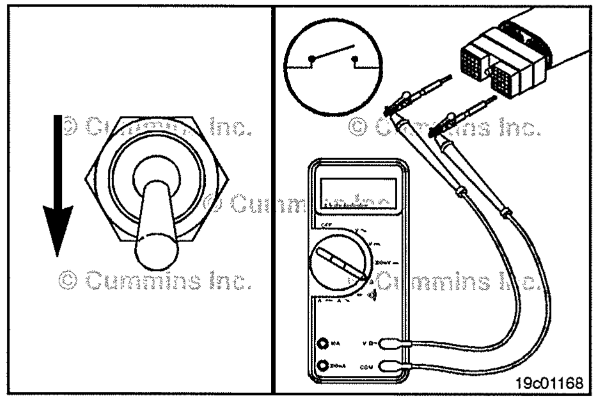
Touch the other probe to engine block or chassis ground.

The multimeter **must** show an open circuit (100k ohms or more).



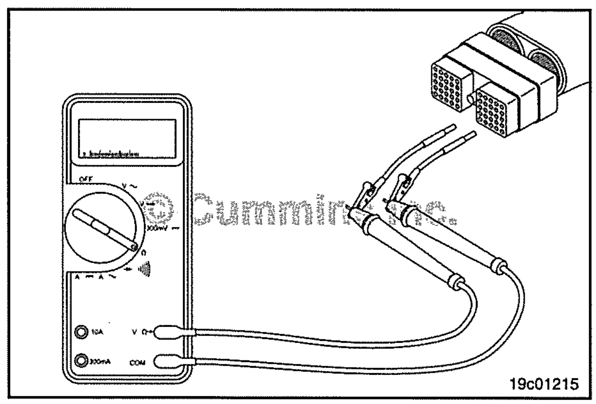
Check for Short Circuit from Pin to Pin

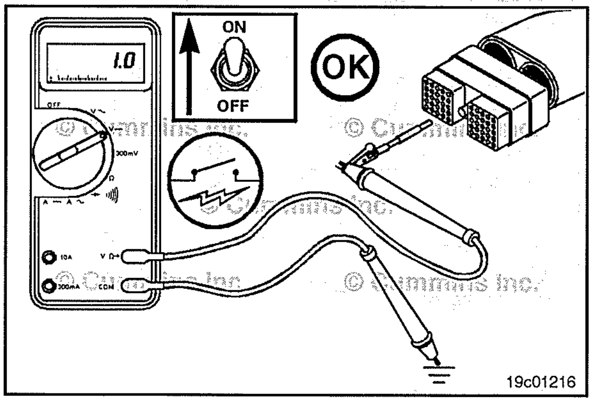
Check for a short circuit from pin-to-pin. Isolate the switch circuit by setting the cab panel switches as described in the previous section. Set the diagnostic test mode switch to the OFF position. Insert a test lead into the switch return pin of the OEM harness connector and connect it to the multimeter probe. With the other lead inserted into the diagnostic test mode switch signal pin of the connector, measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).



Remove the lead from the switch return and test all pins in the connector. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the switch circuit and any pin that shows a closed circuit, provided the switch has previously been checked. Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.





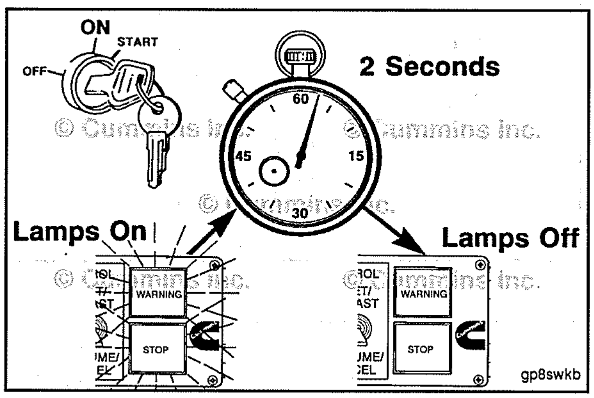
19c01216

Check for Short Circuit to External Voltage Source

Turn the vehicle keyswitch to the ON position. Set the diagnostic test mode switch to ON. Adjust the multimeter to measure VDC. Insert a test lead into the diagnostic test mode switch signal pin of the OEM harness connector. Touch the other lead to the engine block or chassis ground. Measure the voltage. The voltage **must** be 1.5 VDC or less.

If the voltage is **not** correct, there is an external voltage source connected to the circuit or there is a short circuit between the switch circuit and a wire carrying power in the OEM harness. Remove the voltage source or repair the wiring in the OEM harness. Refer to Procedure 019-071.

Connect all components after completing the repair.



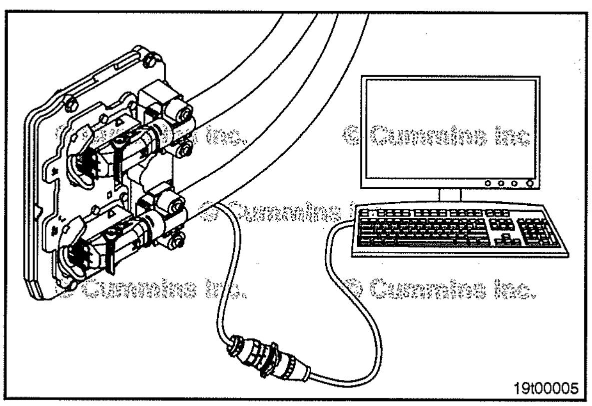
gp8swkb

Engine Control Module (019-031)

Initial Check

Turn the keyswitch to the ON position while monitoring the fault lamps. The fault lamps **must** illuminate for 2 to 3 seconds.

If the lamps do **not** illuminate, check for burned-out bulbs.


19t00005

Turn the keyswitch to the OFF position.

Connect INSITE™ electronic service tool to the vehicle data link.

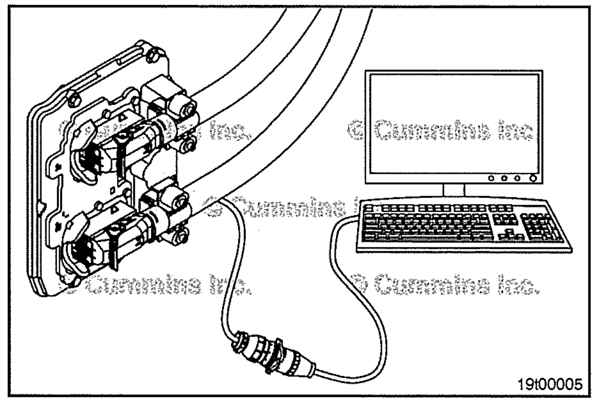
Turn the keyswitch to the ON position.

Select the Monitor Mode on INSITE™ electronic service tool. INSITE™ electronic service tool **must** be able to communicate with the engine control module (ECM). If the ECM will **not** communicate with INSITE™ electronic service tool, use the ECM - No Communication Troubleshooting Tree in Section TF before requesting authorization to replace the ECM.

Record the following values found in the Trip Information section of Features and Parameters, prior to replacing or calibrating the ECM.

- ECM Distance Offset
- ECM Time Offset
- Engine Distance Offset
- Engine Time Offset

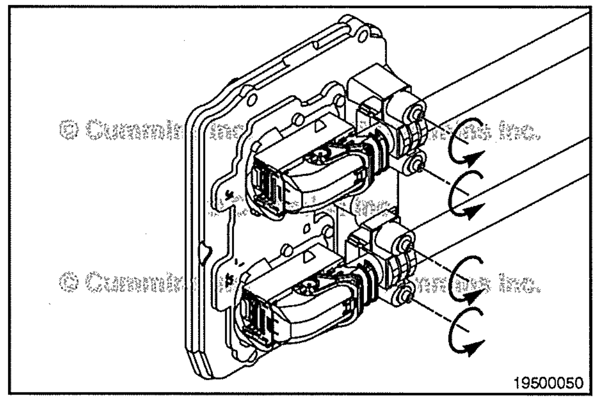
Preparatory Steps



⚠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.

- Record all programmable parameters, features, and calibration information from the old ECM before disconnecting the harness connectors. This information will be needed to program the new ECM.
- Disconnect the batteries. See equipment manufacturer service information.

Remove

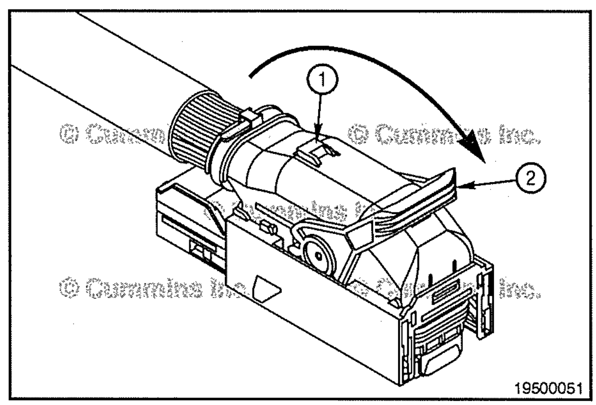


NOTE: Do **not** remove the ECM harness clamps from the wiring harnesses.

NOTE: Do **not** close the lever after the connector has been removed from the ECM. Attempting to do so may cause damage to the connector.

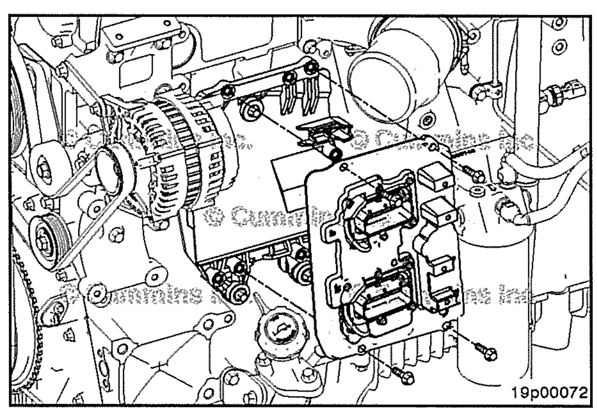
NOTE: Do **not** remove the wire tie from the ECM connector backshell.

Loosen the ECM harness clamp capscrews on the engine wiring harness connector and the OEM wiring harness connector.

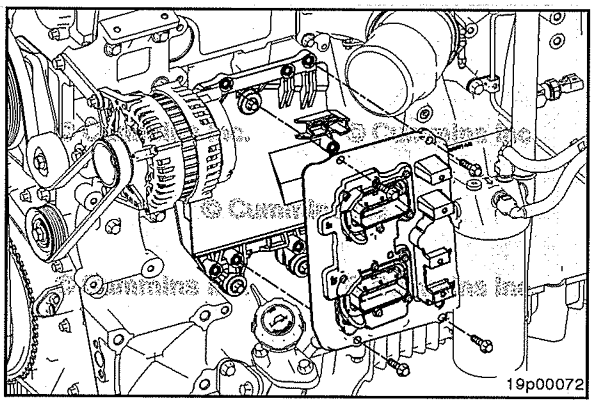


⚠CAUTION⚠
To prevent damage to the ECM connector backshell depress the locking tab prior to lifting the lever. Failure to do so will result in damage to the ECM connector backshell.

Disconnect the OEM harness connector and engine harness connector from the ECM by pressing down on the locking tab (1) and pulling up on the lever (2).



Remove the capscrews that secure the ECM to the ECM mounting plate.



Install

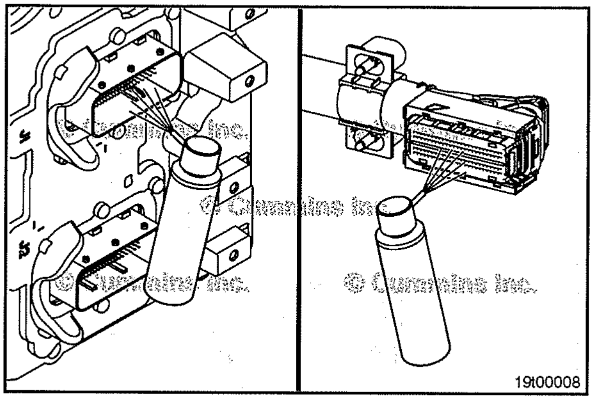
⚠CAUTION⚠

Do not paint the backside of the ECM. Make sure there is no grease or dirt between the ECM and the engine block.

Install the new ECM to the ECM mounting bracket.

Tighten the capscrews.

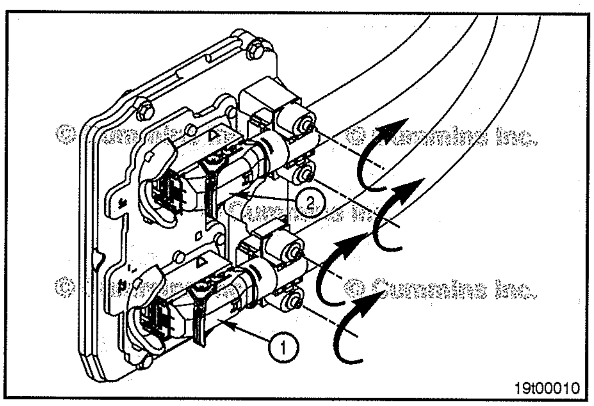
Torque Value: 7.4 N•m [65 in-lb]



⚠CAUTION⚠

Do not blow compressed air into the ECM ports or connectors. Compressed air can contain moisture due to condensation.

Use Cummins® electrical contact cleaner, Part Number 3824510, to remove all dirt and moisture from the ECM connector ports and the harness connectors.



Connect the OEM harness connector (1) and engine harness connector (2) to the ECM by placing the connector into the ECM receptacle. Pull back on the locking lever until the connector is fully seated and the lever locking tab is engaged.

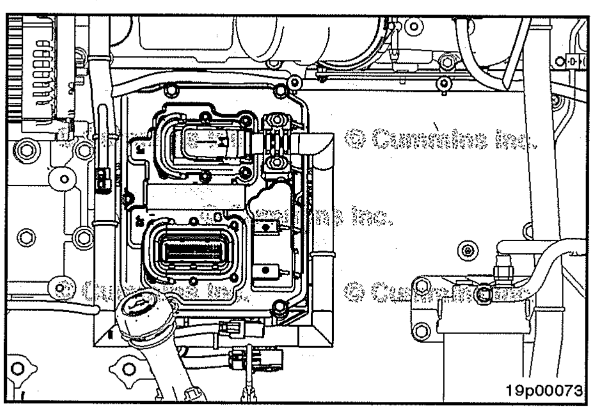
If the wire tie securing the wiring harness to the ECM connector backshell was removed, install a new wire tie.

If the ECM harness clamp was removed, use the following procedure for installation instructions. Refer to Procedure 019-043 in Section 19.

NOTE: Do **not** overtighten the ECM harness clamp capscrews.

Tighten the ECM harness clamp capscrews.

Torque Value: 8 to 10 N•m [71 to 89 in-lb]

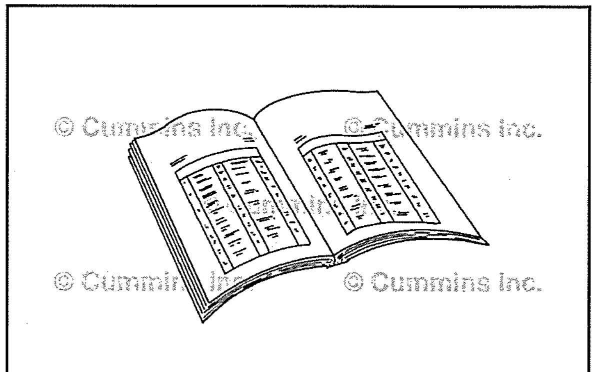


NOTE: When an ECM is replaced, the new ECM **must** be calibrated. Refer to Procedure 019-032 in Section 19.

Use INSITE™ electronic service tool to adjust the following values in the Trip Information section of Features and Parameters after calibrating the ECM.

- ECM Distance Offset
- ECM Time Offset
- Engine Distance Offset
- Engine Time Offset

Finishing Steps



ck800wa

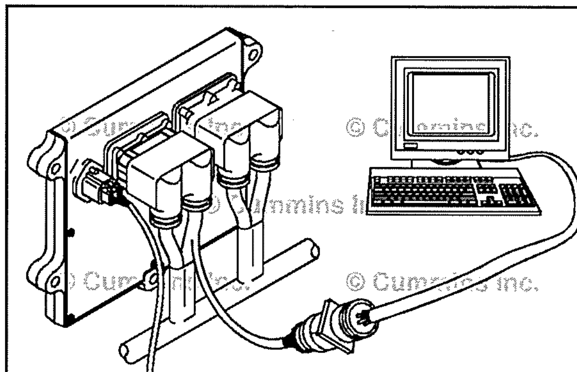
⚠WARNING⚠

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for proper operation.

Engine Control Module Calibration Code (019-032)

General Information



19c01217

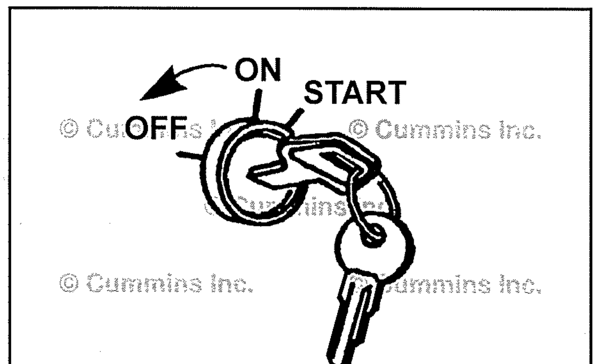
NOTE: Due to the number of various engine control module (ECM) configurations, this procedure has been written to be common. **Not** all illustrations within this procedure will represent the application that is being worked on.

ECM calibrations can be performed by INSITE™ electronic service tool.

After an ECM is replaced or calibrated, the actual engine hours / distance **must** be entered correctly into the ECM.

Record the values of ECM Distance Offset, ECM Time Offset, Engine Distance Offset, and Engine Time Offset prior to replacement or calibration of the ECM. These parameters can be found in the Trip Information section of Features and Parameters.

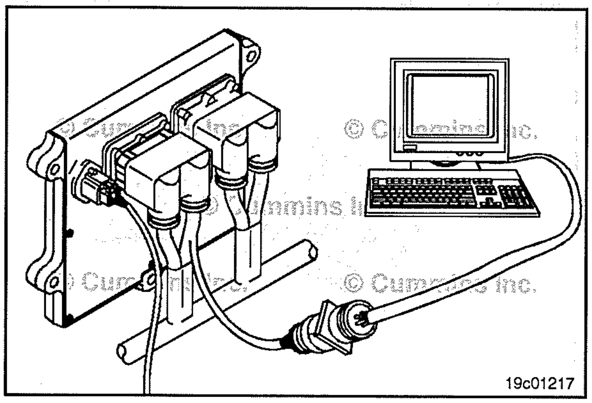
Initial Check



19800470

NOTE: If the tool will **not** communicate with the keyswitch in the ON position, cycle the keyswitch and try again.

The ECM calibration process occurs with the keyswitch turned ON. **Always** follow the instructions on the service tool screens.


19c01217

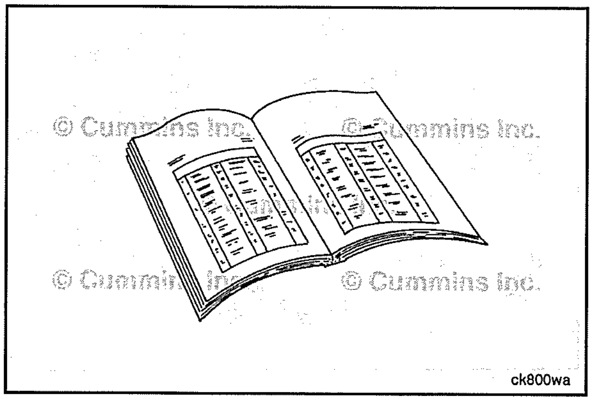
Preparatory Steps

Connect INSITE™ electronic service tool to the service tool data link, which is located on the engine or in the cab.

See the help section within INSITE™ electronic service tool for detailed ECM calibration procedures.

After an ECM is replaced or calibrated, the actual engine hours / distance **must** be entered correctly into the ECM.

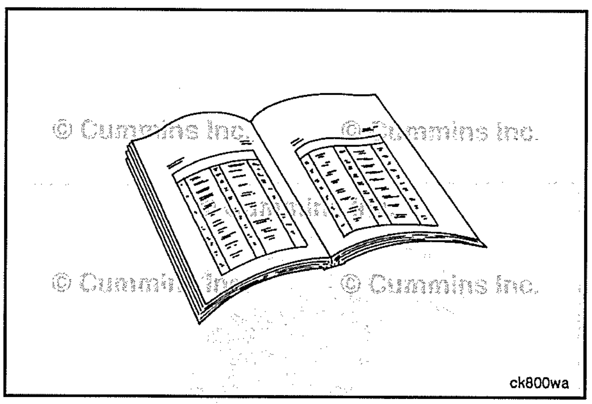
Input the values of ECM Distance Offset, ECM Time Offset, Engine Distance Offset, and Engine Time Offset prior to replacement or calibration of the ECM. These parameters can be found in the Trip Information section of Features and Parameters.


ck800wa

Following calibration download, if new fault codes or fault conditions exist, perform the following steps in order to understand if the calibration is working correctly and is the appropriate calibration for the application.

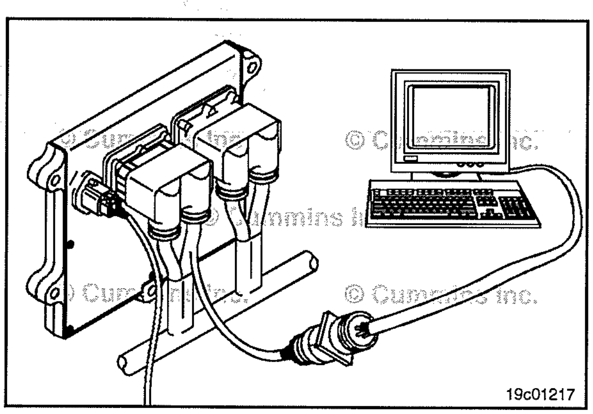
If it is suspected that the calibration is **not** working correctly, make sure that the appropriate calibration was loaded for the engine, equipment, and application.

If no issues are found, no further action is required.


ck800wa

Inspect

Establish if the suspected feature creating the problem is operating correctly. Reference the relevant "Electronic Controlled Fuel System" (Procedure 101-007) in Section 1 of the appropriate Operation and Maintenance Manual or in INSITE™ electronic service tool "Fault Information System" for further information.


19c01217

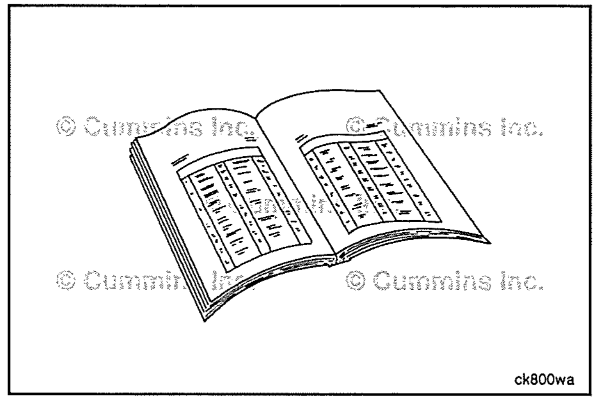
NOTE: To access INSITE™ electronic service tool "Adjustable Engine Features" section, either select Help -> Contents from the menu bar, or press F1 with an individual feature within the Features and Parameters section in INSITE™ electronic service tool highlighted.

Review the INSITE™ electronic service tool help files "Adjustable Engine Features" section to determine if the suspected error is due to an incorrectly set adjustable engine feature.

Use QuickServe™ Online to inspect the calibraton revision history.

1 Log into QuickServe™ Online
2 Select "My Applications"
3 Select "ECM Calibraton Revisions"
4 Enter the calibration code and select "Search"
5 Review the calibration revision information.

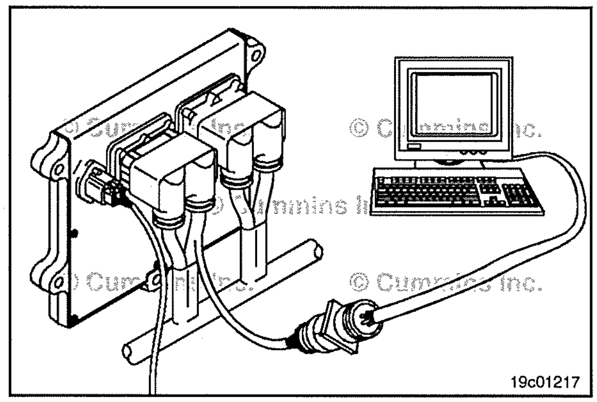
NOTE: The calibration revision history provides information relating to changes made to a calibration each time a new revision is released. This information can be used to establish if there is a commonality between changes made to the calibration and the symptoms being observed. The calibration revision history can also be downloaded in Excel format by selecting “Spreadsheet” in the record filter box.



NOTE: The greater the number of parameters, the slower the rate at which they can be logged. Therefore, **only** log the minimum number of parameters if sample rate is important.

If no issue can be identified using the steps listed above, the following information should be collected to allow the issue to enter the technical escalation chain:

1 Engine specifics engine serial number (ESN), application, rating, engine hours, maintenance history, etc.)
2 ECM codes (the codes before and after, including revision numbers)
3 ECM images (before and after calibration downloads)
4 Data logs (utilize existing, pre-defined parameter groups, found in INSITE™ electronic service tool, or use the relevant wiring diagram to identify if multiple circuits utilize a common supply or ground, or monitor parameters which logically would be linked - i.e. User Fuelling State, Engine Speed, Commanded Fuel Rail Pressure, Measured Fuel Rail Pressure, etc.).



Engine Wiring Harness (019-043)

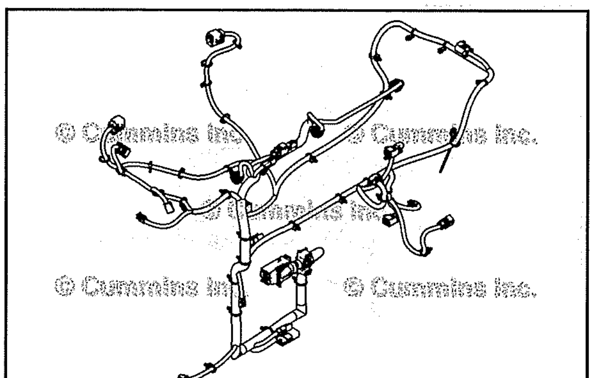
General Information

⚠CAUTION⚠

Never stretch the wiring harness to connect the harness to another connector. Damage to the wiring harness will result.

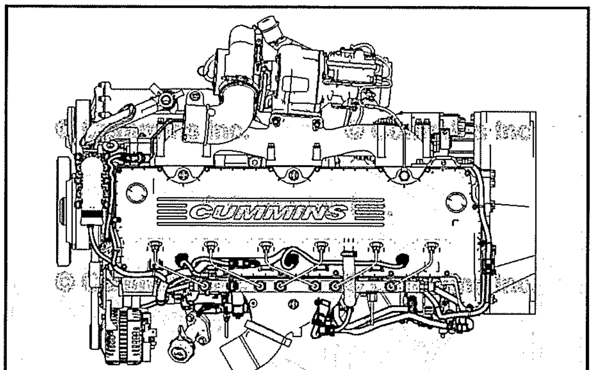
Install the harness to the engine. Start by loosely laying the harness over the engine, starting with the ECM connectors, then routing the harness to the engine sensors. Attach the harness at the proper points/locations called out in the following illustrations.

Use the instructions at the beginning of the Remove section in this procedure and the high level harness routing diagrams and attachment points (circled) in the following illustrations.



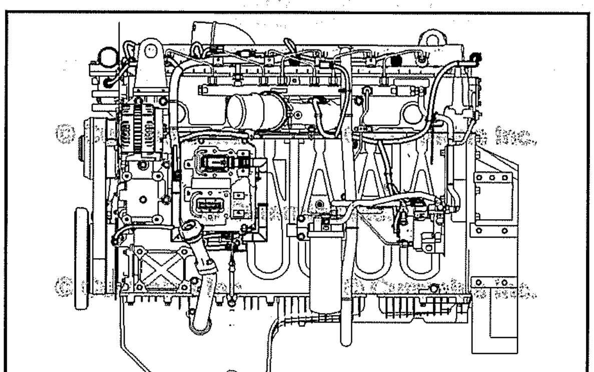
19p00076

This illustration is the main engine wiring harness.



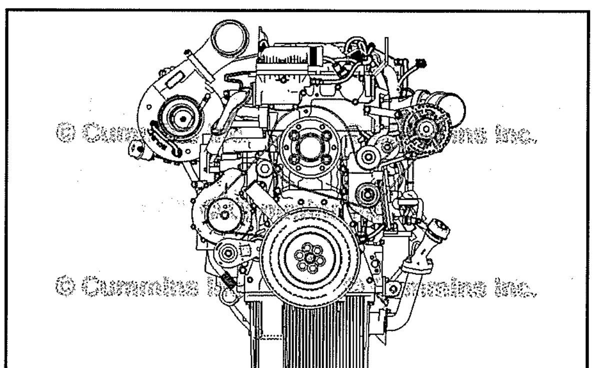
19p00077

This illustration is a top view of the main engine wiring harness.



19p00078

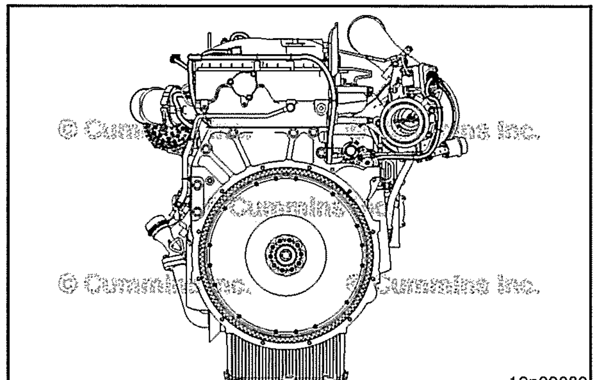
This illustration is a left (cold) side view of the main engine wiring harness.



19p00079

This illustration is a front view of the main engine wiring harness.

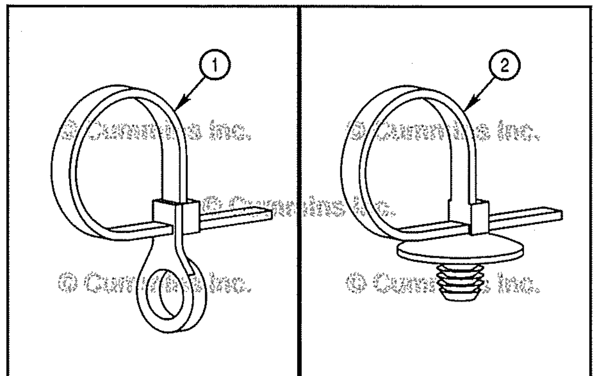
This illustration is a rear view of the main engine wiring harness.



19p00080

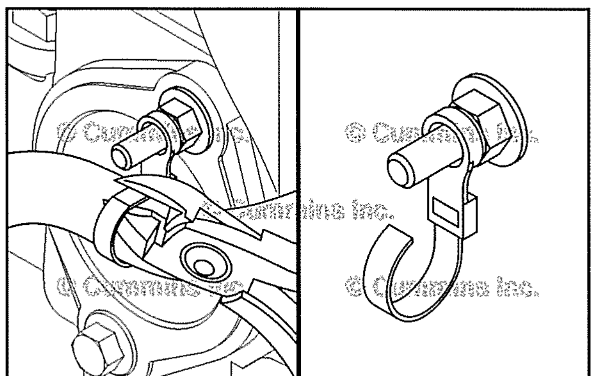
There are two types of connectors used:

- Eyelet style (1) - pushes over a doubled ended stud
- Fir Tree style (2) - pushes into a threaded hole.



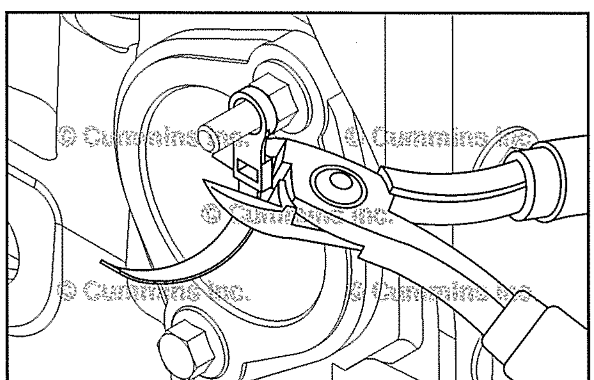
19o00002

To remove the eyelet style, cut the wire tie near the latch of the wire tie so you are left with the wire tie that is illustrated.

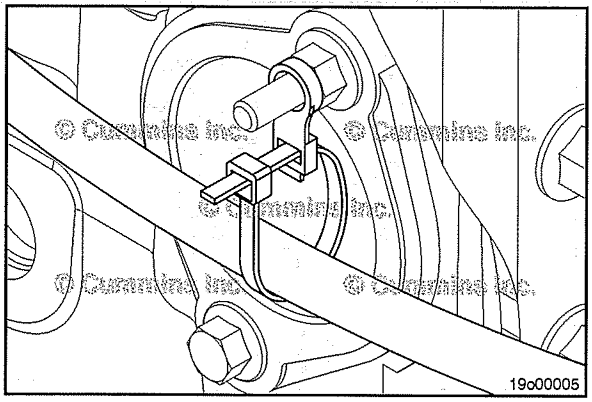


19o00003

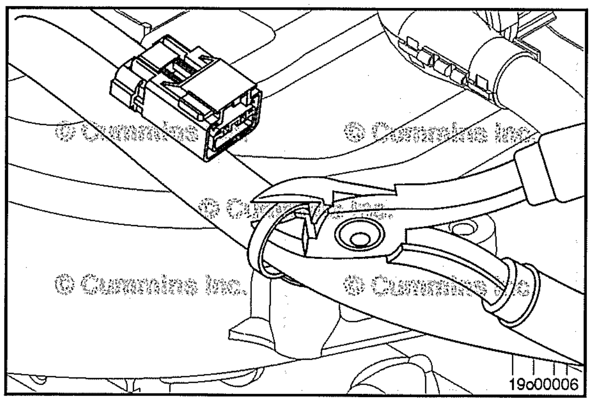
To use the same eyelet, cut off the excess wire tie.



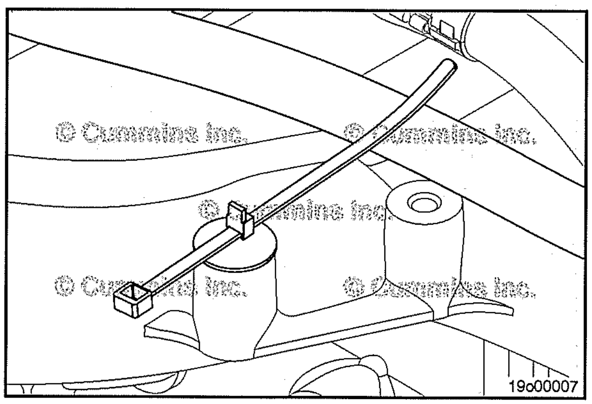
19o00004



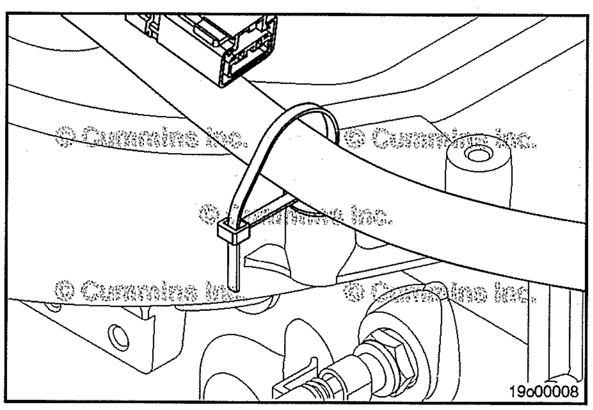
Thread a new wire tie through the existing slot on the eyelet and fasten it around the harness.



To remove the fir tree style, cut the wire tie and remove it from the fir tree connector.

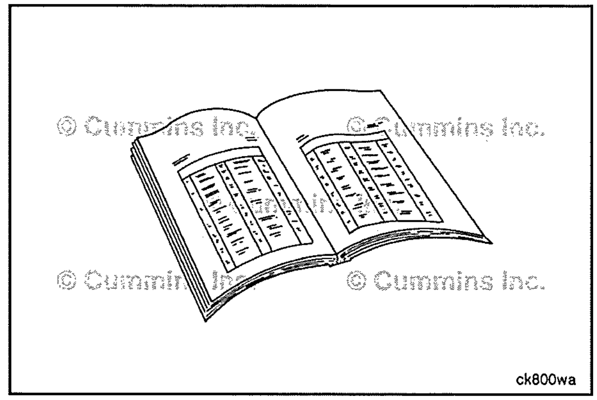


Thread a new wire tie through the slot in the fir tree connector.



If required, both styles of connectors can be removed after the wire tie is cut by turning the connector **counterclockwise**.

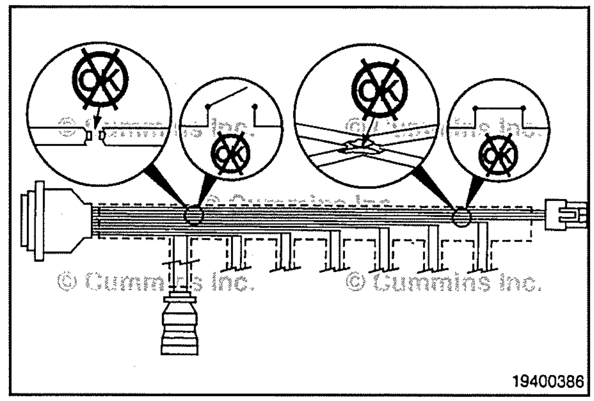
Preparatory Steps



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

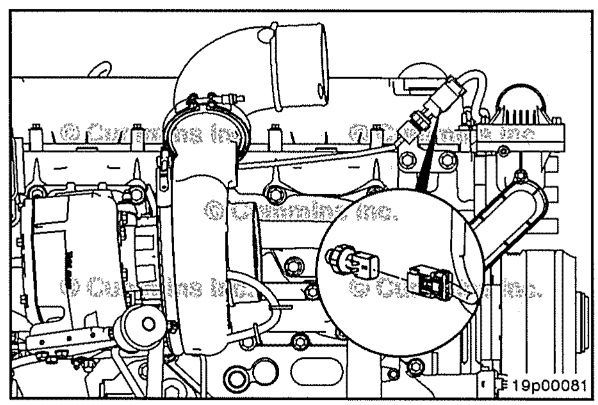
- Disconnect the batteries. See equipment manufacturer service information.

Remove

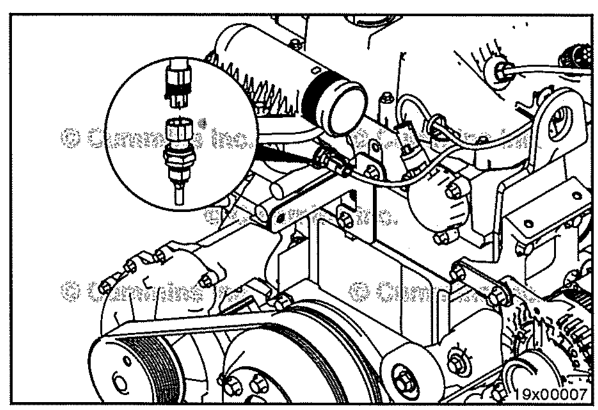


Replace the engine harness if there is an open or short circuit found under the protective covering of the harness body.

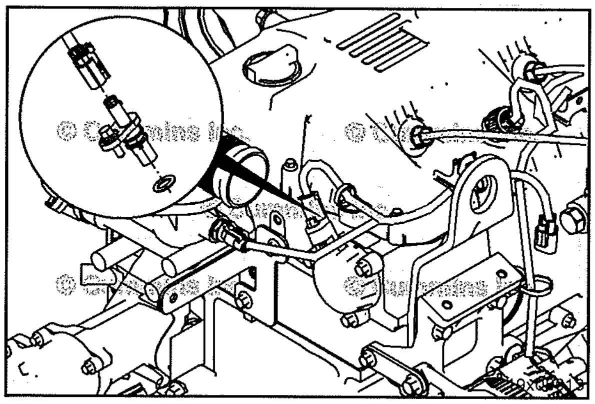
Damaged connectors can be replaced with service repair components.



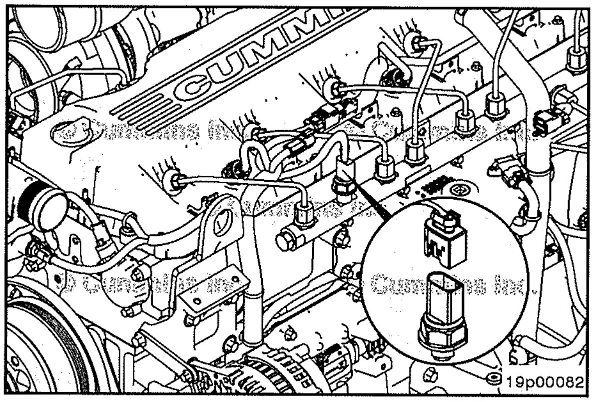
Disconnect the exhaust manifold pressure sensor electrical connector.



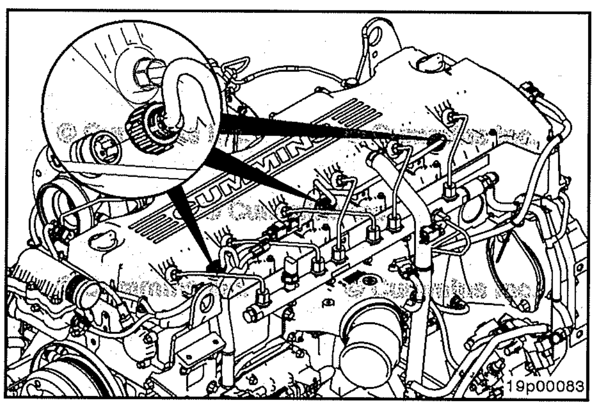
Disconnect the coolant temperature sensor electrical connector.



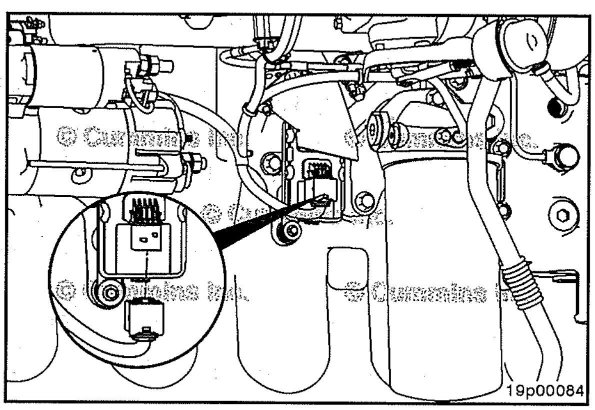
Disconnect the camshaft position sensor electrical connector.



Disconnect the fuel rail pressure sensor electrical connector.

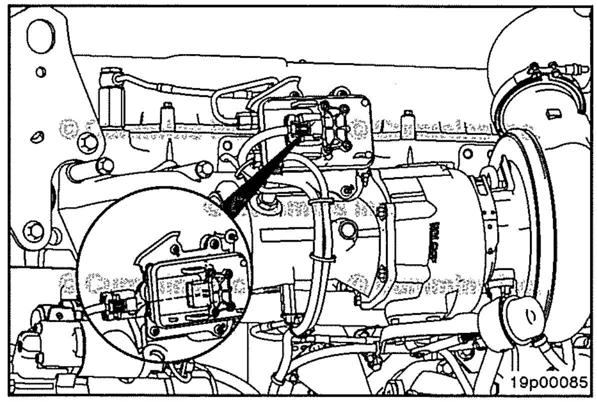


Disconnect the three injector passthrough electrical connectors.

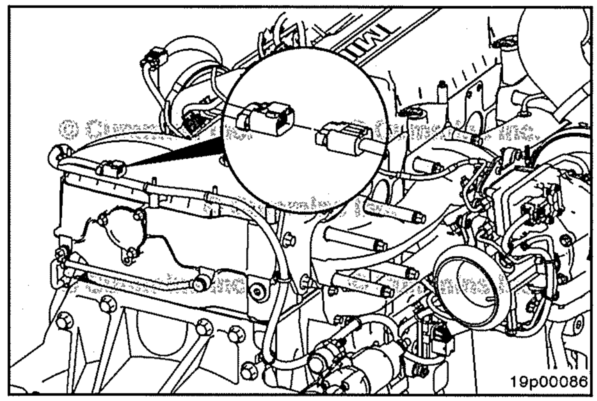


Disconnect aftertreatment intake NOx sensor electrical connector.

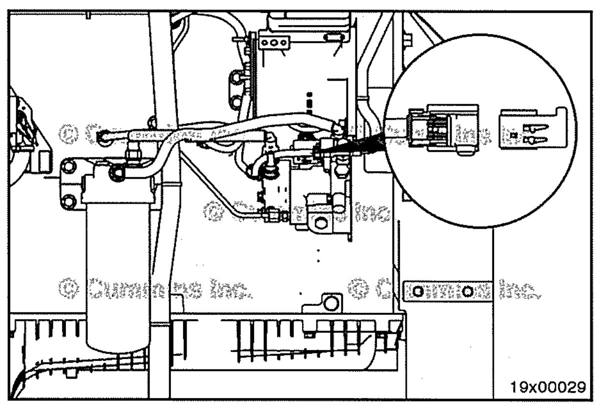
Disconnect exhaust pressure regulator electrical connector.



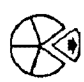
Disconnect temperature and barometric air pressure sensor at rear of head.

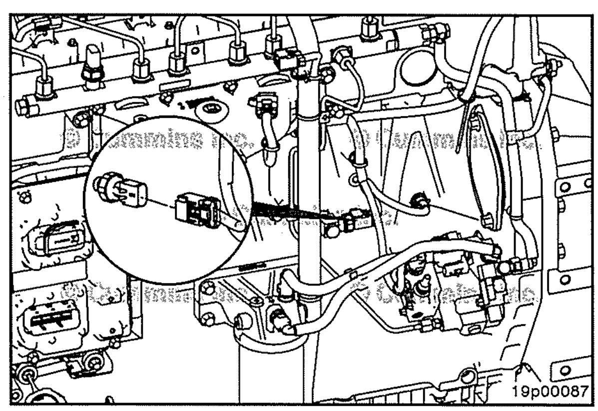


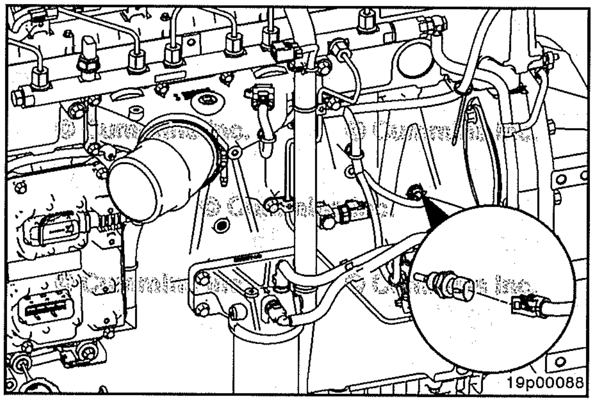
Disconnect the fuel pump actuator electrical connector.



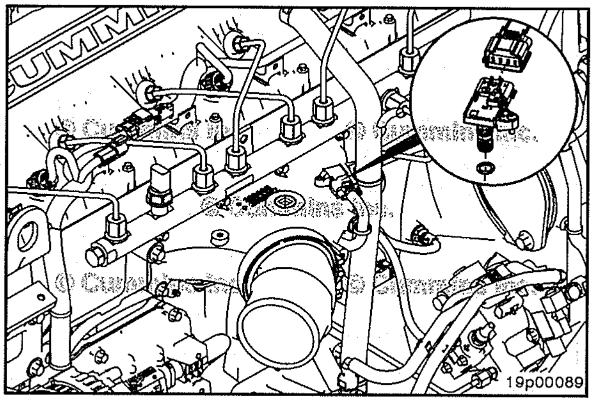
Disconnect the lubricating oil pressure sensor electrical connector.



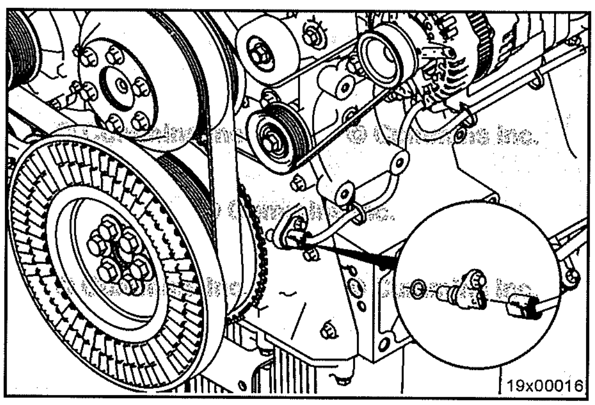




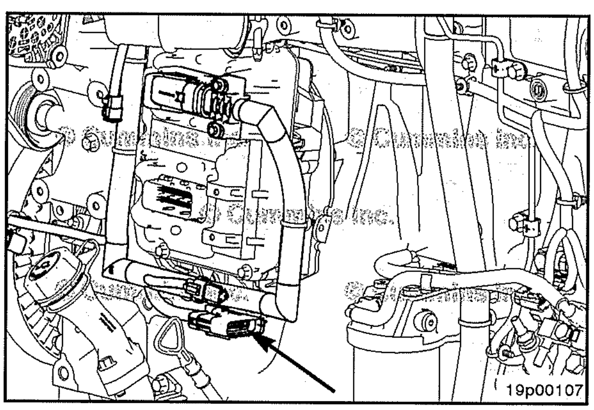
Disconnect the lubricating oil temperature sensor electrical connector.



Disconnect the intake manifold temperature/pressure sensor electrical connector.



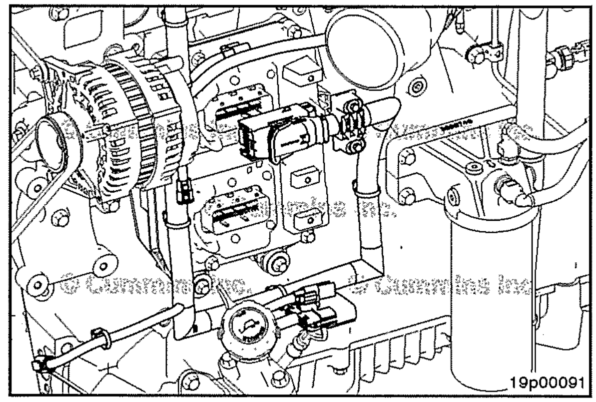
Disconnect the crankshaft position sensor electrical connector.



Disconnect OEM crossover connector.

Disconnect engine wiring harness from ECM.

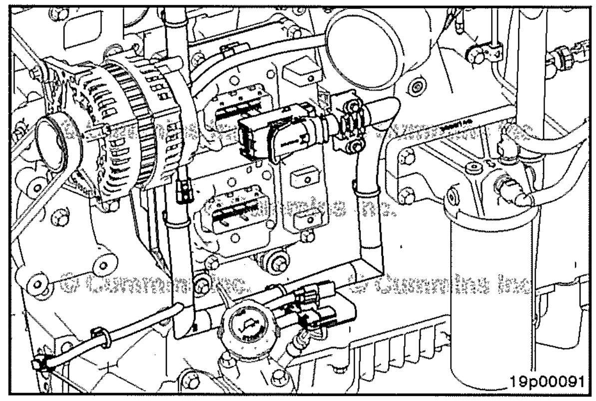
Remove the engine wiring harness from the engine.



19p00091

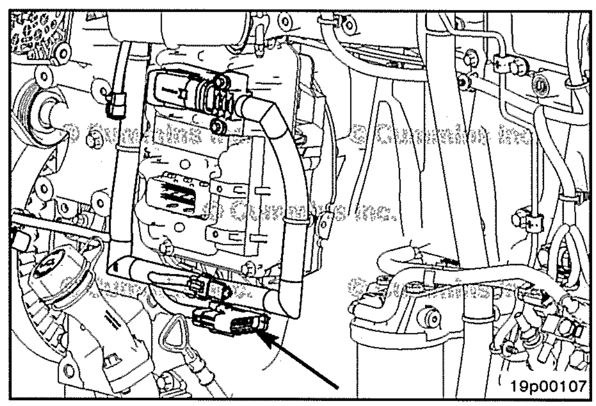
Install

Install the engine wiring harness ECM electrical connector.



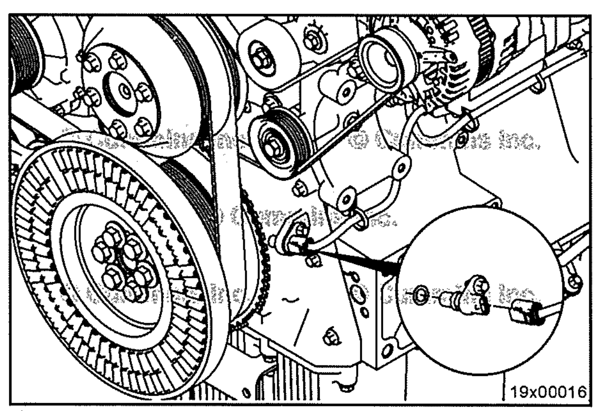
19p00091

Connect OEM crossover connector.

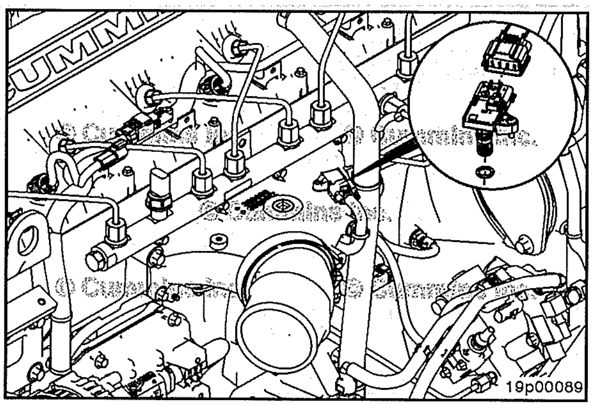


19p00107

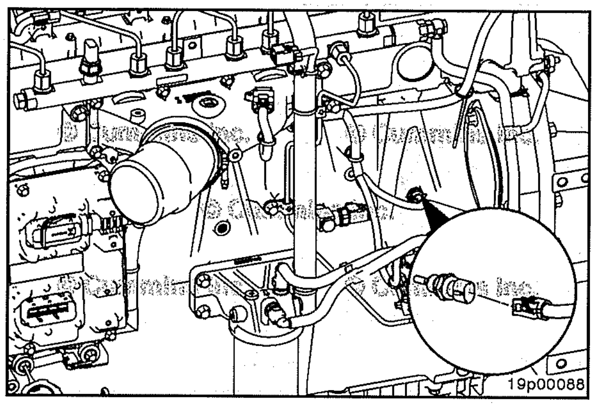
Connect the crankshaft position sensor electrical connector.



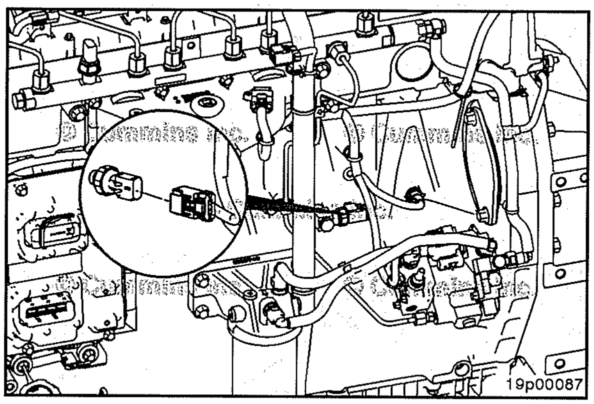
19x00016



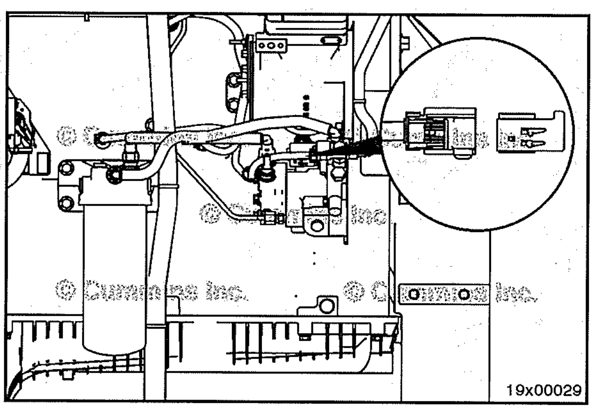
Connect the intake manifold temperature/pressure sensor electrical connector.



Connect the lubricating oil temperature sensor electrical connector.

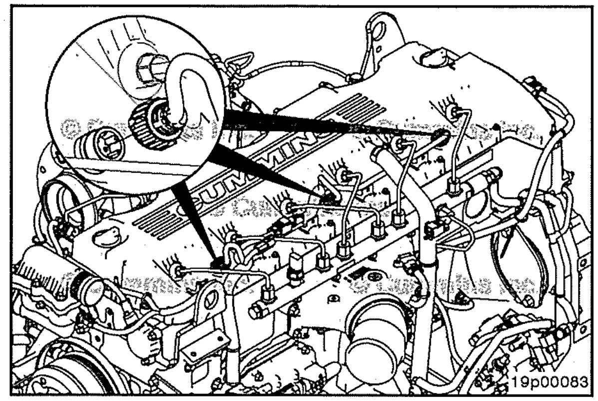


Connect the lubricating oil pressure sensor electrical connector.

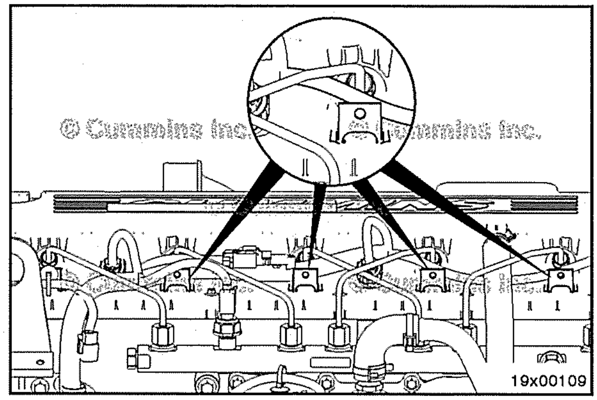


Connect the fuel pump actuator electrical connector.

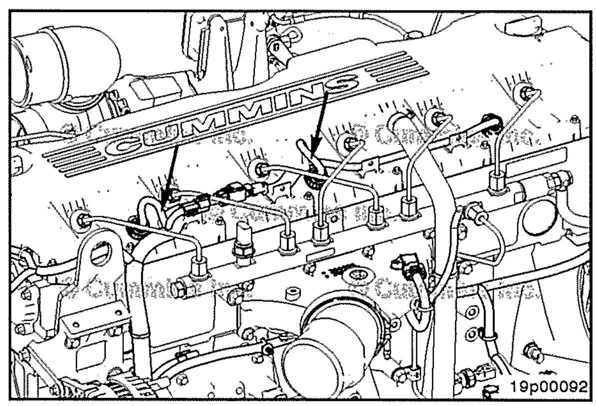
Connect the three injector passthrough electrical connectors.



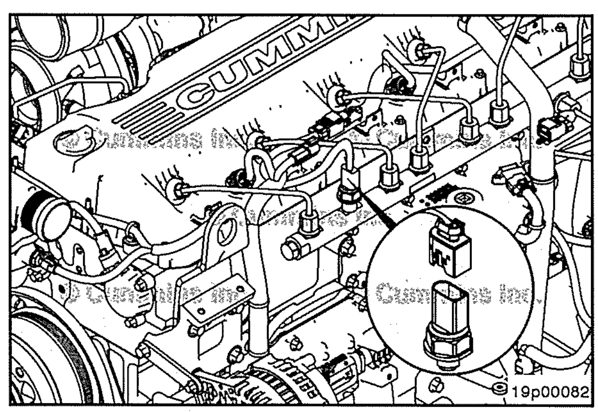
Ensure that the injector wiring harness is UNDERNEATH the fuel lines and zip tied behind the plastic tabs on the valve cover.

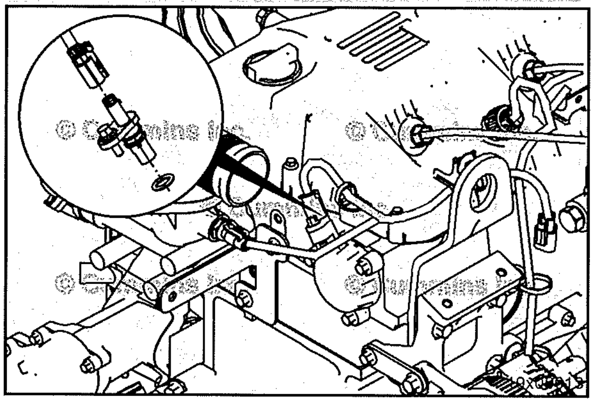


Wire tie injector branches to main harness branch.

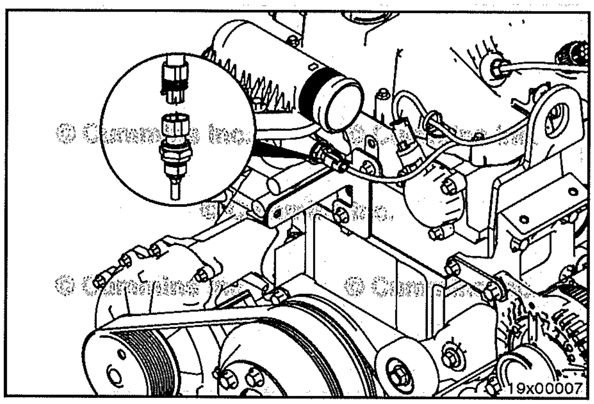


Connect the fuel rail pressure sensor electrical connector.

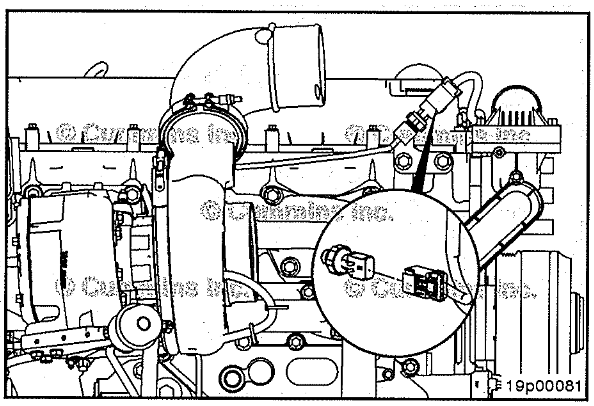




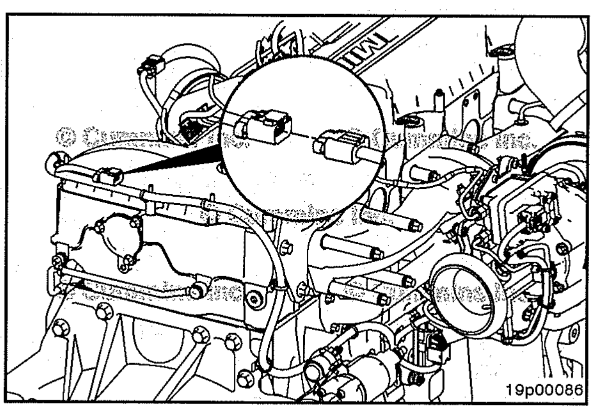
Connect the camshaft position sensor electrical connector.



Connect the coolant temperature sensor electrical connector.

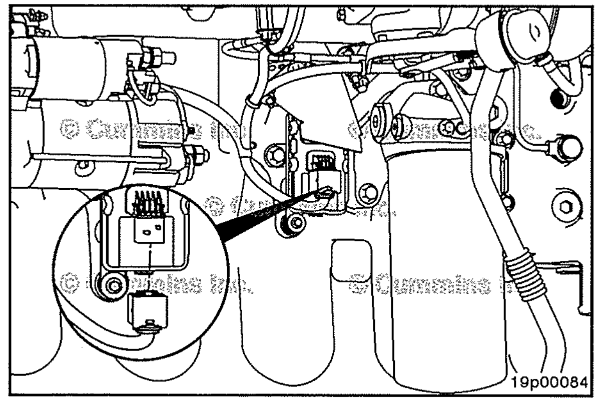


Connect the exhaust manifold pressure sensor electrical connector.

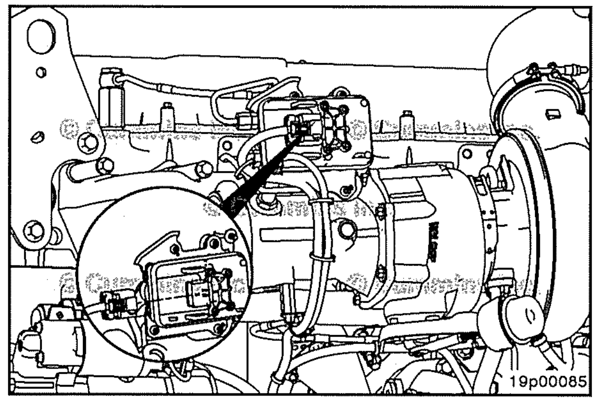


Connect temperature and barometric air pressure sensor at rear of head.

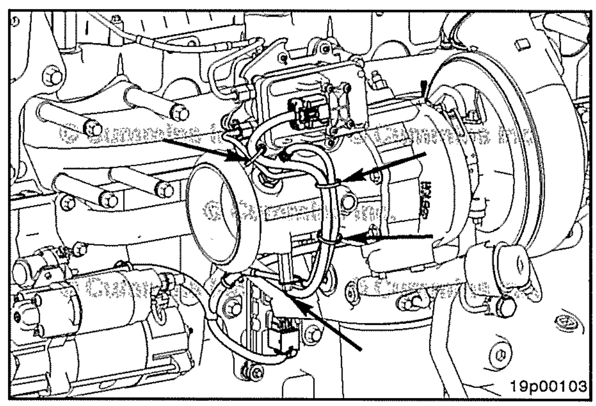
Connect aftertreatment intake NOx sensor electrical connector.



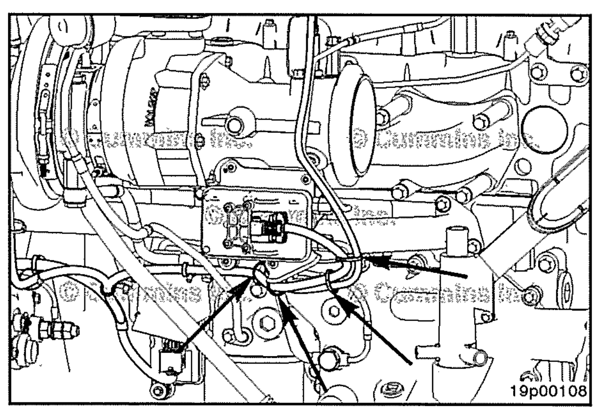
Connect exhaust pressure regulator electrical connector.

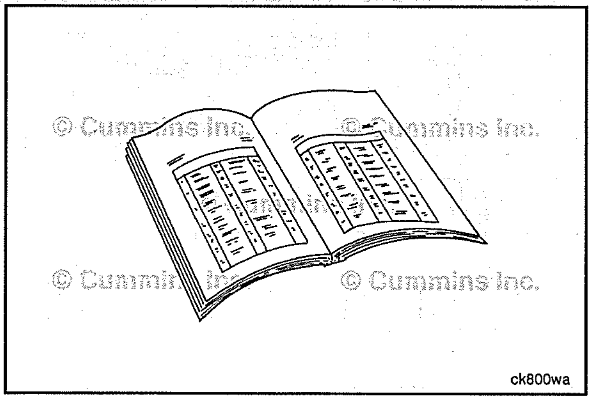


Wire tie wiring harness and intake NOx sensor wires to coolant line in locations shown for rear out turbo configuration. Use high temperature zip ties.



Wire tie wiring harness and intake NOx sensor wires to coolant line in locations shown for front out turbo configuration. Use high temperature zip ties.





Finishing Steps

⚠WARNING⚠

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for active fault codes.

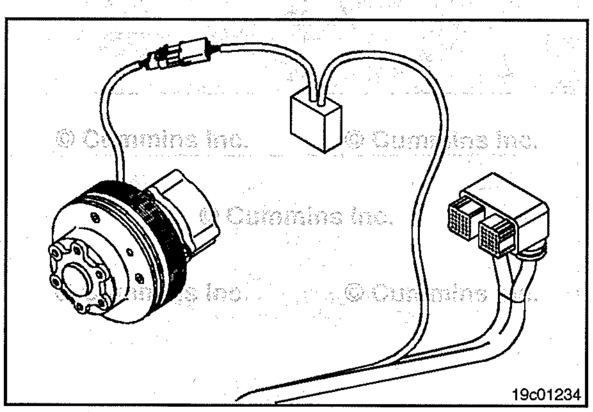
Fan Control Circuit (019-045)

General Information

NOTE: Due to the number of various electronic control module (ECM) configurations, this procedure has been written to be common. Not all illustrations within this procedure will represent the application that is being worked on.

The ECM can control the fan clutch activation. The ECM energizes the air valve solenoid, which in turn controls the fan clutch.

Refer to OEM service manual for more information on troubleshooting and repair of the fan control wiring.



The fan control circuit resides in the original equipment manufacturer (OEM) harness. The fan control signal wire is in the OEM connector on the ECM. The fan control signal wire leads to the fan clutch air solenoid through the OEM wiring harness. The fan control signal is grounded through the clutch body/engine block ground.

Resistance Check

⚠CAUTION⚠

Do not use probes or leads other than, Part Number 3822758. The connector will be damaged. The leads must fit tightly in the connector without expanding the pins of the connector.

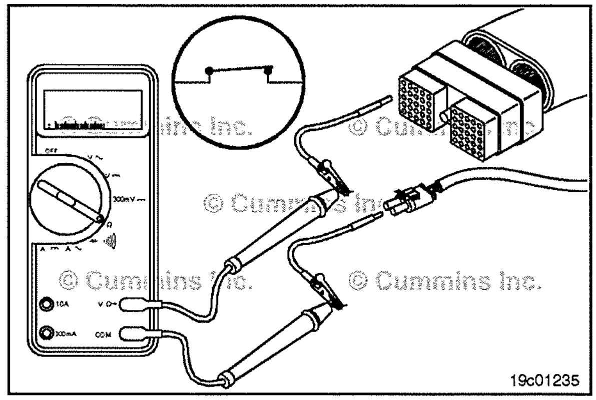
Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Disconnect the OEM wiring at the fan control solenoid.

Insert a test lead into the fan control signal pin of the OEM harness connector and connect it to the multimeter probe.

Touch the other multimeter probe to the connector terminal of the fan clutch solenoid. Make sure the fan clutch solenoid is disconnected.

Measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is closed, it **must** still be checked for a short circuit to ground and a short circuit from pin-to-pin. If the circuit is **not** closed, there is a connection problem or an open circuit in the wiring harness.



19c01235

Check for Short Circuit from Pin to Pin

Check for a short circuit between the fan control signal pin and all of the other pins in the OEM harness. Make sure the fan control solenoid is disconnected. Make sure the battery voltage supply is disconnected.

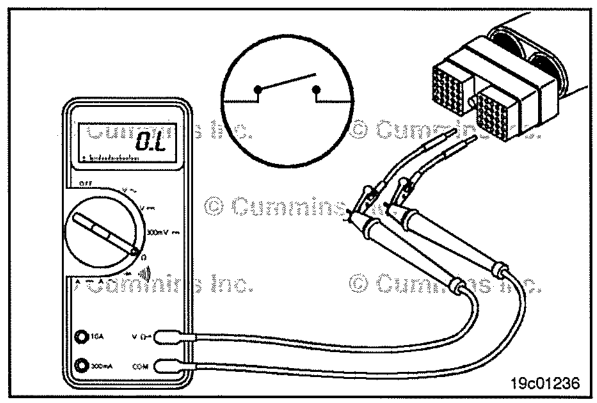
Insert a test lead into the fan control signal pin of the OEM harness connector. Insert the other test lead into all of the other pins of the OEM harness connector, one at a time.

Measure the resistance.

The multimeter **must** show an open circuit (more than 100k ohms).

If the circuit is **not** open, there is a short circuit between the fan control signal pin and any pins that measured a closed circuit.

Repair or replace the OEM wiring harness.



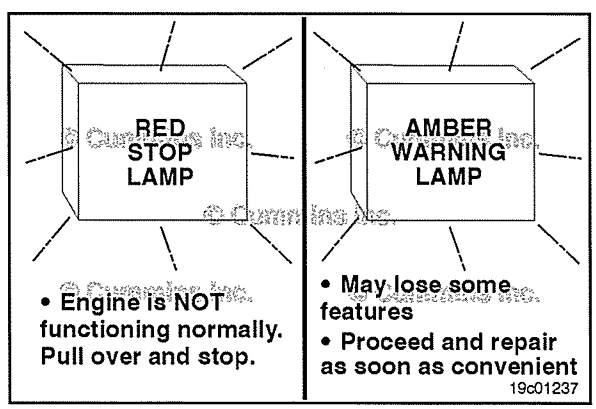
19c01236

Fault Lamp (019-046)

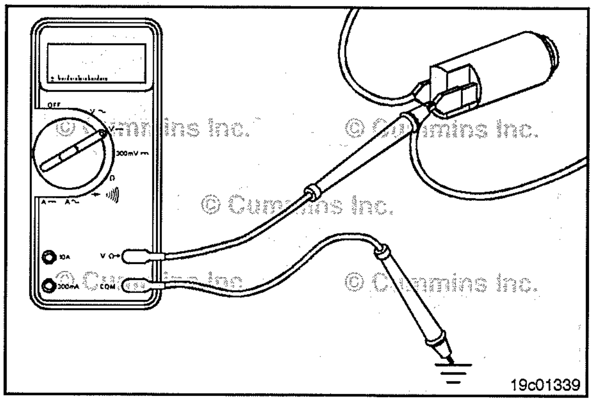
General Information

The fault code warning lamps let the operator know when a part or a system fault is detected. The amber lamp can have the word WARNING printed on it. The red lamp can have the word STOP printed on it

The fault code lamp circuits consist of the light bulb, lamp signal output, and VDC supply from the keyswitch circuit.



19c01237



Voltage Check

Measure the voltage between each fault lamp and ground.

Turn the keyswitch to the ON position.

Touch the positive (+) multimeter probe to the amber warning lamp signal terminal.

Touch the negative (-) multimeter probe to the chassis ground. Measure the voltage.

Repeat this check for the other terminal of the amber fault lamp. The multimeter **must** show the battery voltage.

Touch the positive (+) multimeter probe to the red stop lamp signal terminal.

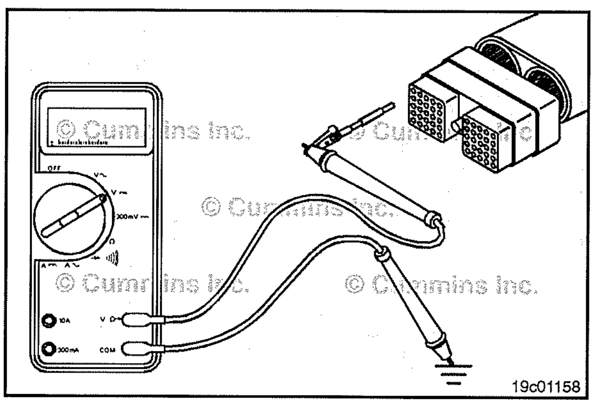
Touch the negative (-) multimeter probe to chassis ground.

Measure the voltage.

Repeat this check for the other terminal of the red fault lamp. The multimeter **must** show battery voltage.

If battery voltage is **not** present, there is a problem with the keyswitch line or the lamp has failed. Refer to the OEM troubleshooting and repair manual for repair procedures.

Connect all components after the repair is complete.



Fault Lamp Circuit (019-047)

Voltage Check

⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Turn the keyswitch to the ON position. Adjust the multimeter to measure VDC. Insert the multimeter lead into the amber warning lamp signal pin and attach it to the multimeter probe. Touch the other multimeter probe to the engine block. Read the display on the multimeter.

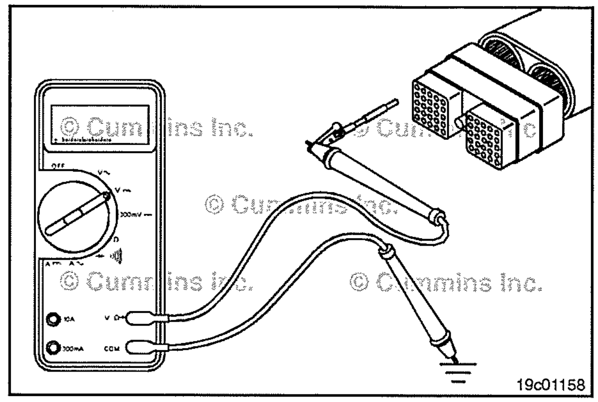
The multimeter **must** show battery voltage. If battery voltage is **not** present, there is a problem with an OEM harness wire, provided the amber warning lamp has previously been checked.

Refer to the OEM troubleshooting and repair manual for repair procedures.

Remove the lead from the amber warning lamp signal pin and insert it into the malfunction indicator lamp (MIL) signal pin. Touch the other multimeter probe to the engine block.

The multimeter **must** show battery voltage. If battery voltage is **not** present, there is a problem with the malfunction indicator lamp (MIL) OEM harness wire, provided the malfunction indicator lamp (MIL) has been previously checked.

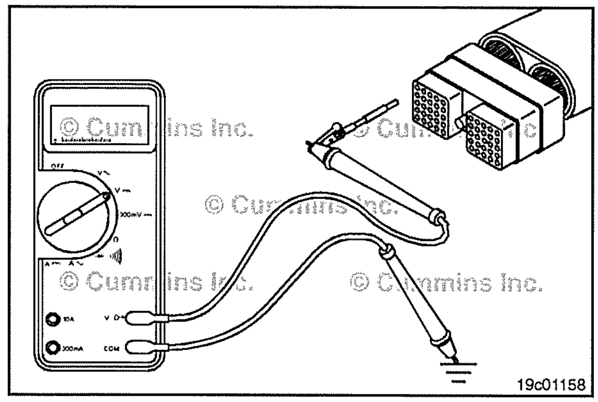
Refer to the OEM troubleshooting and repair manual for repair procedures.



Remove the lead from the malfunction indicator lamp (MIL) signal pin and insert it into the red stop lamp signal pin. Touch the other multimeter probe to the engine block.

The multimeter **must** show battery voltage. If battery voltage is **not** present, there is a problem with the red stop lamp OEM harness wire, provided the red stop lamp has been previously checked. Refer to the OEM troubleshooting and repair manual for repair procedures.

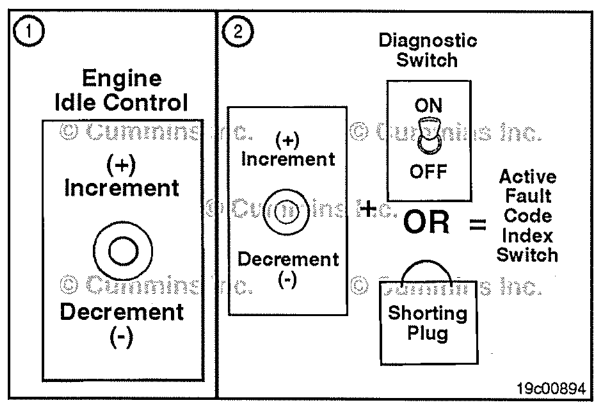
Connect all components after completing the repair.



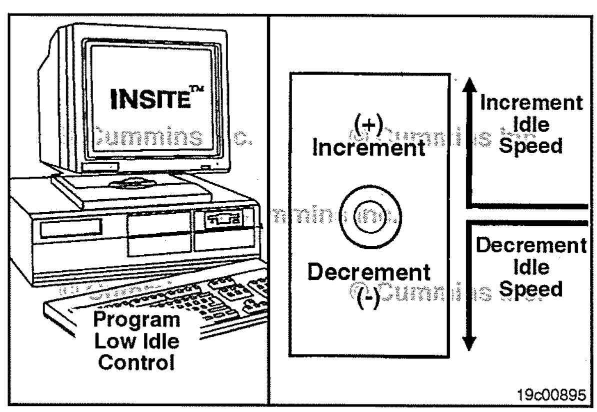
Idle Adjust Switch (019-052)

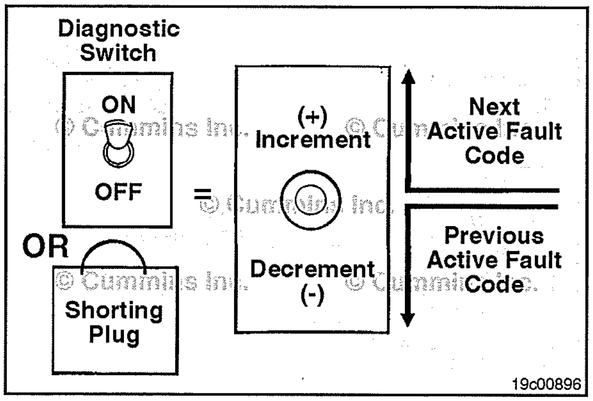
General Information

The idle adjustment feature is a part of the cruise control set/resume multi-functionality switch. Moving the switch to the set position increases the low idle speed and moving the switch to the resume position decreases the low idle speed.

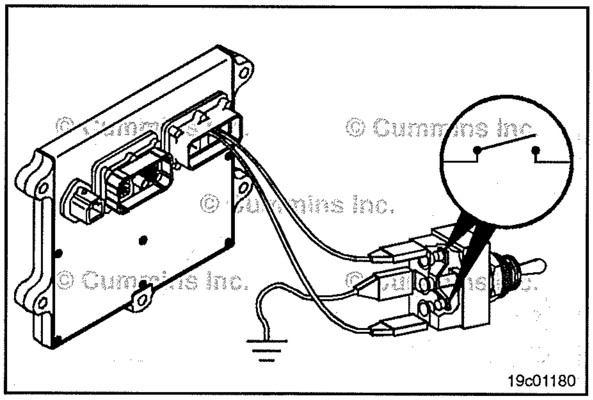


Depending on how the switch is configured, moving the switch in one direction will increase the low idle speed.

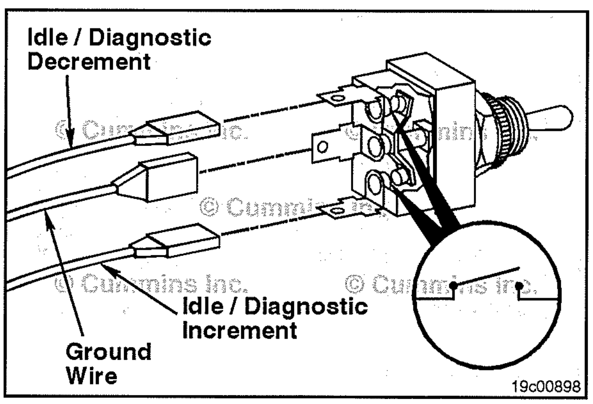




Push the diagnostic switch to the ON position or install the shorting plug. After the first active fault code has flashed out, push the idle adjust switch positive (+) up to advance to the next active fault code. Push the switch again until all of the active fault codes have been recorded.



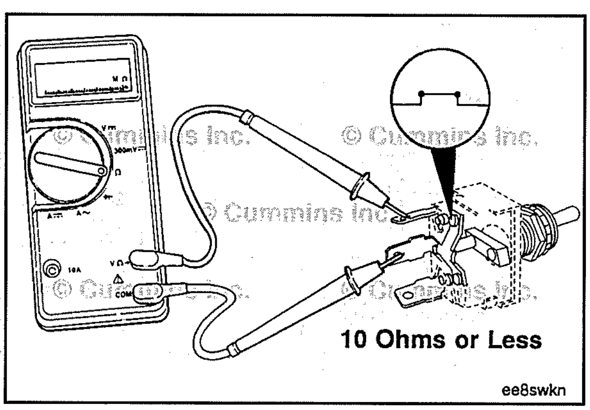
The idle adjust switch circuit consists of the idle/diagnostics increment signal, the idle/diagnostics decrement signal, the return wire, and the two-position switch located in the vehicle.



Resistance Check

If an electronic service tool is available, monitor the idle adjust switch for proper operation. If **not,** follow the troubleshooting procedures in this section.

Remove the three electrical connectors from the switch. Label the wires with the switch location and the circuit name.

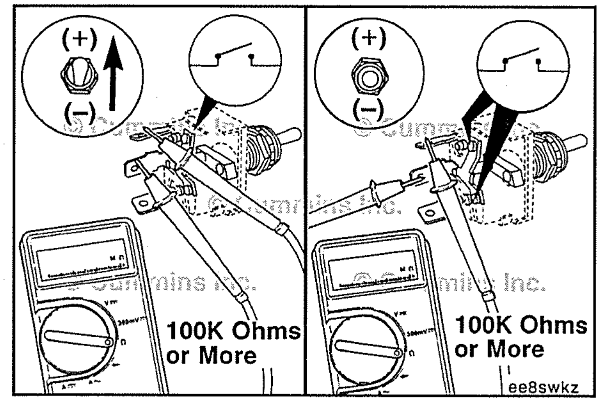


Touch one probe of the multimeter to the center terminal of the switch.

Touch the other probe to the cruise control/PTO resume/accelerate switch signal terminal of the switch.

Hold the idle adjust switch in the positive (+) increment position. The multimeter **must** show an open circuit (100k ohms or more) when the switch is held in the positive (+) increment position and after it is released. If the circuit is **not** open, the switch has failed.

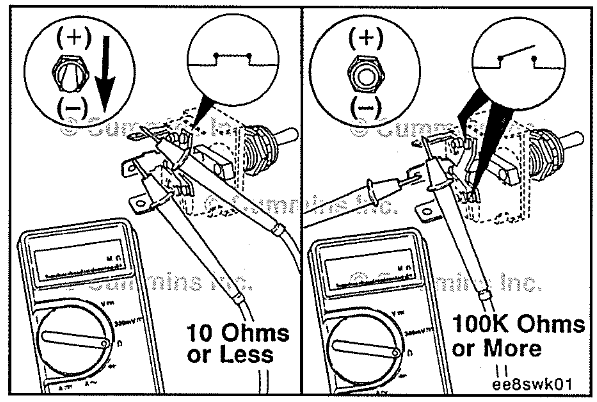
Refer to the OEM troubleshooting and repair manual for the replacement procedures.



Hold the switch in the negative (-) decrement position. The multimeter **must** show a closed circuit (10 ohms or less) when the switch is held in the negative (-) decrement position.

When the switch is released, it **must** show an open circuit (100k ohms or more). If the multimeter does **not** show the correct values, the switch has failed.

Refer to the OEM troubleshooting and repair manual for the replacement procedures.

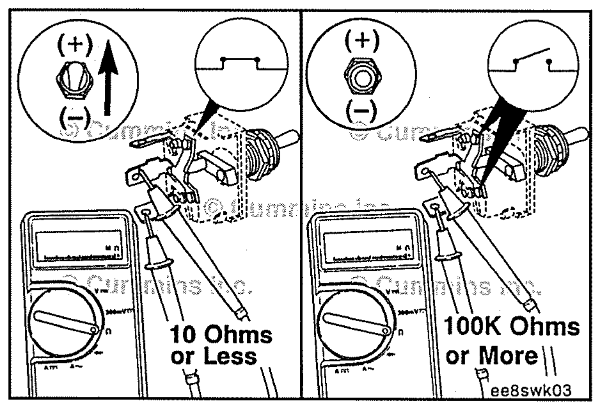


Move the electrical lead from the cruise control/PTO resume/accelerate switch signal terminal to the cruise control/PTO set/coast switch signal terminal.

Hold the idle adjust switch in the positive (+) increment position. The multimeter **must** show a closed circuit (10 ohms or less) while the switch is held in the positive (+) increment position.

When the switch is released, the multimeter **must** show an open circuit (100k ohms or more). If the multimeter does **not** show the correct values, the switch has failed.

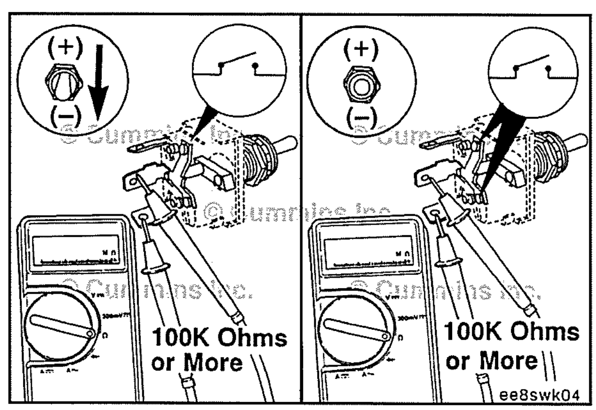
Refer to the OEM troubleshooting and repair manual for the replacement procedures.

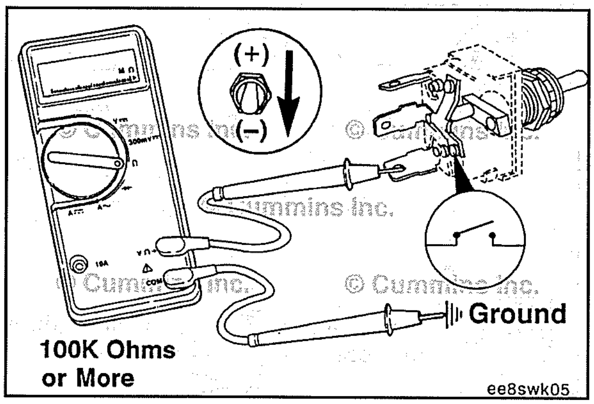


Move the idle adjust switch to the negative (-) decrement position. The multimeter **must** show an open circuit (100k ohms or more) when the switch is held in the negative (-) decrement position and when it is released. If the circuit is **not** open, the switch has failed.

Refer to the OEM troubleshooting and repair manual for the replacement procedures.

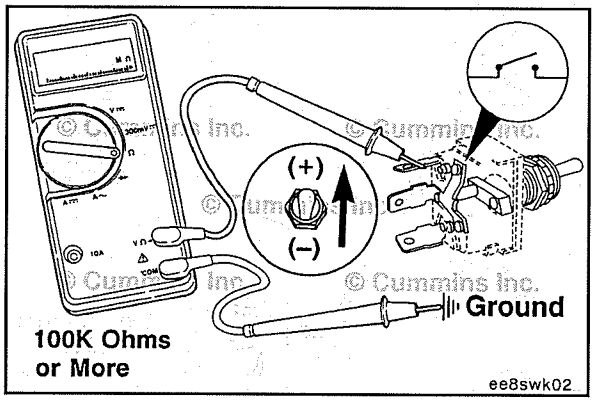
If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.



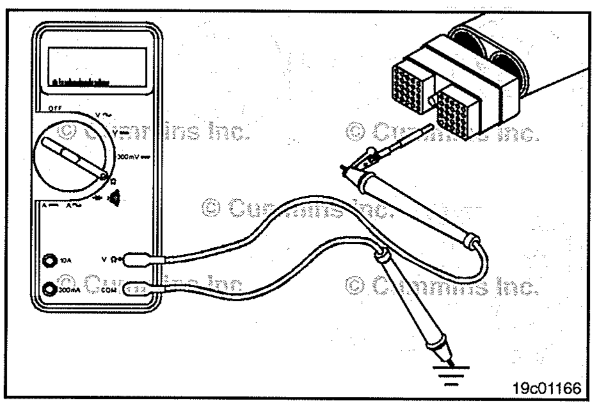


Check for Short Circuit to Ground

Touch one multimeter probe to the cruise control PTO set/coast switch signal terminal of the switch and touch the other multimeter probe to chassis ground. Move the idle adjust switch to the negative (-) decrement position then to the positive (+) increment position. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more) when the switch is in all positions. If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.



Check for a short circuit to ground. Remove the multimeter probe from the cruise control/PTO set/coast switch signal terminal and touch it to the cruise control/PTO resume/accelerate switch signal terminal of the switch. Keep the other multimeter touching chassis ground. Move the switch to the positive (+) increment position then to the negative (-) decrement position. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more) when the switch is in all positions. If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures. If the switch passes all of the previous checks, the switch circuit **must** be checked.



Idle Adjust Switch Circuit (019-053)

Resistance Check

⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

NOTE: The idle/diagnostic increment/decrement switch is the cruise control/PTO/set/resume select switch.

If electronic service tool is available, monitor the idle adjust switch circuit for proper operation. If **not,** follow the troubleshooting procedures in this section.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

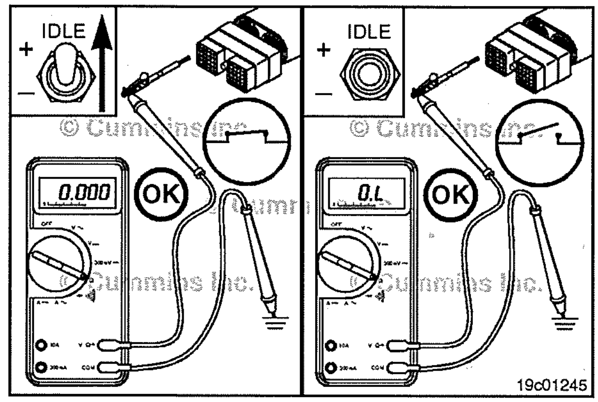
Insert the pin of the test lead into the cruise control/PTO set/coast switch signal in the OEM harness connector. Measure the resistance from the cruise control/PTO set/coast switch signal to the engine block.

Hold the idle adjust switch in the positive (+) increment position.

If the OEM connected the return wire to chassis ground the multimeter **must** show a closed circuit (10 ohms or less) while holding the switch on and return to an open circuit (100K ohms or more) when the switch is released. The circuit **must** remain an open circuit when the switch is in the decrement negative (-) position.

If the OEM connected the return wire to the ECM OEM connector the multimeter **must** show an open circuit (100k ohms or more) while holding the switch on and return to a closed circuit (10 ohms or less) when the switch is released. The circuit **must** remain a closed circuit when the switch is in the decrement negative (-) position.

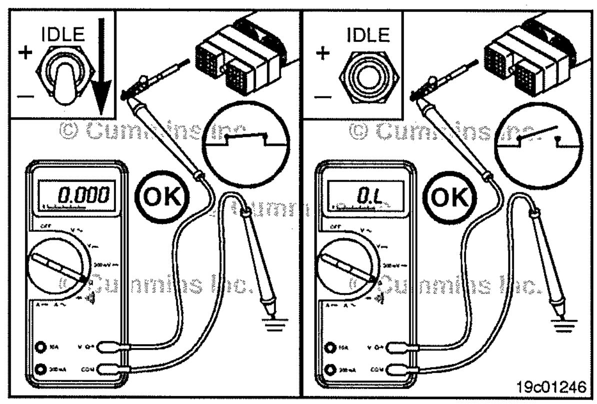
If the resistance values are **not** correct, make sure the return wire and the cruise control/PTO set/coast switch signal wire are properly installed on the idle adjust switch. If both wires are correctly installed, inspect the return wire and the cruise control/PTO set/coast switch signal wire for open circuits, provided the idle adjust switch has been previously checked for short circuits to ground.



Remove the lead from the cruise control/PTO set/coast switch signal and insert it into the cruise control/PTO resume/accelerator switch signal.

Hold the idle adjust switch in the negative (-) decrement position. The multimeter **must** show a closed circuit (10 ohms or less) when the switch is held in the decrement position and an open circuit (100K ohms or more) when the switch is released. The circuit **must** remain an open circuit when the switch is in the positive (+) increment position.

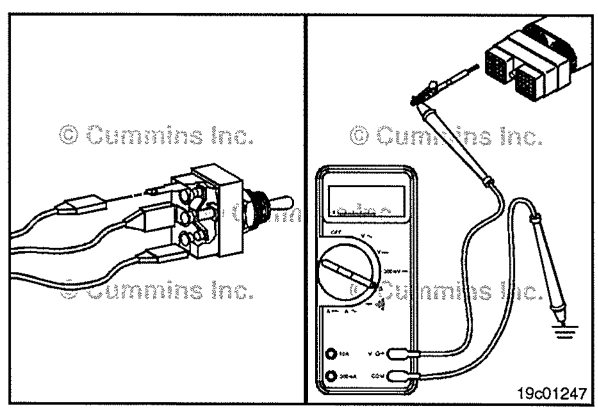
If the resistance values are **not** correct, make sure the cruise control/PTO resume/accelerator switch signal wire is properly installed on the idle adjust switch. If the cruise control/PTO resume/accelerator switch signal wire is properly installed on the idle adjust switch, inspect the cruise control/PTO resume/accelerator switch signal wire for an open circuit, provided the idle adjust switch has been previously checked for short circuits to ground.

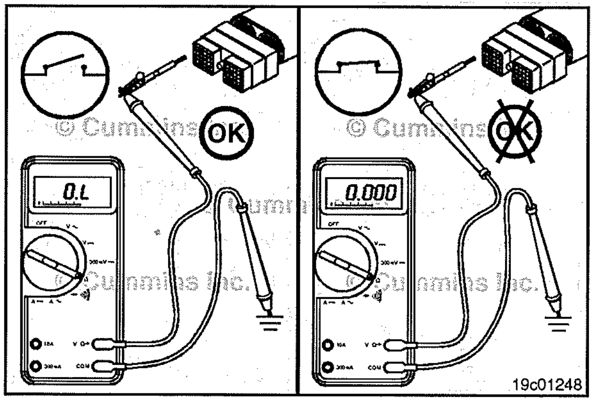


Check for Short Circuit to Ground

Disconnect the idle/diagnostic decrement wire (attached to the cruise control/PTO resume/ accelerator switch signal) from the switch.

Measure the resistance from the cruise control/PTO resume/accelerator switch signal of the OEM harness connector to the engine block.

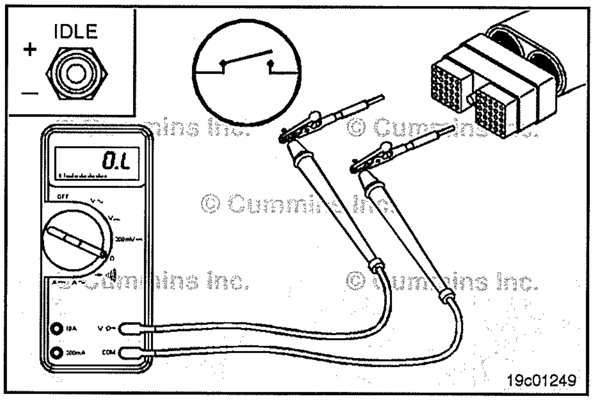




The multimeter **must** show an open circuit (100K ohms or more). If the circuit is **not** open, there is a short circuit to ground in the cruise control/PTO resume/accelerator switch signal circuit, provided the idle adjust switch has been previously checked.

Repair or replace the wire connected to the cruise control/PTO resume/accelerator switch signal in the OEM harness according to the vehicle manufacturer's instructions.

To check the idle/diagnostic increment wire (attached the to cruise control/PTO set/coast switch signal) for short circuits to ground, follow the same procedure as described above for the idle/diagnostic decrement wire.



Check for Short Circuit from Pin to Pin

Measure the resistance from the cruise control/PTO resume/accelerator switch signal of the OEM harness connector to all other pins in the connector. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the wire connected to the cruise control/PTO resume/accelerator switch signal and any pin that measured less than 100k ohms.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's instructions.

Remove the lead from the cruise control/PTO resume/accelerator switch signal of the OEM harness connector and insert it into the cruise control/PTO set/coast switch signal of the connector. Measure the resistance from the cruise control/PTO set/coast switch signal to all other pins in the connector. The multimeter **must** show an open circuit (100k ohms or more).

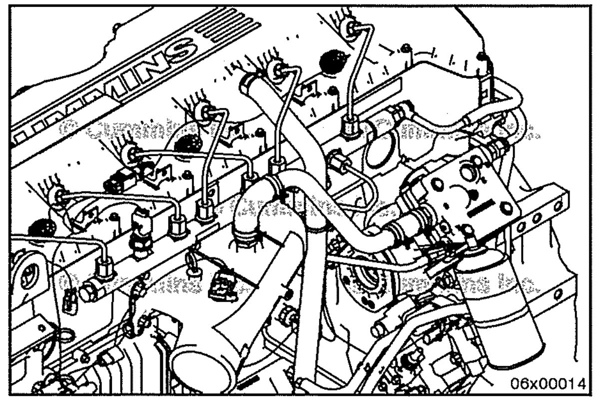
If the circuit is **not** open, there is a short circuit between the wire connected to the cruise control/PTO set/coast switch signal and any pin that measured less than 100k ohms, provided the idle adjust switch has been previously checked.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's instructions.

Connect all components after completing the repair.

Internal Actuator Wiring Harness (019-063)

Preparatory Steps



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

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

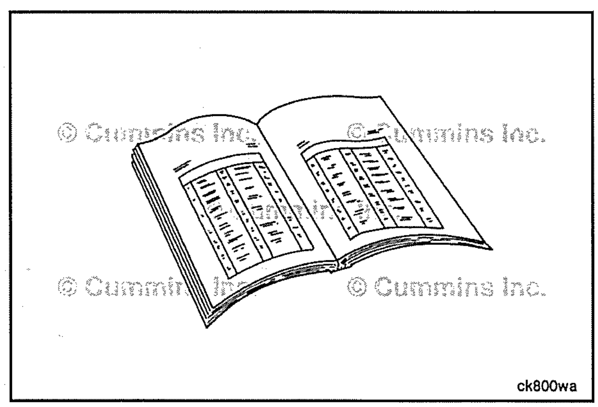
⚠CAUTION⚠
Clean all fittings before disassembly. Dirt or contaminants can damage the fuel system.

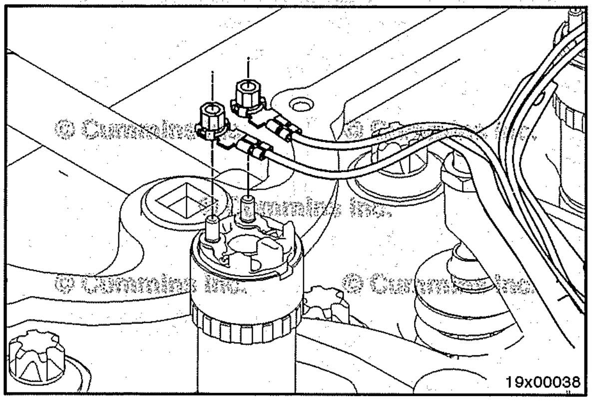
Before servicing any fuel system components, (such as fuel lines, fuel pump, injectors, etc.), which would expose the fuel system or internal engine component to potential contaminants prior to disassembly, clean the fittings, mounting hardware, and the area around the component to be removed. Dirt or 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. Refer to Procedure 000-009 in Section 0.

Clean the injector supply line connections and mating components with electrical contact cleaner, Part Number 3824510, or equivalent.

To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.

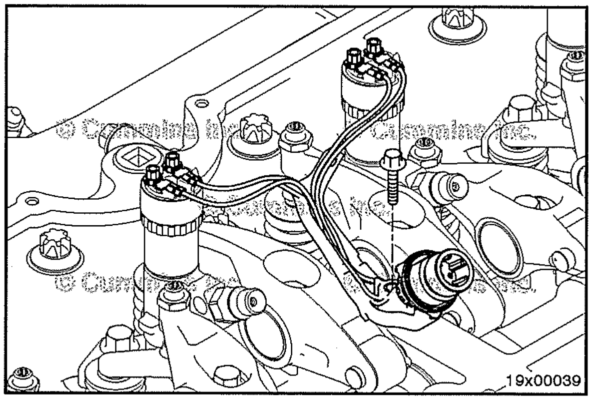
- Disconnect the injector passthrough connectors and internal actuator wiring harness lock rings. Refer to Procedure 019-043 in Section 19.
- Remove the fuel injector supply lines. Refer to Procedure 006-051 in Section 6.
- Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3.



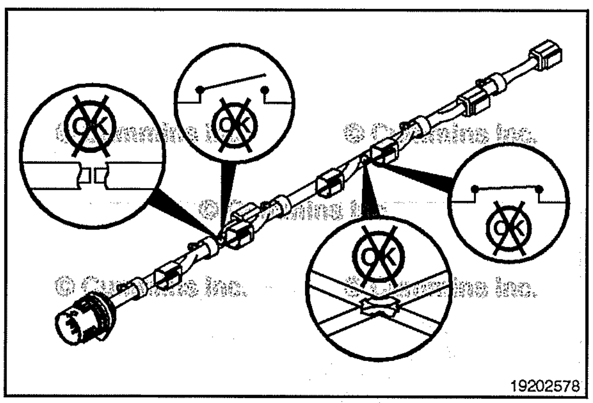


Remove

Disconnect the actuator harness from each of the two injector solenoids.

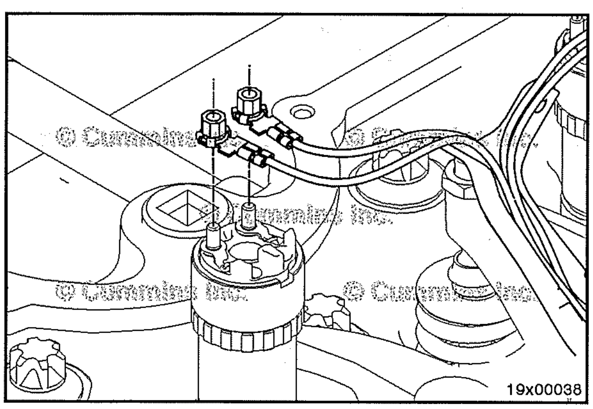


Remove the capscrews securing the actuator harness to the cylinder head.



Inspect for Reuse

Replace or repair the internal actuator harness if there is an open circuit or a short circuit found under the protective covering of the harness body.



Install

Connect the actuator harness to each of the injector solenoids.

Torque Value: 2 N•m [18 in-lb]

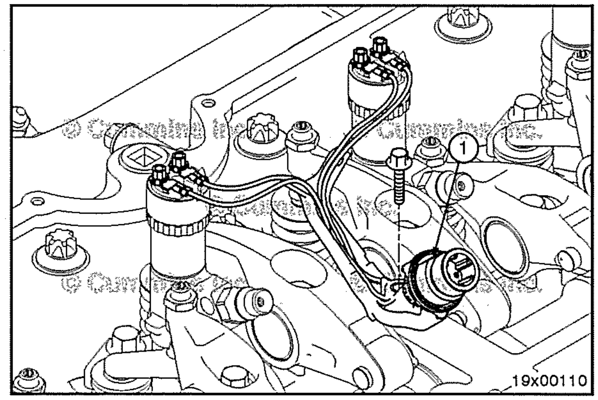
NOTE: Install the injector wires so they will **not** interfere with a rocker lever. If the rocker lever is able to come into contact with the injector harness, it will rub through the wire insulation and cause injector circuit fault codes.

Torque Value: 2 N•m [18 in-lb]

Install the capscrew securing the internal actuator harness to the rocker lever housing.

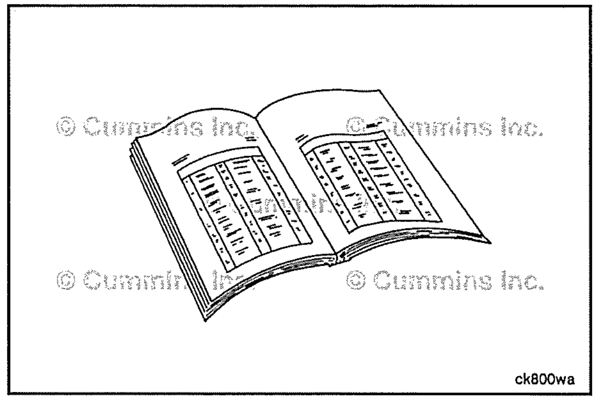
Torque Value: 9.5 N•m [84 in-lb]

NOTE: Verify the passthrough connector is positioned with the locating flat (1) facing up.



Finishing Steps

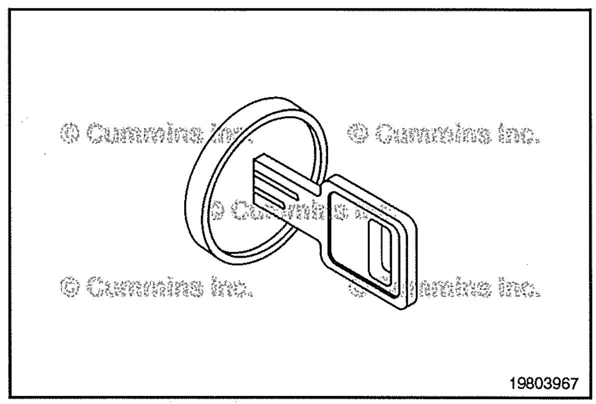
- Install the rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Install the injector supply lines. Refer to Procedure 006-051 in Section 6.
- Install the internal actuator wiring harness lock rings and connect the injector passthrough connectors. Refer to Procedure 019-043 in Section 19.
- Operate the engine and check for proper operation.



Key Switch Power Supply Circuit (019-064)

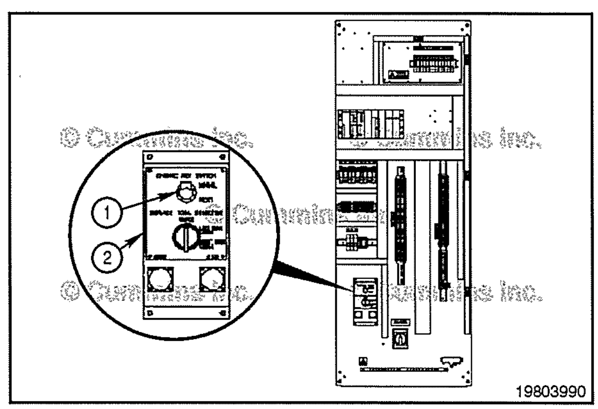
Voltage Check

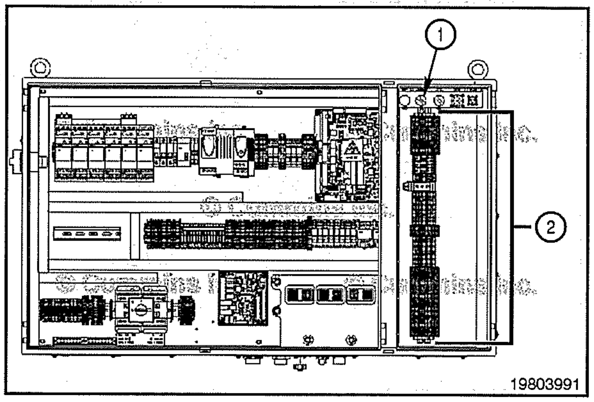
The vehicle keyswitch supplies an input signal to the electronic control module (ECM) which turns the ECM on or off.



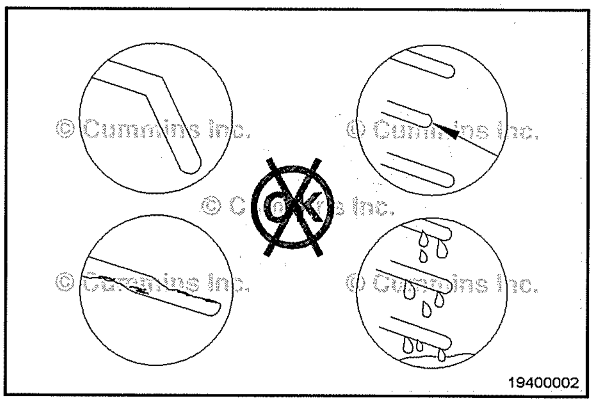
The Generator Set ECM Keyswitch supplies an input signal to all generator set electronic control modules (ECMs) which turns to ECM on or off.

For generator sets using the PowerCommand Supervisor 3100 mounted in the Generator Control Panel (GCP), the ECM keyswitch (1) is mounted on the Service Tool Connector Panel (2), located inside the main panel.





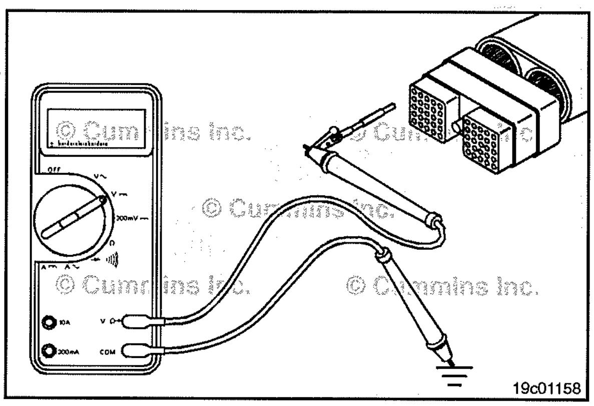
For generator sets using the PowerCommand Supervisor 3300 mounted in the Generator Interface Box, the ECM keyswitch (1) is mounted within the customer terminal box above the customer connection terminal connection strip (2).



Turn the keyswitch to the OFF position.

Disconnect the Actuator harness connector from the ECM.

Inspect the connector pins.



CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Adjust the multimeter to measure VDC.

Insert a test lead into the keyswitch input signal pin of the Actuator connector. Connect the lead to the multimeter probe. Touch the other probe to a clean, unpainted surface on the engine block ground.

Turn the keyswitch to the ON position.

The measured voltage **must** show battery voltage. If the measured voltage is more than 0.5 VDC below battery voltage, continue with the next step.

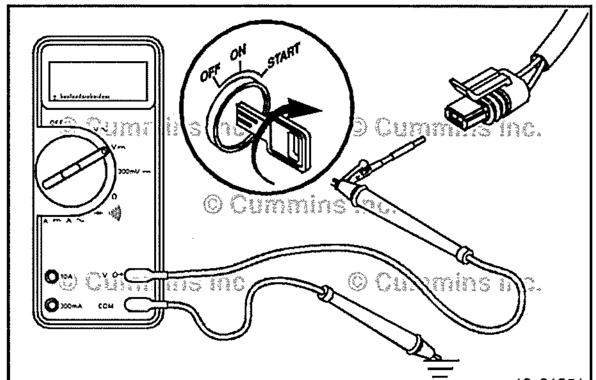
Disconnect the bulkhead connector.

Inspect the connector pins. Refer to the OEM troubleshooting and repair manual for the proper procedure.

Measure the voltage. Refer to the OEM troubleshooting and repair manual for the proper procedure.

The measured voltage **must** show battery voltage. If the voltage is **not** correct, there is a problem with the keyswitch input signal wire, keyswitch, or battery connection.

Repair or replace the wiring harness, keyswitch, or check the battery connections. Refer to the OEM troubleshooting and repair manual for the proper procedures.



19c01251

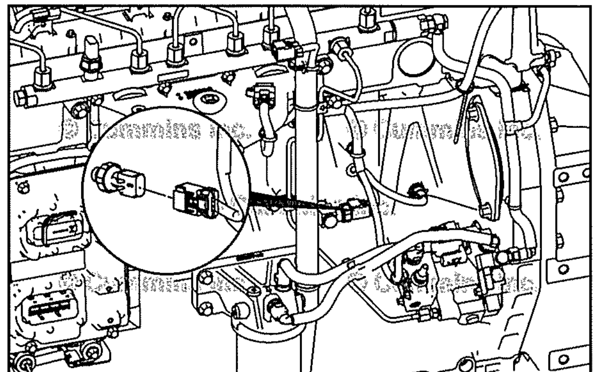
Engine Oil Pressure Sensor/Switch (019-066)

Remove

The engine oil pressure sensor is located on the left (intake) side of the engine near the fuel pump.

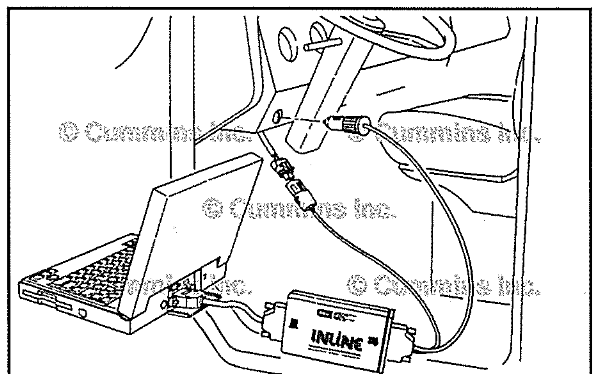
Disconnect the engine wiring harness from the engine oil pressure sensor.

Remove the engine oil pressure sensor.


19p00087

Test

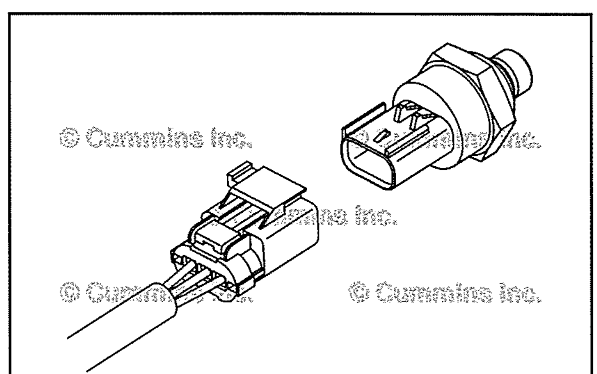
Connect INSITE™ electronic service tool to the data link.

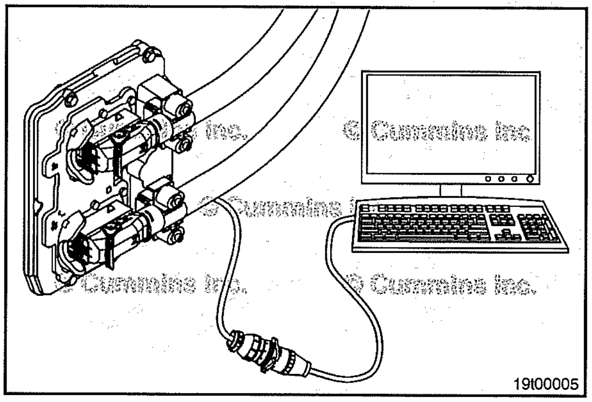


19c01526

Connect the engine harness to the engine oil pressure sensor.

Leave the sensor suspended from the harness.


19c01525



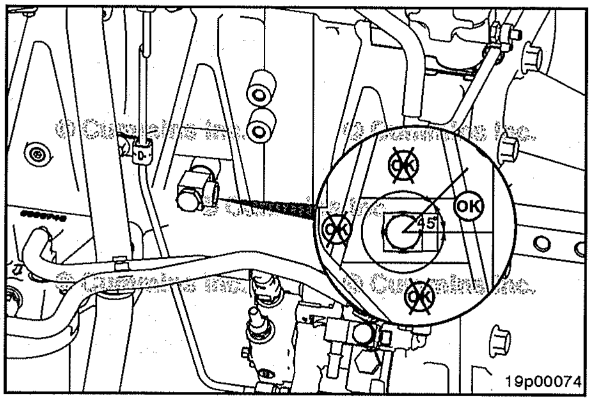
Monitor the lubricating oil pressure with INSITE™ electronic service tool.

The lubricating oil pressure sensor **must** be within ±17.2 kPa [2.5 psi] of 0.

If the engine oil pressure sensor reading is **not** within specifications, the engine oil pressure sensor **must** be replaced.

Disconnect the engine oil pressure sensor from the engine harness.

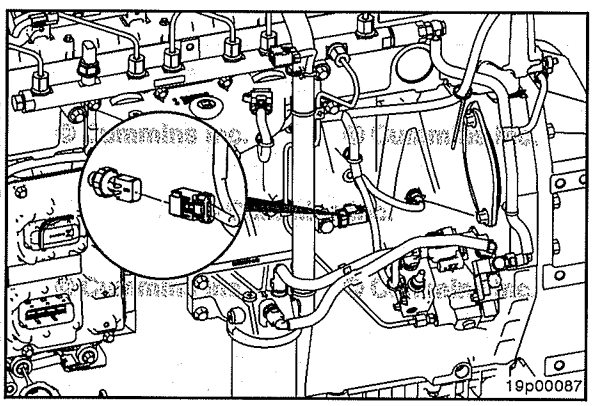
Disconnect INSITE™ electronic service tool.



Install

Verify orientation of 90 degree adaptor fitting.

Fitting should point towards rear with up to 45 degree from horizontal.

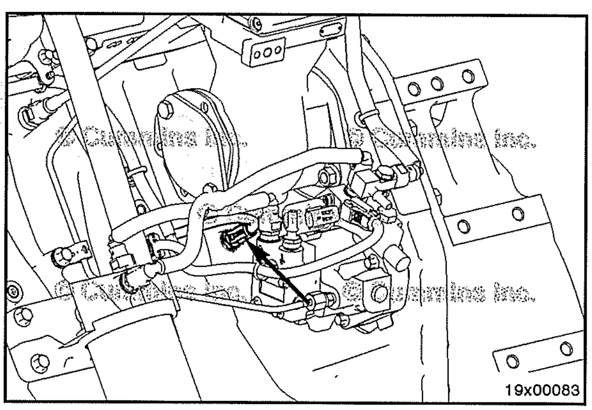


Make sure the o-ring is installed on the sensor.

Install the engine oil pressure sensor.

Torque Value: 20 N•m [177 in-lb]

Connect the engine wiring harness to the engine oil pressure sensor. An audible click will be heard when the connector locks in place.



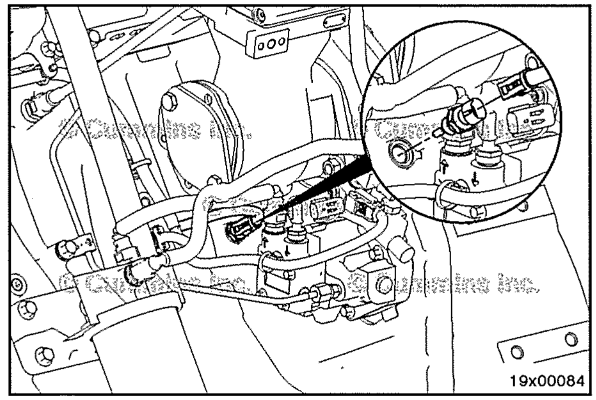
Engine Oil Temperature Sensor (019-067)

Remove

The engine oil temperature sensor is located on the left (intake) side of the engine. It is located on the engine block, between the fuel pump and the air compressor.

Disconnect the engine wiring harness from the engine oil temperature sensor.

Remove the engine oil temperature sensor.



19x00084

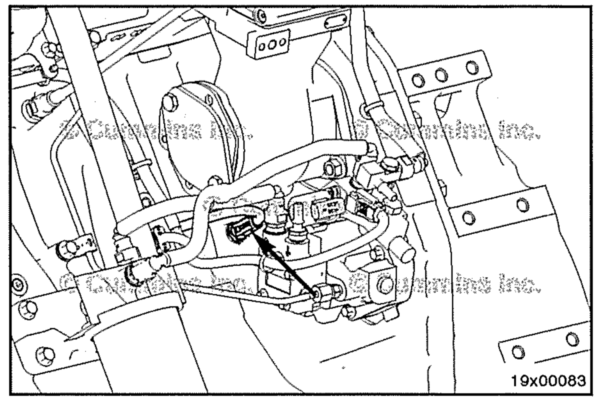
Install

Verify the o-ring is installed on the sensor.

Install the engine oil temperature sensor.

Torque Value: 20 N•m [177 in-lb]

Connect the engine wiring harness to the engine oil temperature sensor. An audible click will be heard when the connector locks in place.



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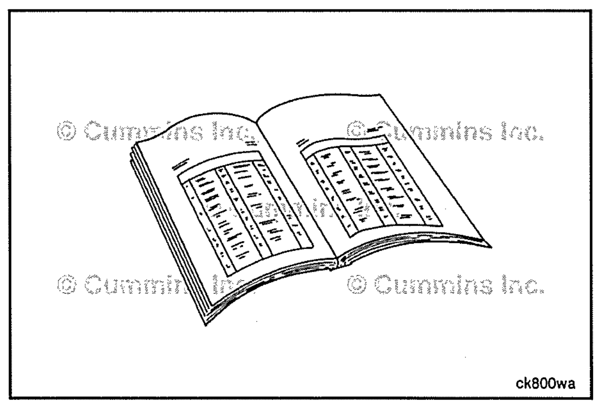
OEM Wiring Harness (019-071)

General Information

The original equipment manufacturer (OEM) harness is supplied and installed by the equipment manufacturer. If repair or replacement is required, see equipment manufacturer service information.



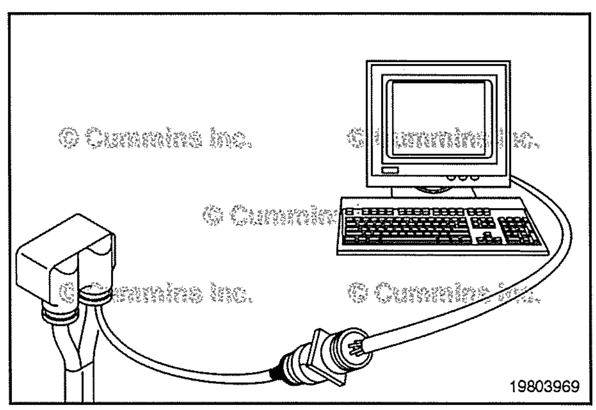
ck800wa

Programmable Features and Parameters Not Correct (019-078)

General Information

This procedure was developed due to the increasing number of parameters and features offered which can affect vehicle performance. Use the following table to troubleshoot performance complaints by locating the appropriate symptom in the left column. Then follow the probable cause and corrective action in the adjacent columns.

Consult the appropriate electronic service tool manual to adjust the parameters or features.



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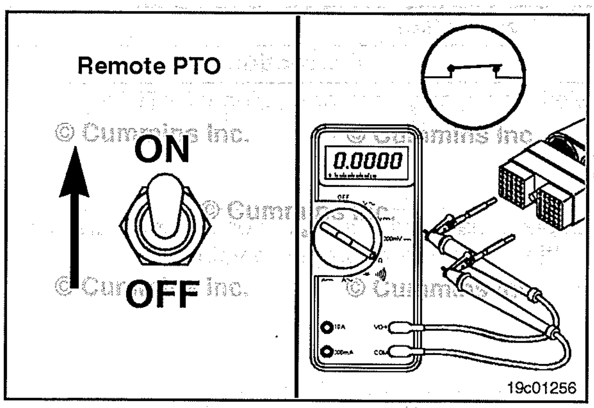
Adjust

Programmable Feature/Parameters Not Correct		
Symptom	**Probable Cause**	**Correction**
Exceeding road speed governor set speed down hills	Cruise control or road speed governor lower droop is set too high.	Change the cruise control or road speed governor lower droop to a lower value. If the problem continues, change the cruise control engine brake activation to lower value.
Poor acceleration up hills	Cruise control and/or road speed governor upper droop is set too high.	Change the cruise control or road speed governor upper droop to a lower value.
Cruise control turns on automatically	Cruise control auto-resume feature is enabled.	Turn off the cruise control auto-resume feature.
Exhaust brakes turn on automatically	Cruise control auto engine brake feature is enabled or exhaust brake switch has failed close.	Turn off the cruise control auto engine brake feature or repair the switch.
Unable to obtain maximum vehicle speed	Gear-down protection feature is enabled.	Turn off or adjust the gear-down protection parameters.
Poor clutch engagement	The low idle speed is set too low for the application.	Increase the low-idle speed using the idle adjust switch. Refer to Procedure 019-052. Increase the low-idle speed parameter.
Speedometer on the dashboard is **not** correct or vehicle exceeding road speed governor set speed	Vehicle speed parameters **not** correct.	Make sure the following are correct: tire size, rear axle ratio, vehicle speed sensor type, and gear teeth per revolution.
Trip information mileage readings are **not** correct	The tire size parameter was changed without resetting the trip information system.	Set the trip information system again whenever the tire size parameter is changed.
Can **not** obtain maximum vehicle speed with semiautomatic transmission	The gear-down protection parameters are **not** correct.	Change the top gear ratio parameter to be equal to the first gear-down ratio, **not** the top gear ratio. For example, on a transmission with a 0.75, 0.87, and 1.0 ratio set, the top gear ratio parameter **must** be set to 0.87.
Engine won't start	Antitheft password active.	Enter antitheft personal identification number (PIN) using RoadRelay™ or delete password with Zap-It.
Low power in lower gears or top gear	Power train protection parameters set too low.	Change power train protection torque limits to match torque capability of the vehicle's transmission.
Semiautomatic transmission will **not** shift into top gear	Top gear ratio setting does **not** match top gear of transmission.	Using INSITE™ electronic service tool, set the proper top gear ratio.
	Centinel™ feature has been turned on but vehicle has a Spicer Top 2™ transmission.	Turn off the Centinel™ feature and turn on the Top 2 feature using INSITE™ electronic service tool.
Engine recently started overheating because the fan will **not** turn on	Fan control feature is **not** set properly.	Verify all fan control feature parameters are properly set for the vehicle.
Fan will **not** turn off	Fan control feature is **not** set properly.	Verify all fan control feature parameters are properly set for the vehicle.
Fan control switch will **not** turn on the fan	Fan control 1 accessory switch control is turned off.	Turn on fan control 1 accessory switch control using INSITE™ electronic service tool.

Programmable Feature/Parameters Not Correct		
Symptom	**Probable Cause**	**Correction**
Unable to obtain maximum vehicle speed	Cruise control maximum vehicle speed or accelerator maximum vehicle speed **not** set high enough.	Verify or change settings using INSITE™ electronic service tool.
	Driver reward system is penalizing the driver with reduced top vehicle speed or cruise control maximum speed for poor fuel economy or extended idle time.	Explain feature to the driver or change parameter settings to more appropriate values.
Accelerator pedal has no effect on engine speed	Vehicle is in PTO mode and PTO accelerator override is turned on in the ECM.	Turn off PTO accelerator override using INSITE™ electronic service tool.
	Vehicle has a multiplexed throttle pedal and the multiplexing feature has been turned off.	Verify that the throttle pedal is multiplexed. Turn on the multiplexing feature for the throttle pedal using INSITE™ electronic service tool.
Remote accelerator control has no effect on engine speed	Remote accelerator feature has been turned off.	Turn on the remote accelerator feature using INSITE™ electronic service tool.
	Vehicle has a multiplexed remote accelerator control and the multiplexing feature has been turned off.	Verify that the remote accelerator control is multiplexed. Turn on the multiplexing feature for the remote throttle control using INSITE™ electronic service tool.
Lamps do **not** operate	5 A or 15 A Power fuse in engine harness blown.	Check fuses and verify the ECM is getting power on the keyswitch wire.
	Vehicle has multiplexed lamps and the multiplexing feature has been turned off.	Verify that the lamps are multiplexed. Turn on the multiplexing feature for the lamps using INSITE™ electronic service tool.
Engine brakes do **not** operate	Vehicle has multiplexed engine brake switches and the multiplexing feature has been turned off.	Verify that the engine brake switches are multiplexed. Turn on the multiplexing feature for the engine brake switches using INSITE™ electronic service tool.
Engine will **not** respond to one or all of the operator's switch(es)	Vehicle has multiplexed switches and the multiplexing feature has been turned off.	Verify that the switches are multiplexed. Turn on the multiplexing feature for the switches using INSITE™ electronic service tool.



Remote PTO Switch Circuit (019-079)

Resistance Check

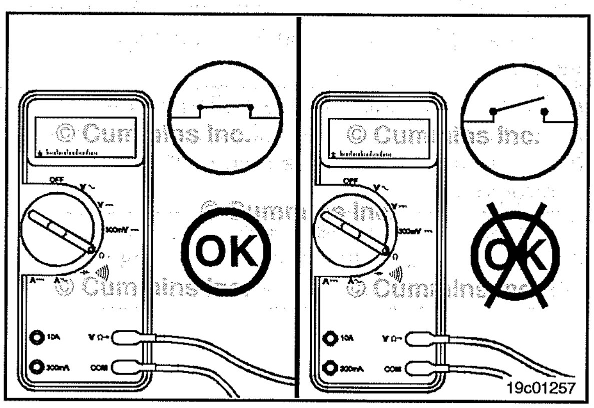
CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Insert a test lead into the remote power take-off (PTO) switch return pin of the OEM harness connector and connect it to the multimeter probe. Insert the other test lead into the remote PTO switch signal pin of the connector and connect it to the other probe.

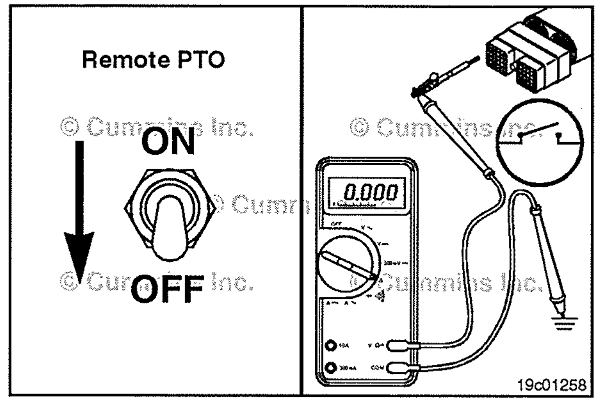
Make sure the switch is connected to the circuit. Move the remote PTO switch to the ON position. Measure the resistance with the multimeter. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the switch return wire and the remote PTO switch signal wire for an open circuit. Repair or replace the OEM harness, provided the switch has been previously checked. Refer to the OEM troubleshooting and repair manual for the procedures.



If the resistance is correct, the remote PTO switch return wire and the remote PTO switch signal wire **must** be checked for a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.

Connect all components after the repair is complete.

Check for Short Circuit to Ground



⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

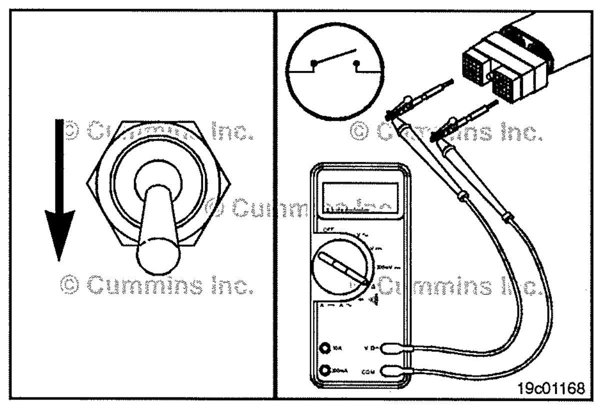
Insert the test lead into the remote PTO switch signal pin in the OEM harness connector and connect it to the multimeter probe. Touch the other probe to engine block ground.

With the remote PTO switch in the OFF position, read the resistance.

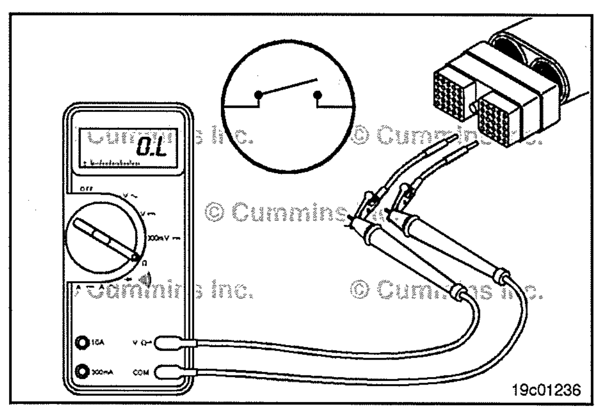
The multimeter **must** show an open circuit (100k ohms or more).

If the resistance values are **not** correct, make sure the remote PTO switch signal wire and the ground wire are properly installed on the switch. If both wires are correctly installed, inspect the wires for a short to ground circuit, provided the remote PTO switch has been previously checked.

Check for Short Circuit from Pin to Pin



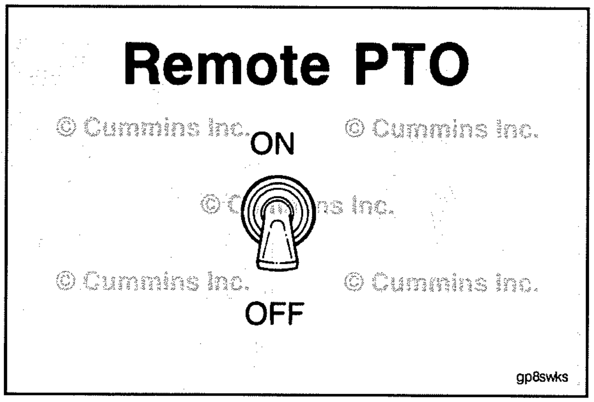
Check for a short circuit from pin to pin. Set the remote PTO switch to the OFF position. Insert the test lead into the remote PTO switch return pin of the OEM harness connector and connect it to the multimeter probe. With a test lead connected to the other multimeter probe, check all the other pins in the connector. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).



Remove the lead from the remote PTO switch return pin and insert it into the remote PTO switch signal pin of the harness connector. With the other test lead, check all other pins in the connector. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the switch circuit and any pin that did **not** measure an open circuit, provided the switch has previously been checked. Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

Connect all components after completing the repair.

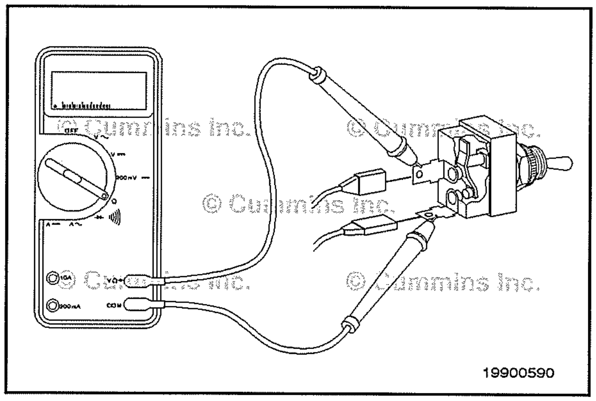


Remote PTO Switch (019-080)

General Information

A remote PTO switch is available for applications where PTO operation control is desired away from the operator controls.

The remote PTO switch circuit consists of the remote PTO switch signal wire and a switch common return.

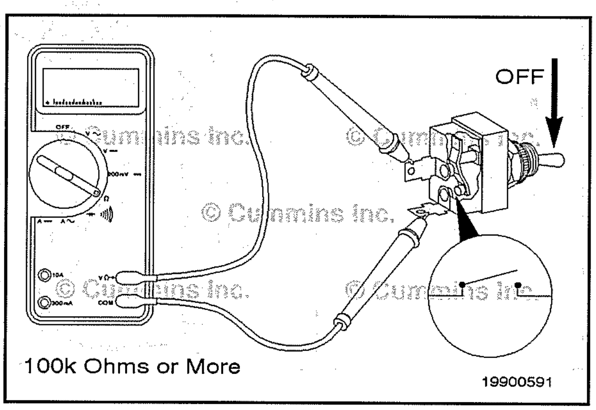


Resistance Check

Locate the desired ON/OFF toggle switch.

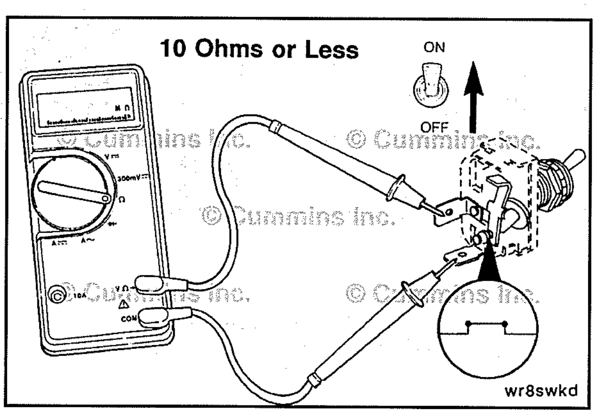
Remove and tag the two connectors from the terminals on the switch.

Touch the multimeter probes to the terminals on the switch.



Move the switch to the OFF position and measure the resistance. The multimeter **must** show 100k ohms or more (open circuit). If the circuit is **not** open, the switch has failed.

Replace the switch. Refer to the OEM troubleshooting and repair manual for the replacement procedures.



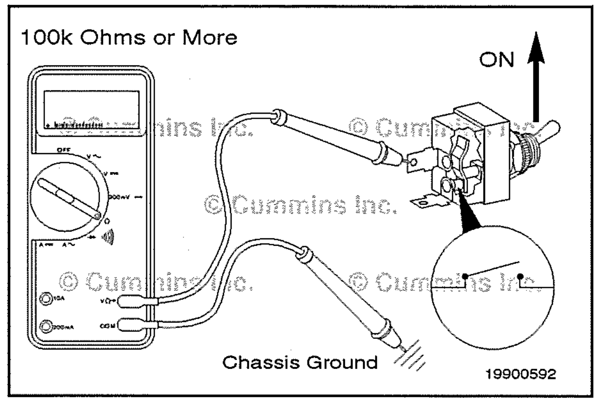
Move the switch to the ON position and measure the resistance. The multimeter **must** show 10 ohms or less (closed circuit). If the circuit is **not** closed, the switch has failed.

Replace the switch. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position and measure the resistance. The multimeter **must** show 100k ohms or more (open circuit). If the circuit is **not** open, the switch has failed. Replace the switch. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.

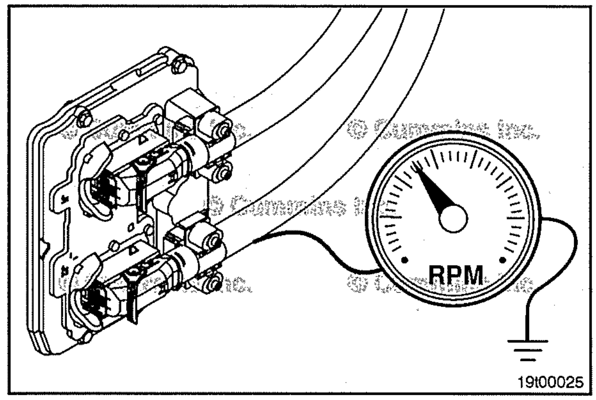


Tachometer Circuit (019-083)

General Information

The engine control module (ECM) can supply an output signal to operate the vehicle tachometer.

The circuit is the tachometer signal wire and a return line in the original equipment manufacturer (OEM) harness.



Resistance Check

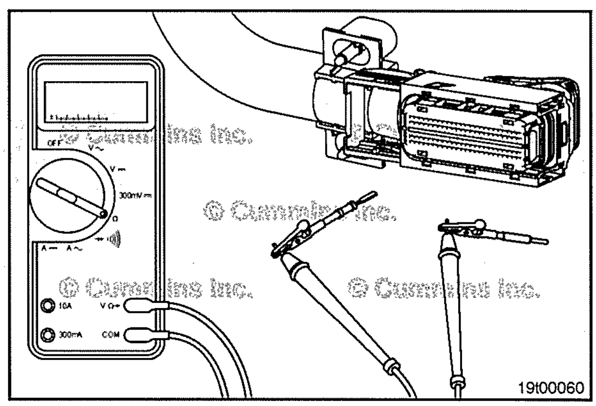
⚠CAUTION⚠

Do not use probes or leads other than Cummins® Part Number 2892510. The connector will be damaged.

Disconnect the OEM harness from the ECM.

Disconnect the tachometer from the OEM harness.

Insert the test lead into the tachometer signal pin of the OEM harness connector and connect it to the multimeter probe.

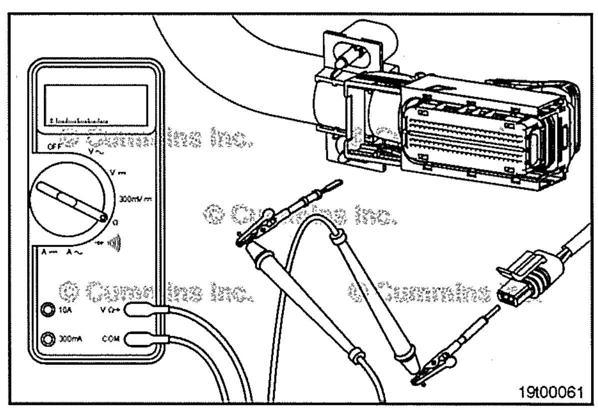


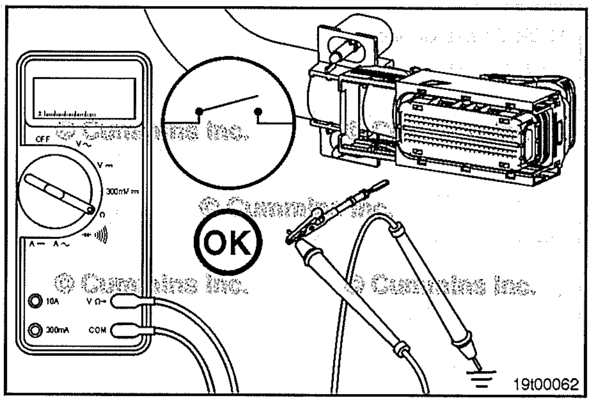
Locate the tachometer connector of the OEM harness.

Connect the other lead to the multimeter probe and connect it to the tachometer signal pin of the tachometer connector that is coming from the engine ECM. See equipment manufacturer service information for wiring schematics.

Adjust the multimeter to the resistance setting. Measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, there is an open circuit or the wires in the tachometer connector are reversed. Repair or replace the wire connected to the tachometer signal pin in the OEM harness according to the vehicle manufacturer's procedures.





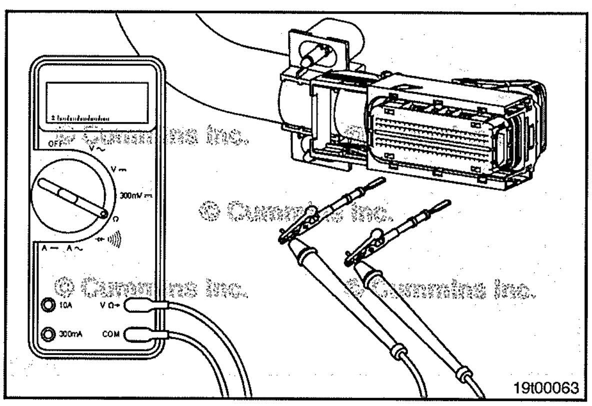
Check for Short Circuit to Ground

Disconnect the tachometer from the OEM harness.

Insert the test lead into the tachometer signal pin of the OEM harness connector and connect it to the multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open in either of the prior checks, repair the wires which have incorrect readings. See equipment manufacturer service information for the repair procedures.

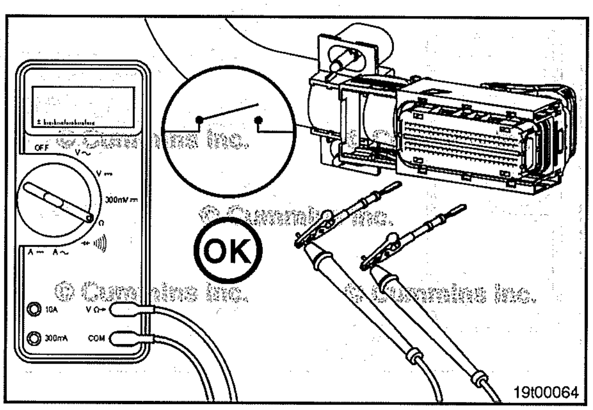


Check for Short Circuit from Pin to Pin

Disconnect the tachometer from the OEM harness. Insert the test lead into the tachometer signal pin of the OEM harness connector and connect it to the multimeter probe. Insert the other lead into any pin, except the tachometer switch return, of the OEM harness connector, and connect it to the other multimeter probe. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Measure the resistance from the tachometer signal pin to all other pins in the OEM connector. The multimeter **must** show an open circuit.

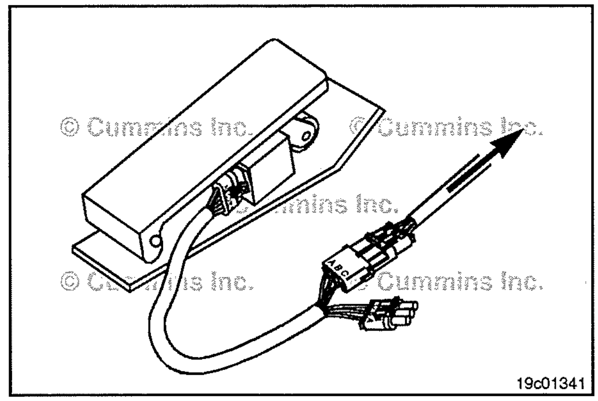


Remove the test lead from the last tested pin, insert it into the tachometer switch return pin. Measure the resistance from the tachometer switch return pin to the tachometer signal pin in the OEM harness connector.

The multimeter **must** show an open circuit (100k ohms or more) at all pins. If any pin-to-pin check does **not** measure as an open circuit, there is a short between the tachometer signal pin and any other pin that did **not** measure an open circuit. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

Accelerator Pedal or Lever Position Sensor (019-085)

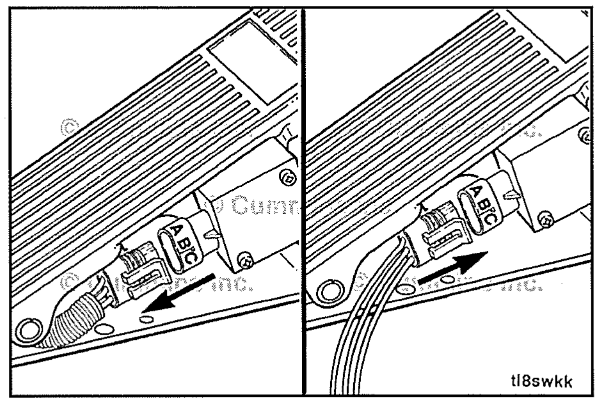
General Information



The accelerator pedal or lever position sensor will vary with OEM. Refer to the vehicle manufacturer's manual for the specific troubleshooting and repair procedures. This section contains troubleshooting and repair procedures for one typical accelerator pedal or lever position sensor.

The accelerator pedal or lever position sensor sends a signal to the ECM when the operator pushes on the accelerator pedal or lever. The accelerator position circuit consists of the accelerator pedal or lever position sensor, the ECM, accelerator pedal/lever position +5 volt, accelerator pedal/lever position signal, and accelerator pedal/lever position return wires.

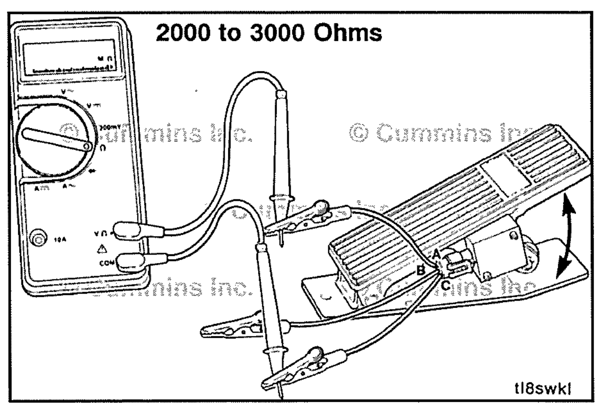
Resistance Check



If an electronic service tool is available, monitor the accelerator position sensor for proper operation. If **not**, follow the troubleshooting procedures in this section.

Disconnect the 3-pin connector from the accelerator position sensor.

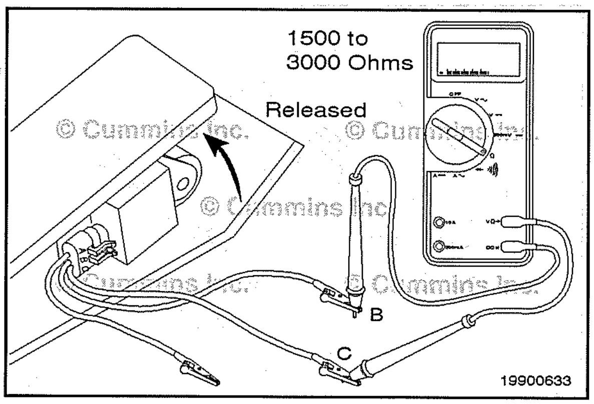
Connect the test connector.



Connect the multimeter positive (+) test lead to the accelerator pedal/lever position +5 volt supply test connector wire. Connect the negative (-) multimeter test probe to the accelerator pedal/lever position return test connector wire.

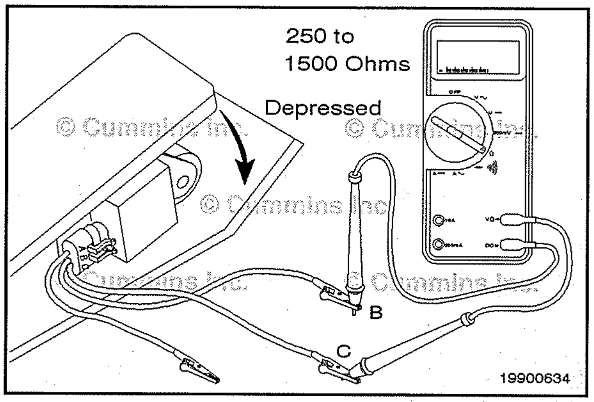
Measure the resistance. The multimeter **must** show between 2000 and 3000 ohms when the accelerator pedal is released (idle position) or depressed (full-fuel position).

If the resistance is **not** within the specification, the accelerator position sensor has failed. Replace the accelerator position sensor. Refer to the OEM troubleshooting and repair manual for the procedures.

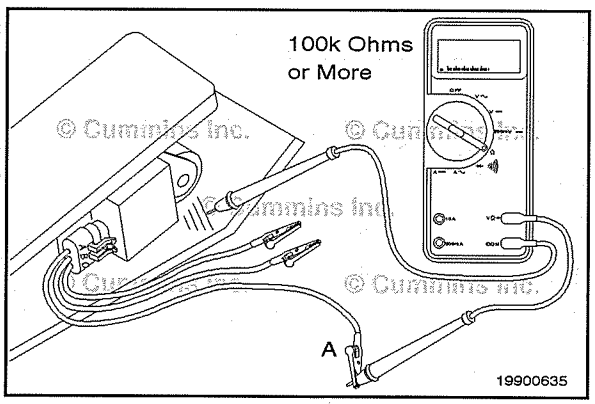


Remove the multimeter probe from the accelerator pedal/lever position +5 volt supply test connector wire and connect it to the accelerator pedal/lever position signal test connector wire.

When the accelerator pedal is in the released (idle) position, measure the resistance. The multimeter **must** show between 1500 and 3000 ohms.



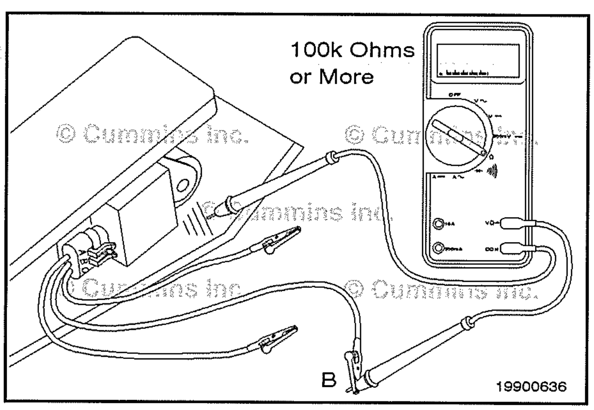
Depress the accelerator pedal assembly (full-fuel position) and measure the resistance. The multimeter **must** show between 250 and 1500 ohms. This resistance value **must** be at least 1000 ohms lower than the resistance value of 1500 to 3000 ohms measured in the above check. If the resistance values in the two previous steps are **not** within the specification, the accelerator position sensor has failed. Replace the accelerator position sensor according to the vehicle manufacturer's procedures. If the resistance values are within the specifications, the accelerator position sensor **must** still be checked for a short circuit to ground.



Check for Short Circuit to Ground

Connect the multimeter positive (+) probe to the accelerator pedal/lever position return test connector wire. Touch the negative (-) multimeter probe to the chassis ground and measure the resistance.

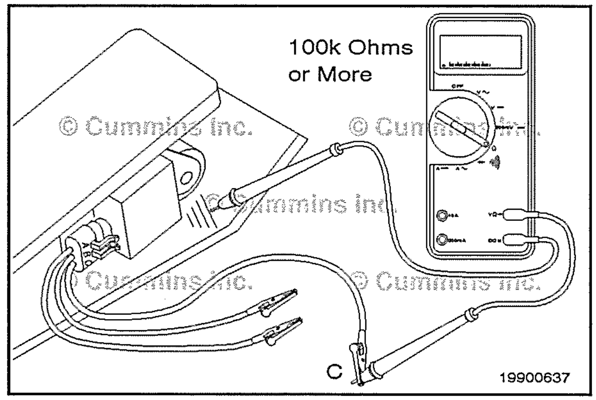
The multimeter **must** show an open circuit (100k ohms or more).



Remove the multimeter positive (+) probe from accelerator pedal/lever position return test connector wire and connect it to the accelerator pedal/lever position signal test connector wire. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the multimeter positive (+) probe from the accelerator pedal/lever position signal test connector wire and connect it to the accelerator pedal/lever position +5 volt supply test connector wire. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

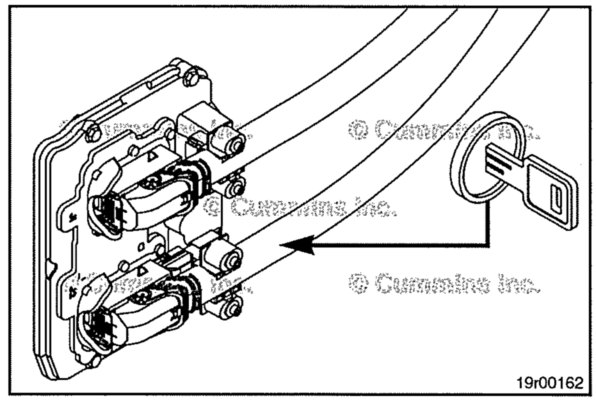


If the resistance values are **not** within the specifications in the previous check, the accelerator position sensor has failed. Replace the accelerator position sensor according to the vehicle manufacturer's procedures.

If the accelerator position sensor has passed all the previous checks, connect the sensor to the wiring harness. The accelerator position sensor circuit **must** still be checked.

Unswitched Battery Supply Circuit (019-087)

General Information



The engine control module (ECM) receives constant voltage from the batteries through the ECM battery supply positive (+) wire that is connected directly to the positive (+) battery post. There is one in-line 30-ampere fuse in the ECM supply wire to protect the ECM. The ECM receives switched battery input through the keyswitch input signal when the vehicle keyswitch is turned ON. The ECM battery supply negative (-) wire is connected directly to the negative (-) battery post.

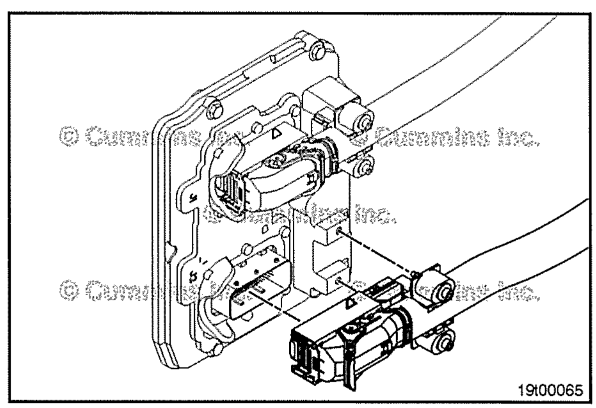
The ECM battery supply positive (+) wire and the ECM battery supply negative (-) wire are in the ECM power harness.

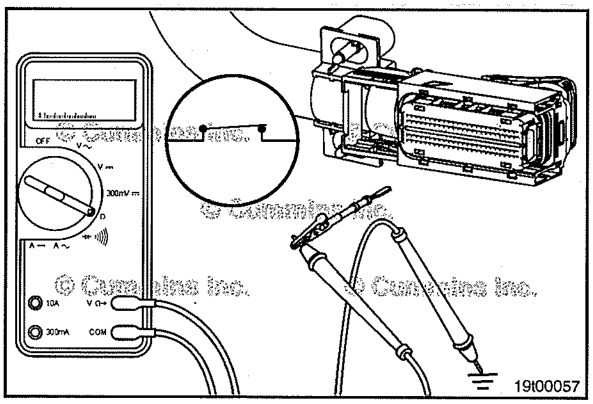
Always check the ECM battery supply fuse when troubleshooting the ECM and power supply circuit.

Check the battery voltage. Refer to Procedure 019-008 in Section 19.

Resistance Check

Disconnect the ECM power harness connector from the ECM.



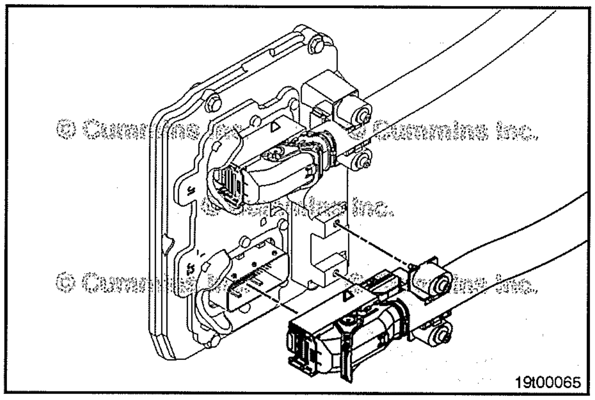


Adjust the multimeter to measure resistance.

Insert a test lead into the ECM battery supply negative (-) pin of the original equipment manufacturer (OEM) harness connector. Attach it to a multimeter probe.

Touch the other multimeter probe to the engine block ground and measure the resistance.

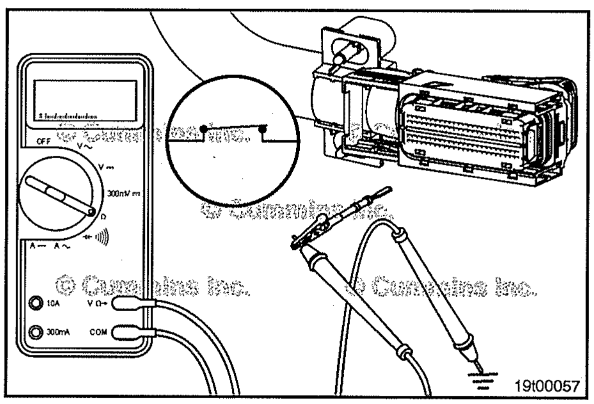
The multimeter **must** show a closed circuit, 10 ohms or less. Repeat this for all ECM battery supply negative (-) pins in the OEM harness connector.



If the resistance value is **not** correct, check the OEM harness battery supply negative (-) circuit.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

When the checks have been completed, connect the OEM harness connector.



Voltage Check

Check the battery voltage supply at the ECM battery supply positive (+) pin of the OEM harness connector.

Turn the keyswitch to the OFF position. Disconnect the OEM harness connector from the ECM. Set the multimeter to measure VDC.

Measure the voltage from the ECM battery supply positive (+) to ground.

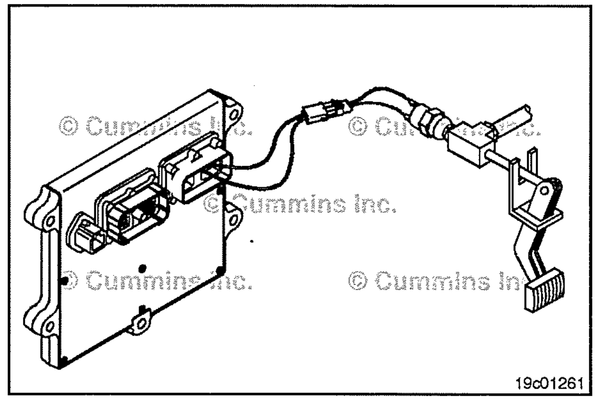
The voltage **must** read battery voltage at this pin.

If the voltage is **not** correct, repair or replace the ECM power harness.

Repeat this step for all battery supply positive (+) pins in the OEM harness connector.

Brake Pedal Position Switch (019-088)

General Information

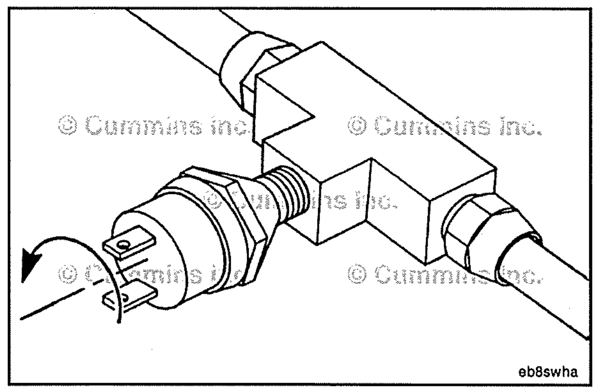


CAUTION

When troubleshooting the brake line switch circuit, make sure the brake pressure switch is identified. The vehicle brake light pressure switch, which is not a part of the Signature system, is commonly mistaken for the brake line switch used in the Signature system.

The brake pedal position switch detects the position of the service brake pedal. Certain features such as cruise control and PTO respond to the state of the brake pedal position switch and disengage when the brakes are applied. The circuit has a normally-closed switch, switch return wire, and brake pedal position switch signal wire of the OEM harness. The brake pedal position switch is mounted in the low pressure side of the vehicle pneumatic brake system. When the vehicle brakes are applied, the normally-closed switch opens and disables the cruise control operation.

Remove



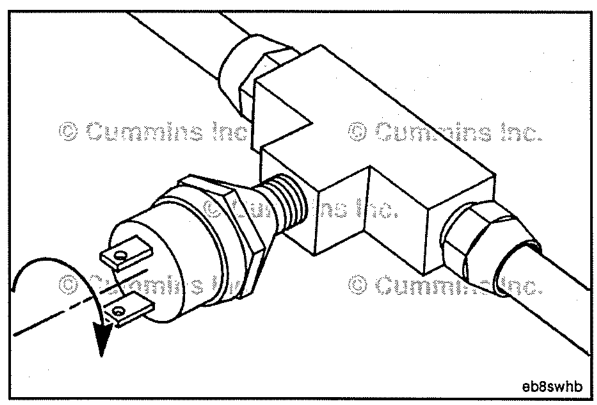
WARNING

To avoid personal injury or death, do not apply the vehicle brakes when the switch is removed from the brake line fitting.

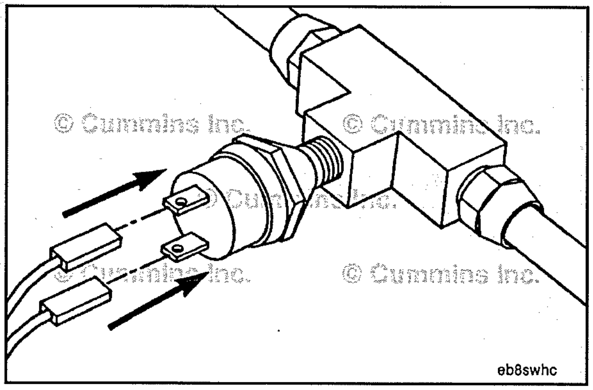
Disconnect the OEM harness from the brake pedal position switch.

Remove the brake pedal position switch from the fitting.

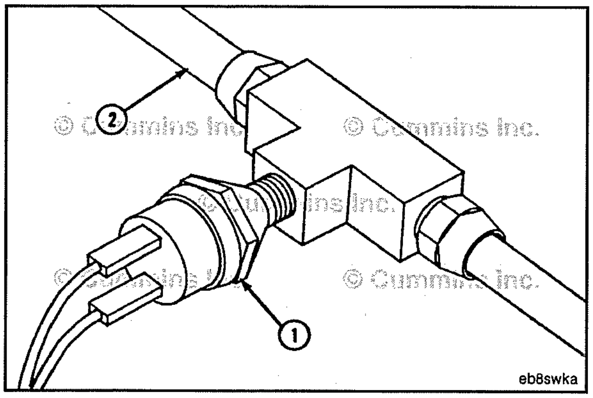
Install



Install the new brake pedal position switch into the fitting according to the vehicle manufacturer's procedures.



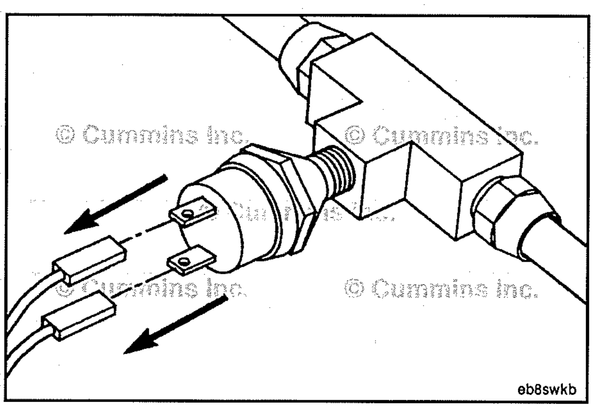
Connect the two wire connectors to the brake pedal position switch.



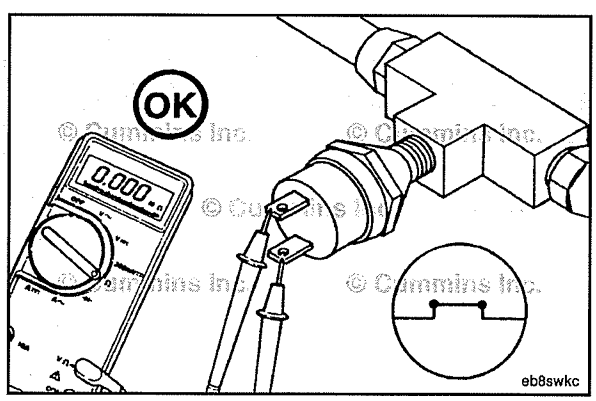
Resistance Check

If an electronic service tool is available, monitor the brake pedal position switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

The brake pedal position switch (1) will be located in the vehicle brake line (2). The location will depend on the OEM installation procedures.



Disconnect the two wire connectors from the brake pedal position switch.



Connect the probes of the multimeter to the brake pedal position switch terminals.

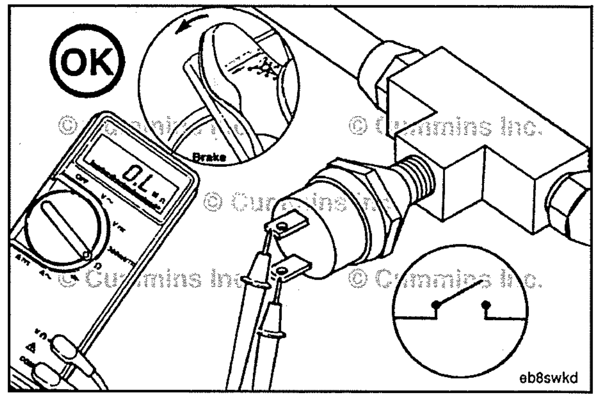
Measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less) when the brakes are **not** applied. If the circuit is **not** closed, replace the brake pedal position switch.

⚠CAUTION⚠
The vehicle must have enough air pressure to activate the brakes.

Depress the vehicle brake pedal. The multimeter **must** show an open circuit (100k ohms or more) when the brakes are applied. If the circuit is **not** open, replace the brake pedal position switch.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

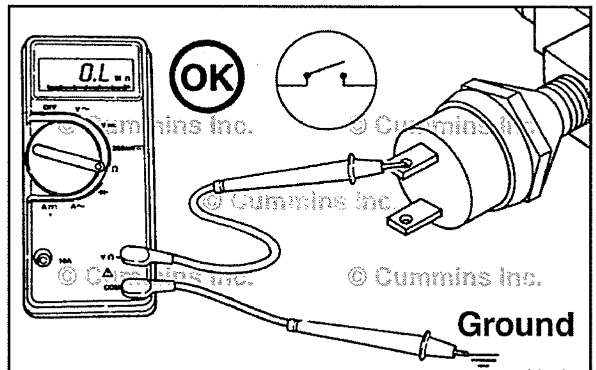


eb8swkd

Check for Short Circuit to Ground

Touch one multimeter probe to one of the brake pedal position switch terminals. Touch the other multimeter probe to chassis ground. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more) when the brake pedal is released. If the circuit is **not** open, replace the brake pedal position switch.

If the brake pedal position switch passed all the previous checks, connect the switch to the wiring harness. The brake pedal position switch circuit **must** still be checked.



eb8swke

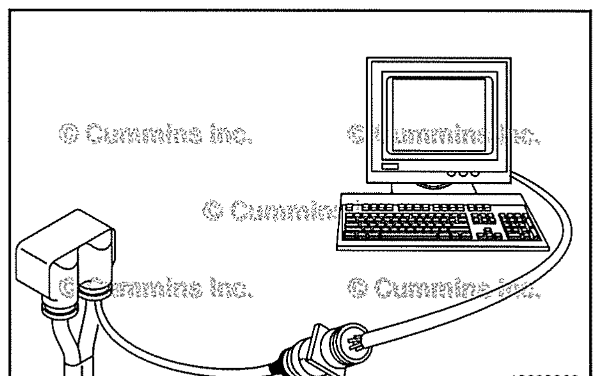
Brake Pedal Position Switch Circuit (019-089)

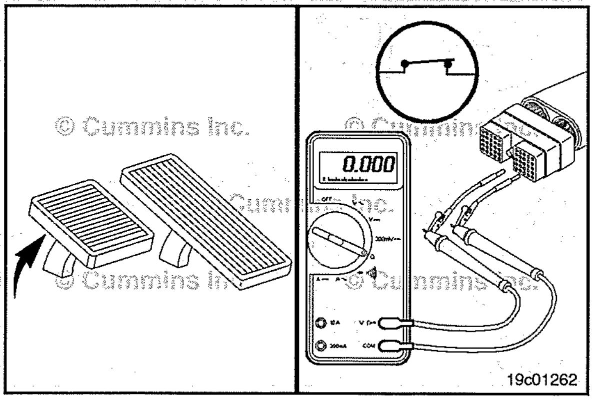
Resistance Check

⚠CAUTION⚠
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If electronic service tool is available, monitor the brake pedal position switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

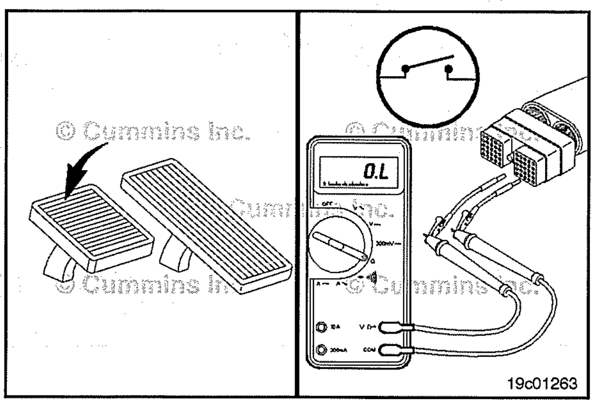

19803969



Make sure the brake pedal position switch is connected to the circuit.

Insert a test lead into the brake pedal position switch signal pin of the OEM harness connector. Attach the lead to a multimeter probe. Insert the other test lead into the switch return pin of the connector and attach it to the other probe.

Adjust the multimeter to the resistance setting and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less) when the brakes are **not** engaged (brake pedal released). If the circuit is **not** closed, there is a problem with the OEM harness, provided the brake pedal position switch has been previously checked.

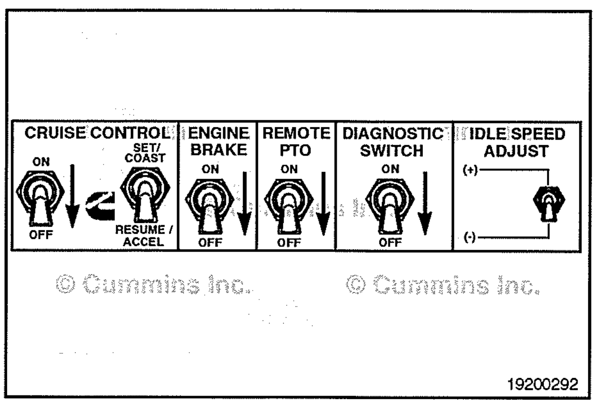


CAUTION

The vehicle must have enough air pressure to activate the brakes.

Depress the vehicle brake pedal and repeat the resistance check. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a problem with the OEM harness, provided the brake pedal position switch has been previously checked.

If the values are correct, the circuit **must** still be checked for a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.



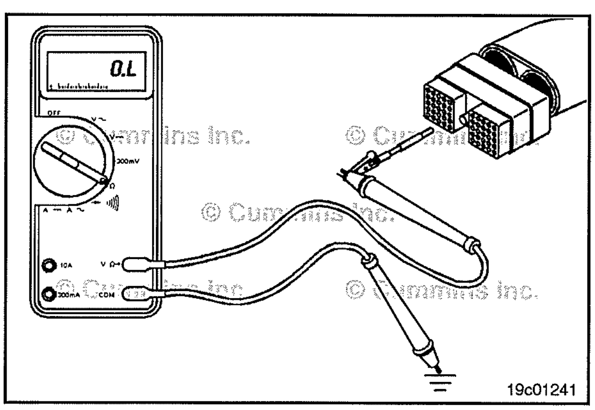
Check for Short Circuit to Ground

To isolate the brake pedal position switch circuit when checking for a short circuit, turn all cab panel switches to the OFF or neutral position.

Disconnect the OEM harness connector from the ECM and the OEM harness from the brake pedal position switch.

Set the service brake using the trailer brake hand valve.

Disconnect the clutch pedal position switch, accelerator position switch and the idle validation on/off switch.



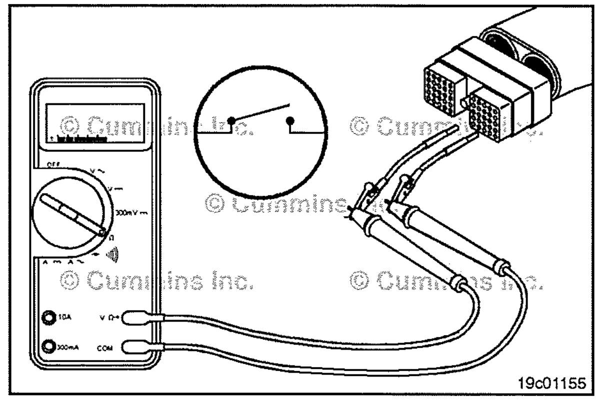
Insert a test lead into the brake pedal position switch signal pin of the OEM harness connector. Connect the lead to the multimeter probe. Remove the alligator clip from the other multimeter probe and touch the probe to the engine block.

The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the brake pedal position switch signal wire, provided that the switch has been previously checked.

Repair or replace the wire connected to the brake pedal position switch signal pin in the OEM harness according to the vehicle manufacturer's procedures.

Measure the resistance.

Check for Short Circuit from Pin to Pin

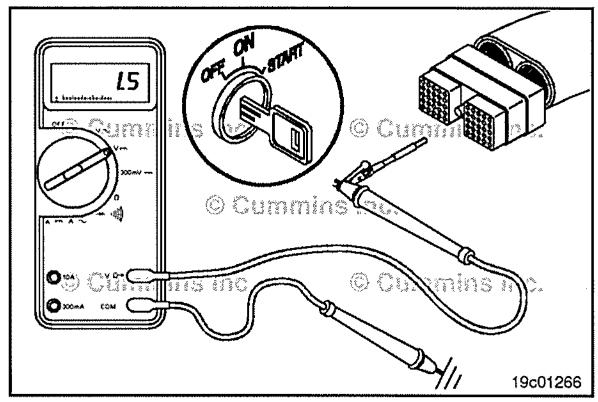


Isolate the brake pedal position switch circuit by disconnecting the brake pedal position switch connector and the OEM harness connector at the ECM. Insert a test lead into the brake pedal position switch signal pin of the OEM harness connector. Insert the other test lead into the switch return pin of the OEM harness connector. Connect the alligator clips to the multimeter probes. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the switch return pin and test all other pins in the connector. The multimeter **must** show an open circuit (100k ohms or more) at all pins. If the circuit is **not** open, there is a short circuit between the wire connected to the service brake switch signal pin and any pin that did **not** show an open circuit.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

Check for Short Circuit to External Voltage Source



Disconnect the brake pedal position switch from the OEM harness and disconnect the OEM harness from the ECM. Turn the vehicle keyswitch to the ON position. Adjust the multimeter to measure VDC. Insert a test lead into the brake pedal position switch signal pin and connect it to the positive multimeter probe. Remove the lead from the negative multimeter probe and touch the probe to the engine block ground. Measure the voltage. The voltage **must** be 1.5 VDC or less.

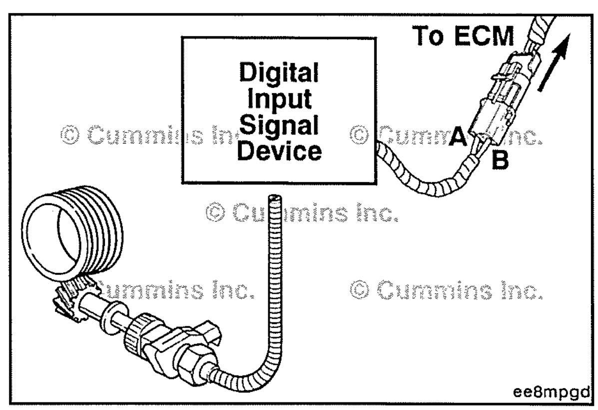
NOTE: An external voltage source is any wire in the OEM wiring that carries voltage.

If the voltage is more than 1.5 VDC, there is a short circuit between the wire connected to the brake pedal position switch signal pin and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.

Connect all components after completing the repair.

Vehicle Speed Sensor, Digital Input (019-090)

General Information

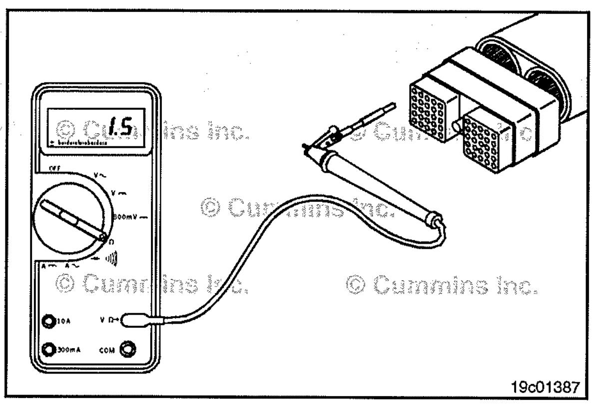


The digital input signal device is an OEM optional part. It changes the signal pulses from AC to DC. This part is near the transmission or in the vehicle cab. The DC voltage pulses are then sent to the ECM and computed into miles per hour.

The digital vehicle speed sensor circuit consists of the speed sensor, the digital vehicle speed sensor +5 volt supply wire, the digital vehicle speed sensor signal wire, and the digital vehicle speed sensor return wire.

CAUTION

When the OEM-supplied signal conditioner is internally grounded, do not connect the vehicle speed sensor signal negative (-) wire to the ECM. This will create a ground loop in the system that will inject unwanted electrical noise into the system. Only the digital vehicle speed sensor +5 volt supply wire is required in this case.



Resistance Check

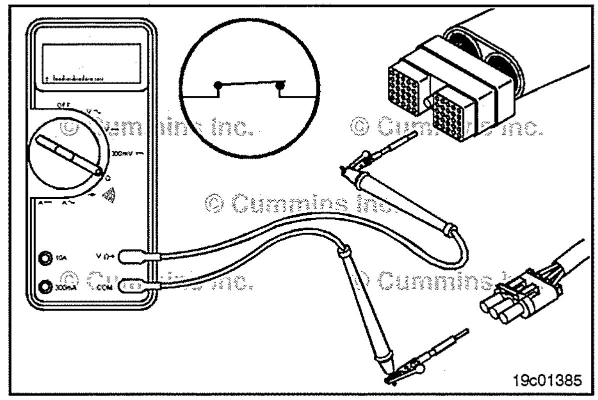
CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Disconnect the digital vehicle speed sensor from the OEM harness.

Insert a test lead into the digital vehicle speed sensor +5 volt supply pin in the OEM harness connector, and connect it to the multimeter probe.



Insert the other test lead to the digital vehicle speed sensor +5 volt supply in the vehicle speed sensor connector and connect the alligator clip to the other multimeter probe. Adjust the multimeter to the resistance setting and measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, there is an open circuit. Repair or replace the wire connected to the digital vehicle speed sensor +5 volt supply pin in the OEM harness according to the vehicle manufacturer's procedures.

Remove the lead from the digital vehicle speed sensor +5 volt supply pin and insert it into the digital vehicle speed sensor signal pin of the OEM harness connector. Remove the multimeter lead from the digital vehicle speed sensor +5 volt supply at the speed sensor connector and connect it to the digital vehicle speed sensor signal pin in the vehicle speed sensor connector. Measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less).

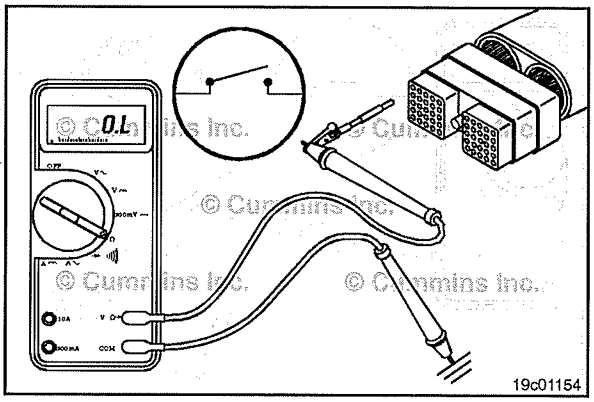
If the circuit is **not** closed, there is an open circuit. Repair or replace the wire connected to the vehicle speed sensor signal pin in the OEM harness according to the vehicle manufacturer's procedures.

Remove the lead from the digital vehicle speed sensor signal pin and insert it into the digital vehicle speed sensor return pin of the OEM harness connector. Remove the multimeter lead from the digital vehicle speed sensor signal pin at the speed sensor connector and connect it to the digital vehicle speed sensor return pin in the vehicle speed sensor connector. Measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, there is an open circuit. Repair or replace the wire connected to the vehicle speed sensor return pin in the OEM harness according to the vehicle manufacturer's procedures.

If the values are correct, the circuit **must** still be checked for a short circuit to ground and a short circuit from pin-to-pin.



Check for Short Circuit to Ground

Disconnect the vehicle speed sensor from the OEM harness. Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Insert a test lead into the digital vehicle speed sensor signal return pin of the OEM harness connector, and connect it to the multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the test lead from the digital vehicle speed sensor signal return pin and insert it into the digital vehicle speed sensor +5 volt supply pin of the OEM harness connector. Touch the other multimeter probe to the engine block ground. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

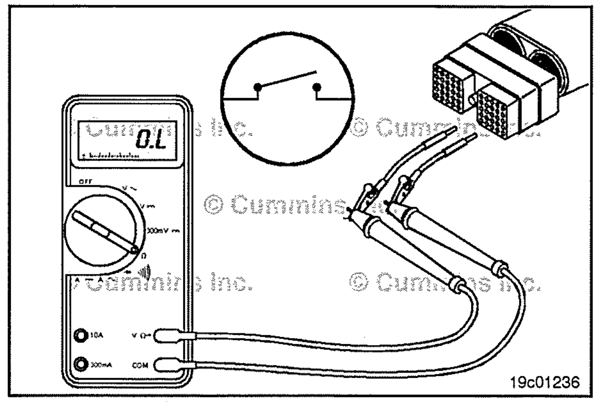
Remove the test lead from the digital vehicle speed sensor signal +5 volt supply pin and insert it into the digital vehicle speed sensor signal pin of the OEM harness connector. Touch the other multimeter probe to the engine block ground. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open in either of these checks, there is a short circuit to ground in the digital vehicle speed sensor circuit in the OEM harness.

Repair the wires which have a short circuit according to the vehicle manufacturer's procedures.

Check for Short Circuit from Pin to Pin



Disconnect the vehicle speed sensor from the OEM harness.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Insert one test lead into the digital vehicle speed sensor +5 volt supply pin of the OEM harness connector, and connect it to the multimeter probe. Connect the other test lead to the other multimeter probe and check all pins in the OEM harness connector.Measure the resistance.

The multimeter **must** show an open circuit at all pins (100k ohms or more).

Remove the test lead from the digital vehicle speed sensor +5 volt supply pin, and insert it into the digital vehicle speed sensor signal return pin.

Use the other test lead to check all pins in the connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the test lead from the digital vehicle speed sensor return pin, and insert it into the digital vehicle speed sensor signal signal pin.

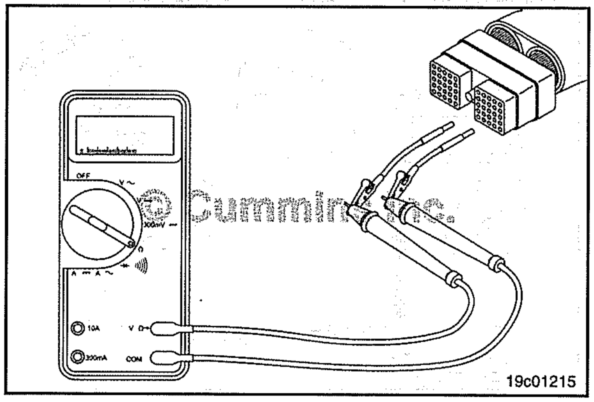
Use the other test lead to check all pins in the connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open in any of the checks, repair the wires that have the short circuit according to the vehicle manufacturer's procedures.

NOTE: If the values are correct for all of the circuit checks in Procedure 019-090, the vehicle speed sensor circuit is good.

The problem is in the vehicle speed sensor. Repair or replace the vehicle speed sensor according to the vehicle manufacturer's procedures.



Vehicle Speed Sensor Circuit (019-093)

Resistance Check

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

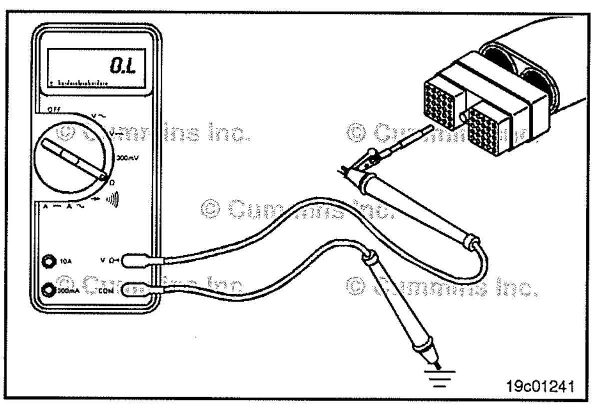
Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Make sure the vehicle speed sensor is connected to the OEM harness.

Insert a test lead into the magnetic vehicle speed sensor signal positive (+) pin in the OEM harness connector. Insert the other lead into the magnetic vehicle speed sensor signal negative (-) pin of the connector.

Connect the two alligator clips to the two probes of the multimeter. Adjust the multimeter to the resistance setting and measure resistance. When measuring the resistance with the sensor connected, refer to the OEM troubleshooting and repair manual for the correct resistance value. If the value is **not** correct, there is a problem with the OEM harness, provided that the vehicle speed sensor component has been previously checked.

NOTE: Repair or replace the OEM harness. Refer to Procedure 019-071, or to the OEM troubleshooting and repair manual for OEM harness replacement.

If the value is correct, the circuit **must** still be checked for a short circuit to ground and a short circuit from pin-to-pin.



Check for Short Circuit to Ground

Check for a short circuit to ground. Insert the multimeter probe with attached test lead into the magnetic vehicle speed sensor signal positive (+) pin of the OEM harness connector. Touch the other multimeter probe to the engine block. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

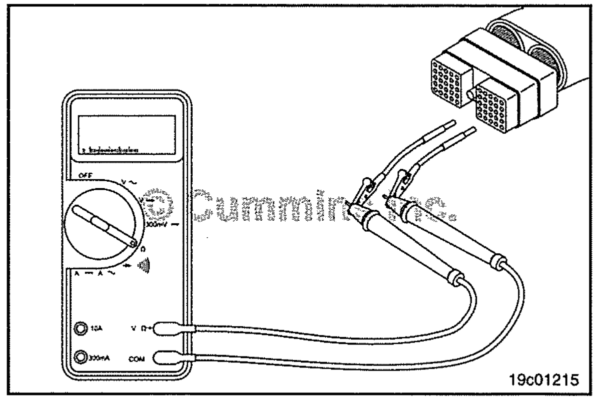
If the circuit is **not** open, there is a short circuit to ground in the vehicle speed sensor circuit in the engine harness or OEM harness.

Repair the wires which are shorted in the circuit according to the vehicle manufacturer's procedures.

Check for Short Circuit from Pin to Pin

Check for a short circuit from pin-to-pin. Insert the multimeter probe with attached test lead into the magnetic vehicle speed sensor signal positive (+) pin of the OEM harness connector. Insert the other test lead into all the other pins, one at a time, to check for a short to another pin.

Measure the resistance. The multimeter **must** show an open circuit (more than 100k ohms).



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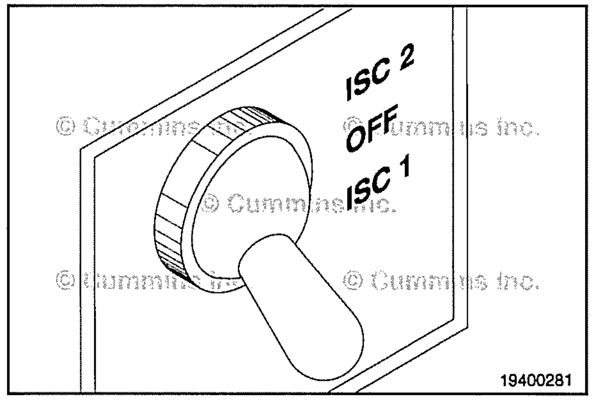
Intermediate Speed Control Switch (019-107)

General Information

The intermediate speed control switch circuit signals the engine control module (ECM) that the operator is requesting the engine to run at a preset engine speed between low idle and high idle. Depending on the configuration, up to eight speeds are available. This procedure can **not** cover every possible configuration, but the functionality checks provided in this procedure will be similar for all of them.



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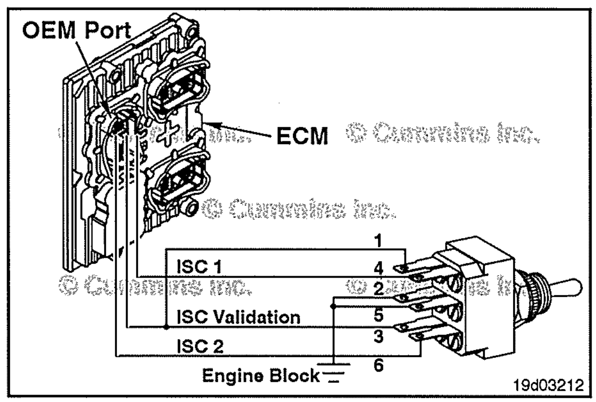
The intermediate speed control circuit is shown for intermediate speed control 1 and intermediate speed control 2 features. The calibration can have **only** one intermediate speed control active feature. The intermediate speed control circuit is wired with a double pole, double throw, three-position switch.



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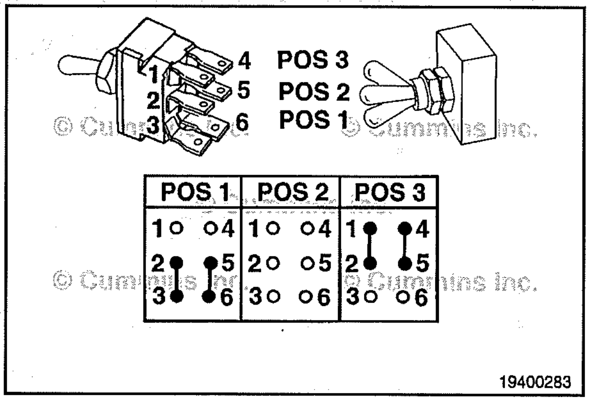


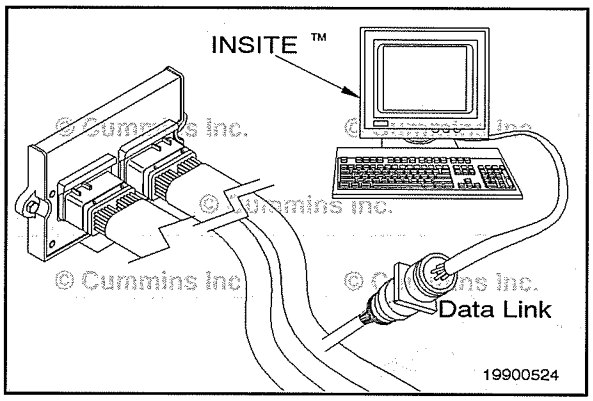
The double pole, double throw, three position switch, functions to selectively ground the three intermediate speed control input wires to the ECM. Reference the wiring diagram for terminal locations. The logic of the switch is shown.

The lines that connect the switch terminals at the three lever positions are lines of continuity between the terminals.

In position 1, switch terminals number 2, 3 and 5, 6 are connected, which shorts intermediate speed control 2 and intermediate speed control validation (pins 25 and 33) to ground.

In position 2, no pins are grounded.

In position 3, switch terminals number 1, 2 and 4, 5 are connected, which shorts intermediate speed control 1 and intermediate speed control validation (pins 23 and 33) to ground.

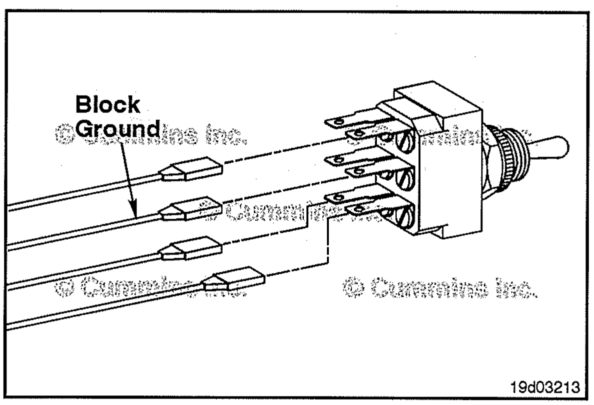


Initial Check

Connect an electronic service tool to the vehicle data link.

Turn the keyswitch to the ON position.

Operate the intermediate speed control switch while monitoring with INSITE™ electronic service tool. The INSITE™ electronic service tool reading should change with the switch position.



Resistance Check

Use the following steps for the intermediate speed control switch:

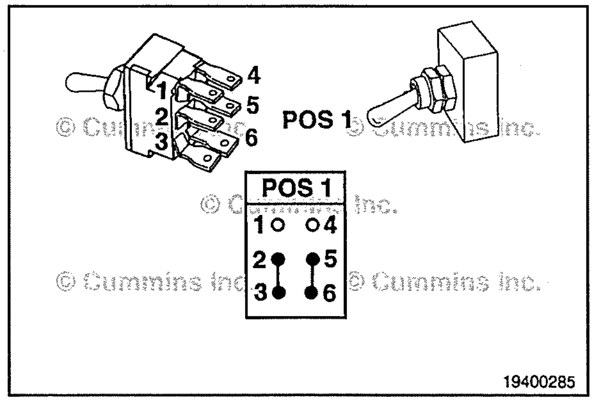
- If INSITE™ electronic service tool is available, monitor the ISC switch for proper operation. If **not**, follow the troubleshooting procedures in this section.
- Remove the four connectors from the switch. Label the wires with the switch location and the wire numbers before removing them from the switch.

With the switch in position 1, measure the resistance from switch terminal 2 to switch terminal 3. The resistance **must** be 10 ohms or less.

Measure the resistance from switch terminal 5 to switch terminal 6. The resistance **must** be 10 ohms or less.

Measure the resistance from switch terminal 1 to all switch terminals. The resistance **must** be 100K ohms or more.

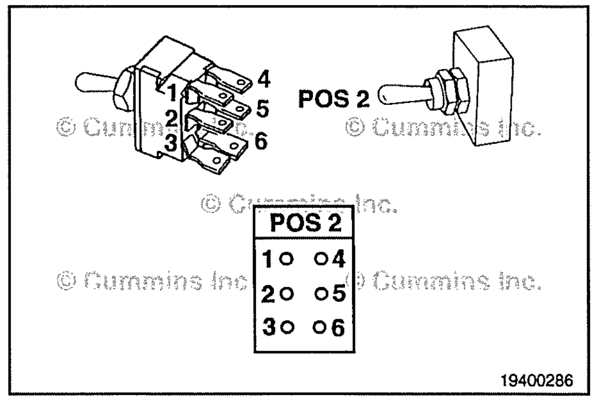
Measure the resistance from switch terminal 4 to all other terminals. The resistance **must** be 100K ohms or more.



Move the switch lever to position 2.

Measure the resistance from switch terminal 1 to all other terminals. The resistance **must** be 100K ohms or more.

Measure the resistance from switch terminal 2 to all other terminals. The resistance **must** be 100K ohms or more.



Move the switch lever to position 3.

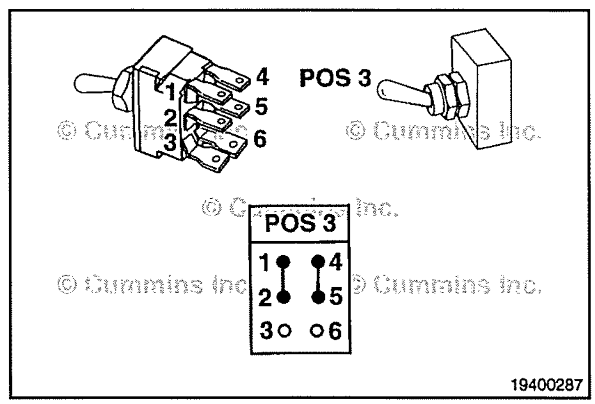
Measure the resistance from switch terminal 1 to terminal 2. The resistance **must** be 10 ohms or less.

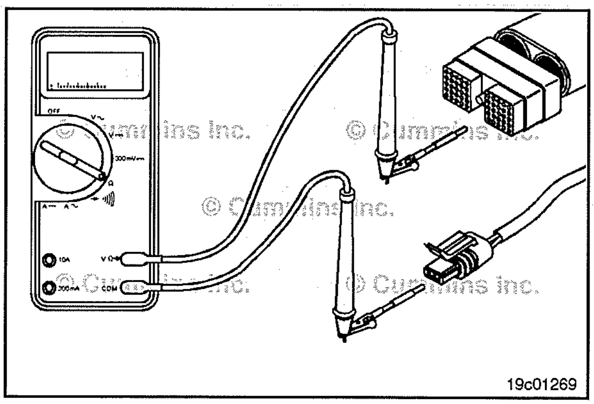
Measure the resistance from switch terminal 4 to terminal 5. The resistance **must** be 10 ohms or less.

Measure the resistance from switch terminal 3 to all other terminals. The resistance **must** be 100K ohms or more.

Measure the resistance from switch terminal 6 to all other terminals. The resistance **must** be 100K ohms or more.

If the multimeter does **not** show the correct values, the switch has malfunctioned. Verify the switch type and terminal location numbers. Refer to the original equipment manufacturer (OEM) service manual for replacement and to verify the switch type and terminal location.





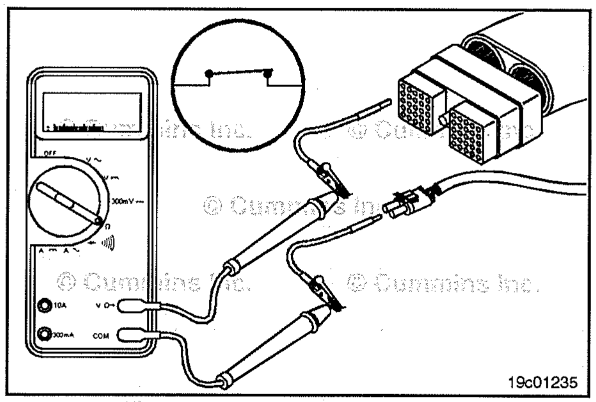
CAUTION

The leads must fit tightly in the connector without expanding the pins in the connector, otherwise the connector will be damaged.

Use the following steps for the variable intermediate speed control switch.

Disconnect the OEM harness connector from the ECM. Disconnect the variable intermediate speed control switch from the OEM harness. Set the multimeter to measure resistance.

Insert a test lead into the variable intermediate speed control switch SIGNAL pin of the OEM harness connector. Connect the alligator clip to a multimeter probe. Insert the second test lead to the SIGNAL pin of the intermediate speed control switch and connect the clip to the other multimeter probe. Measure the resistance.



The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the SIGNAL wire.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

Repeat the resistance check for the RETURN wire. Measure the resistance from the variable intermediate speed control switch RETURN pin of the OEM harness connector to the variable intermediate speed control switch RETURN pin of the switch.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the RETURN wire.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

Repeat the resistance check for the 5 volt SUPPLY wire. Measure the resistance from the variable intermediate speed control switch 5 volt SUPPLY pin of the OEM harness connector to the variable intermediate speed control switch 5 volt SUPPLY pin of the switch.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

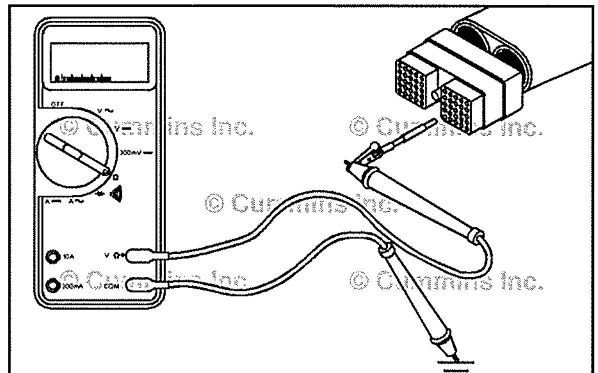
If the measured value is more than 10 ohms, there is an open circuit in the 5 volt SUPPLY wire.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

Check for Short Circuit to Ground

Disconnect the OEM harness connector from the ECM. Disconnect the variable intermediate speed control switch from the OEM harness. Set the multimeter to measure resistance.

Insert the test lead into the variable intermediate speed control switch SIGNAL pin of the OEM harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.



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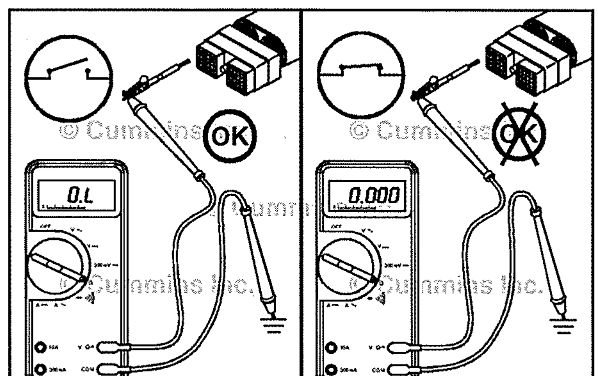
The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the SIGNAL wire.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.



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Repeat the short-to-ground check for the RETURN wire. Measure the resistance from the variable intermediate speed control switch RETURN pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the RETURN wire.

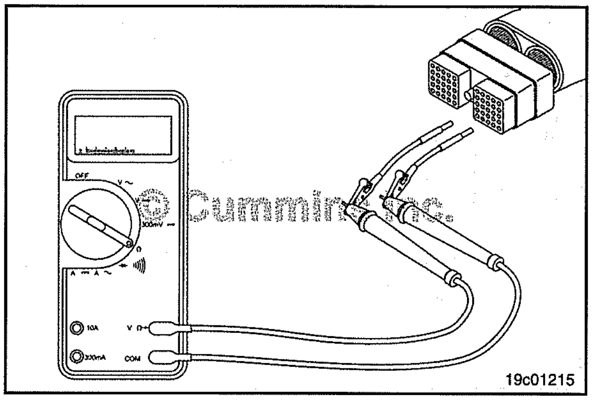
Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

Repeat the short-to-ground check for the 5 volt SUPPLY wire. Measure the resistance from the variable intermediate speed control switch 5 volt SUPPLY pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the 5 volt SUPPLY wire.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.



Check for Short Circuit from Pin to Pin

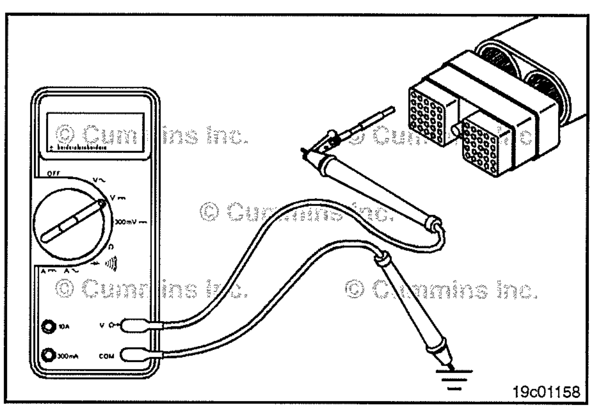
Disconnect the OEM harness connector from the ECM. Disconnect the variable intermediate speed control switch from the OEM harness. Set the multimeter to measure resistance.

Measure the resistance from the variable intermediate speed control switch SIGNAL pin in the OEM harness connector to all other pins in the connector.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit between the SIGNAL wire and any other pin that measured a closed circuit.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.



Check for Short Circuit to External Voltage Source

Disconnect the OEM harness connector from the ECM. Disconnect the variable intermediate speed control switch from the OEM harness. Set the multimeter to measure volts of direct current (VDC). Turn the vehicle keyswitch to the ON position.

Insert the test lead connected to the positive (+) multimeter probe into the variable intermediate speed control switch SIGNAL pin of the OEM harness connector. Touch the negative (-) multimeter probe to engine block ground and measure the voltage.

If there is voltage present, there is a short circuit from the SIGNAL wire to an external voltage source.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

Repeat the short to external voltage source check for the RETURN wire. Measure the voltage from the variable intermediate speed control switch RETURN pin of the OEM harness connector to engine block ground.

If there is voltage present, there is a short circuit from the RETURN wire to an external voltage source.

Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

Repeat the short to external voltage source check for the 5 volt SUPPLY wire. Measure the voltage from the variable intermediate speed control switch 5 volt SUPPLY pin of the OEM harness connector to engine block ground.

The multimeter **must** show a voltage of less than 5.5-VDC. If the voltage is greater than 5.5-VDC, there is a short circuit from the 5 volt SUPPLY wire to an external voltage source.

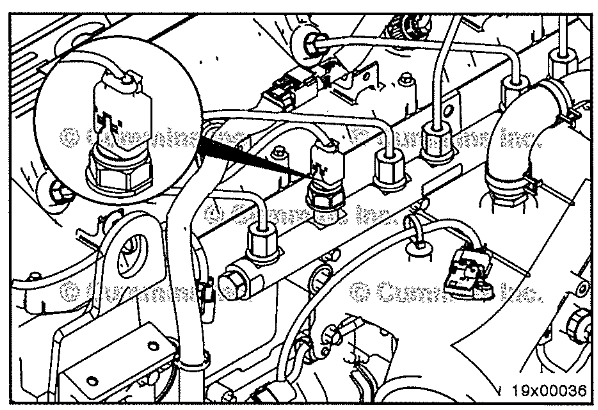
Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.

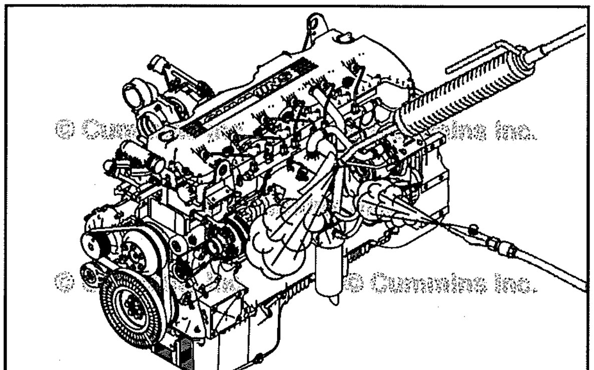
Rail Fuel Pressure Sensor (019-115)

General Information

The fuel rail pressure sensor is located on the fuel rail, mounted on the cylinder head. This sensor features an integrated sealing washer that can **not** be replaced. If the sealing washer is damaged the sensor **must** be replaced.

NOTE: It is **not** necessary to remove the fuel rail pressure sensor from the fuel rail as part of another repair. **Only** remove the pressure sensor from the fuel rail if the sensor is being replaced.





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Preparatory Steps

⚠WARNING⚠

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

⚠WARNING⚠

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

⚠CAUTION⚠

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. Refer to Procedure 000-009 in Section 0.

Clean the injector supply line connections and mating components with contact cleaner, Part Number 3824510 or equivalent.

To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.

WARNING

Normal engine operation creates highly pressurized fuel in the fuel line which will remain in the fuel line after engine shutdown. Never open the fuel system when the engine is operating. Before servicing the fuel system, always loosen the pump to rail fuel line at the rail to vent the pressure. Keep hands clear of the line when loosening. High-pressure fuel spray can penetrate the skin, resulting in serious personal injury or death.

WARNING

When servicing the engine do not use the starting motor to rotate the 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.

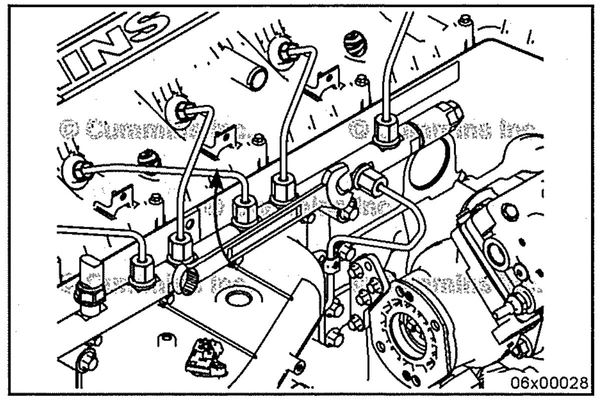
Before servicing the fuel system, loosen the pump-to-rail line at the rail to vent the fuel pressure.

Keep hands clear of the line when loosening the fuel rail nut.

Tighten the fuel rail nut.

Torque Value: 25 N•m [221 in-lb]

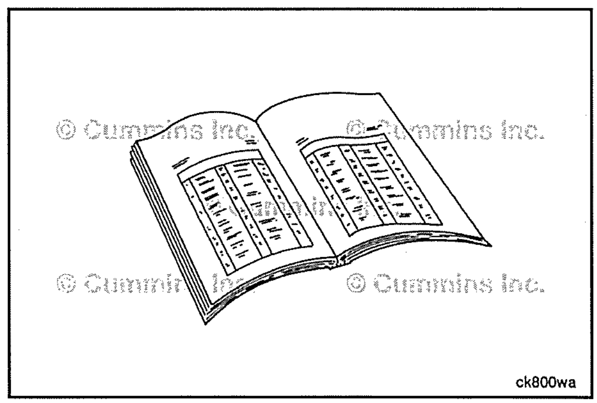
NOTE: A machined slot in this fitting directs the fuel spray toward the cylinder block.



WARNING

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

- Disconnect the batteries. See equipment manufacturer service information.

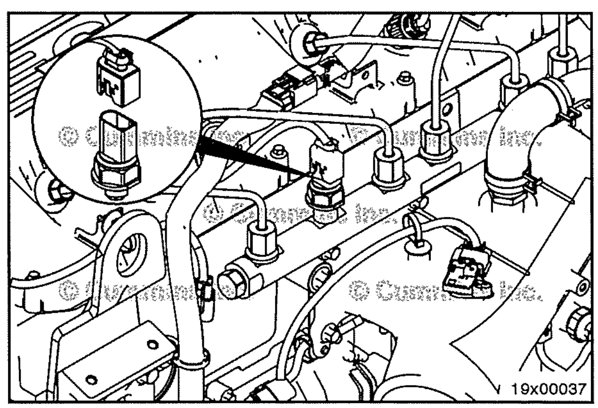


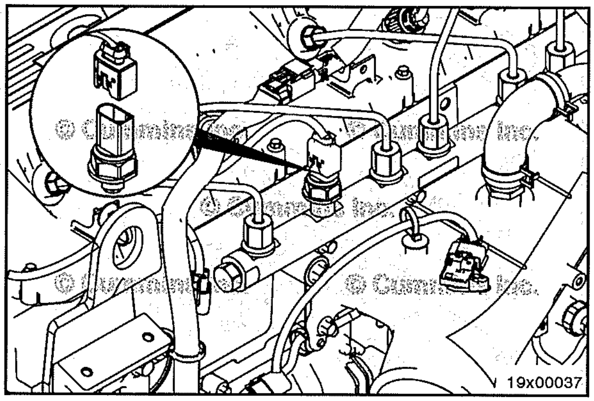
Remove

Clean the area around the fuel pressure sensor.

Disconnect the pressure sensor connector from the engine harness.

Remove the fuel pressure sensor.



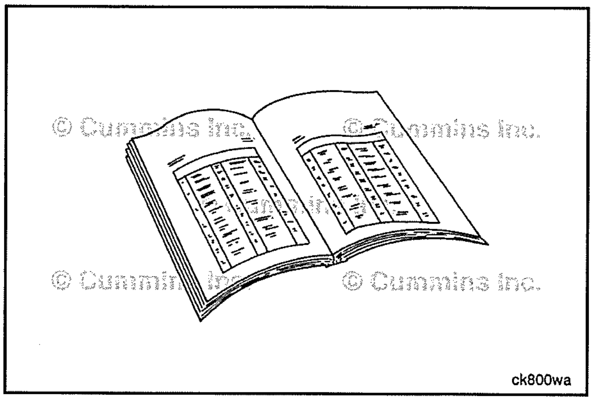


Install

Install a new fuel pressure sensor.

Torque Value: 47 N•m [35 ft-lb]

Connect the engine harness to the fuel pressure sensor.

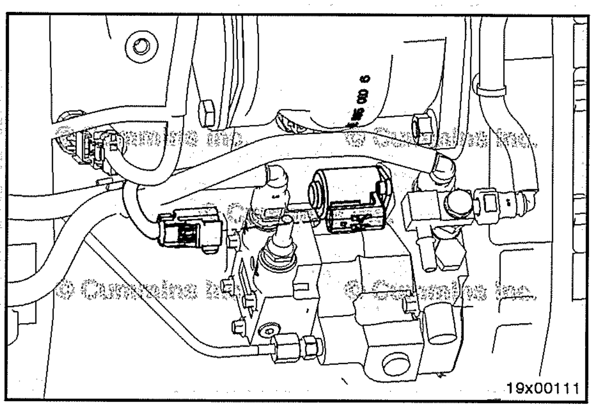


Finishing Steps

WARNING

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



Fuel Pump Actuator (019-117)

Preparatory Steps

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.

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 fuel pump actuator and surrounding area with electrical contact cleaner, Part Number 3824510, or equivalent.

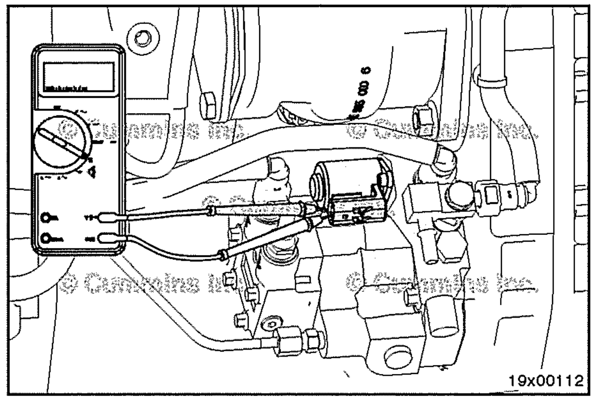
To prevent damage from debris and contamination, cover, cap, or plug any openings as soon as possible when servicing the fuel system. Caps and plugs can be found in Clean Care Kit, Part Number 4919073.

Disconnect the fuel pump actuator harness connector.

Initial Check

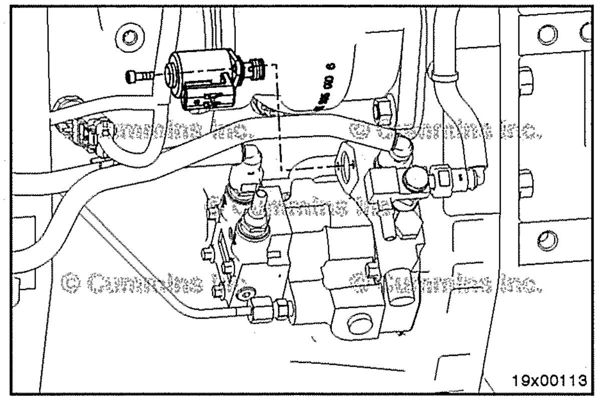
Measure the fuel pump actuator resistance.

The maximum resistance is 2.5 ohms.



Remove

Remove the capscrews and fuel pump actuator.



Install

Lubricate the o-ring with clean oil before installation. Do **not** use grease.

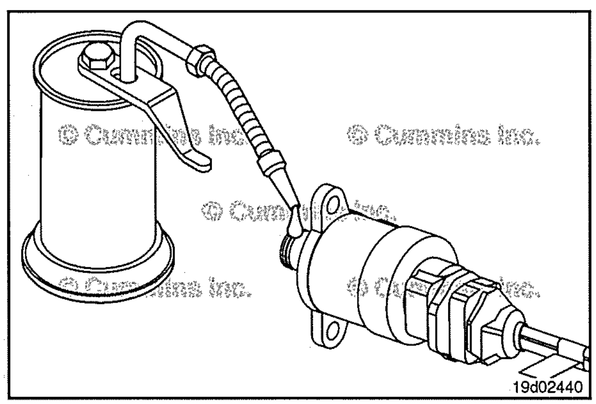
Press the fuel pump actuator fully into the fuel pump housing. Use a slight twisting motion. Do this before starting the capscrews.

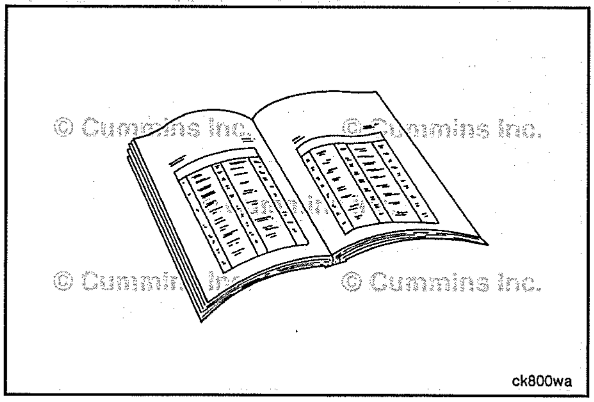
NOTE: Fully installing the fuel pump actuator prior to starting the capscrews reduces the risk of side loading the plunger and reduced component life.

NOTE: Be sure the fuel pump actuator flange is flush with the mounting surface on the fuel pump before tightening the capscrews.

Install and tighten the capscrews.

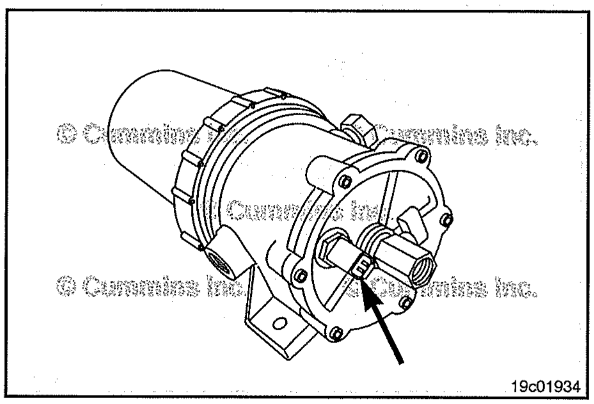
Torque Value: 5.6 N•m [50 in-lb]





Finishing Steps

- Connect the fuel pump actuator harness connector.
- Operate the engine to normal operating temperature and check for leaks and proper operation.

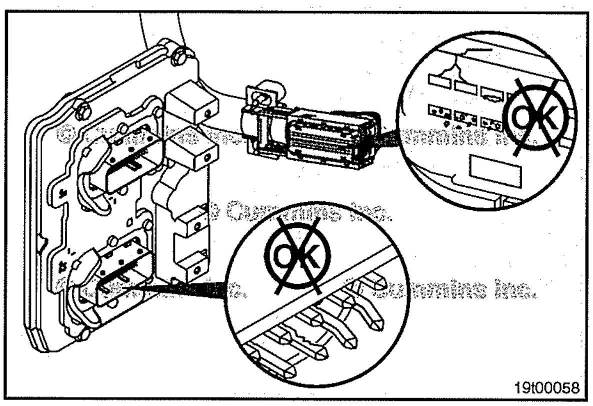


Water in Fuel Sensor (019-127)

General Information

The water-in-fuel sensor separator is located at the base of the suction side fuel filter. The water-in-fuel sensor sends a signal to the engine control module (ECM) when a set volume of water has accumulated in the fuel filter. The water-in-fuel circuit contains two wires, the water-in-fuel RETURN wire and the water-in-fuel SIGNAL wire.

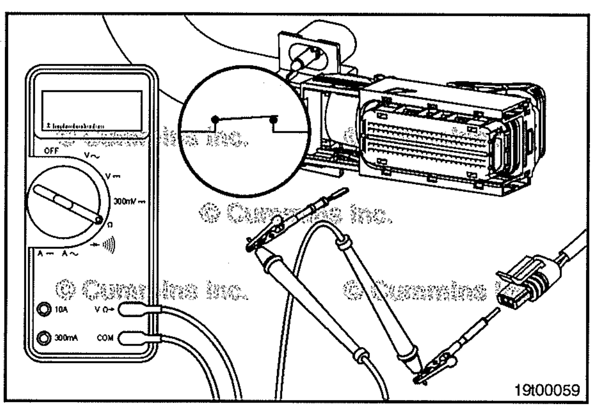
Use the following procedure to drain the water from the filter. Refer to Procedure 006-066 in Section 6.



Resistance Check

Disconnect the engine harness from the ECM. Disconnect the water-in-fuel sensor from the original equipment manufacturer (OEM) harness. Check for dirty or damaged pins on the ECM connector and the water-in-fuel sensor connector of the OEM harness.

Use the following procedure for general inspection techniques. Refer to Procedure 019-361 in Section 19.



CAUTION

To reduce the possibility of pin and connector damage, use test lead, Part Number 3822758, when taking a measurement.

Measure the resistance of the water-in-fuel sensor return circuit at the ECM connector of the wiring harness and the water-in-fuel sensor connector of the OEM wiring harness.

The multimeter **must** show a closed circuit (10 ohms or less).

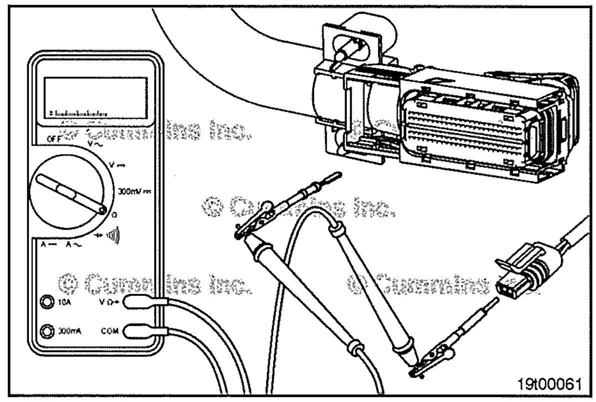
If more than 10 ohms are measured, there is an open circuit in the RETURN wire.

Troubleshoot all interconnects for an open circuit. Repair or replace the wiring harness. Refer to Procedure 019-071 in Section 19.

Measure the resistance of the water-in-fuel sensor signal circuit at the ECM connector of the wiring harness and the water-in-fuel sensor connector of the OEM wiring harness.

The multimeter **must** show a closed circuit (10 ohms or less).

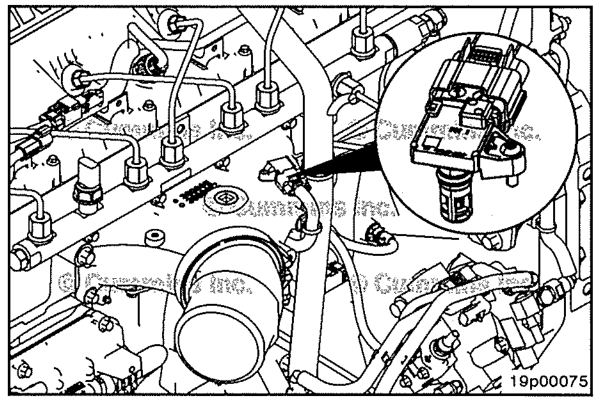
If more than 10 ohms are measured, there is an open circuit in the SIGNAL wire. Troubleshoot all interconnects for an open circuit. Repair or replace the wiring harness. Refer to Procedure 019-071 in Section 19.



Intake Manifold Pressure/Temperature Sensor (019-159)

General Information

The intake manifold temperature sensor and intake manifold pressure sensor are combined into a single sensor. The sensor is located in the air intake connection.

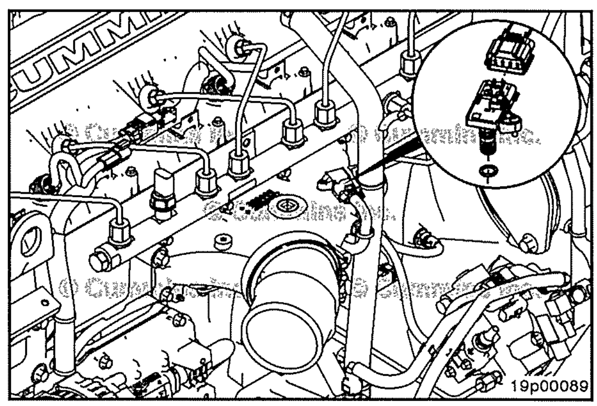


Remove

Lift up on the locking tab and pull the electrical connectors apart.

Remove the capscrew.

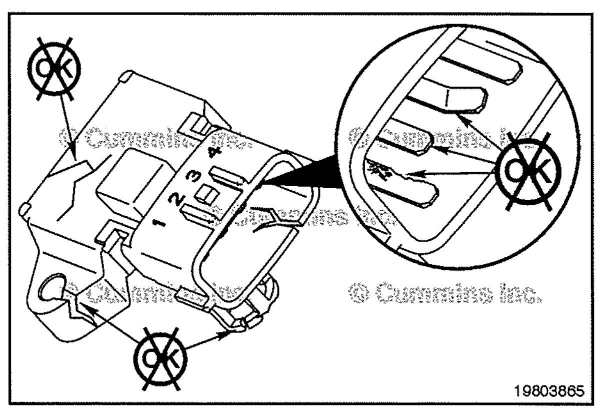
Remove the sensor from the engine by pulling straight up on the sensor. Be careful **not** to damage the o-ring seal or the plastic cage surrounding the sensor tip when removing the sensor. Do **not** pry the sensor, as damage to the plastic cage can occur.

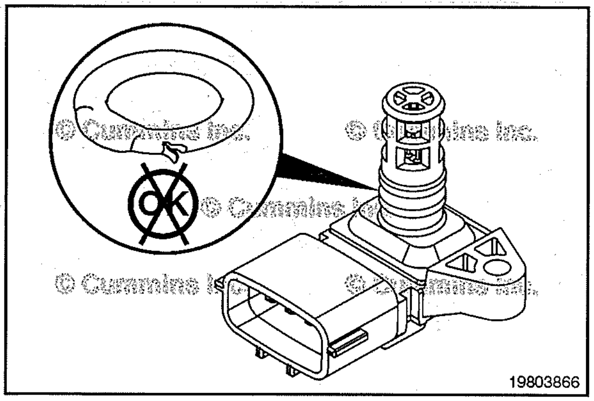


Inspect for Reuse

Inspect the engine harness connector and the intake manifold pressure/temperature sensor for the following:

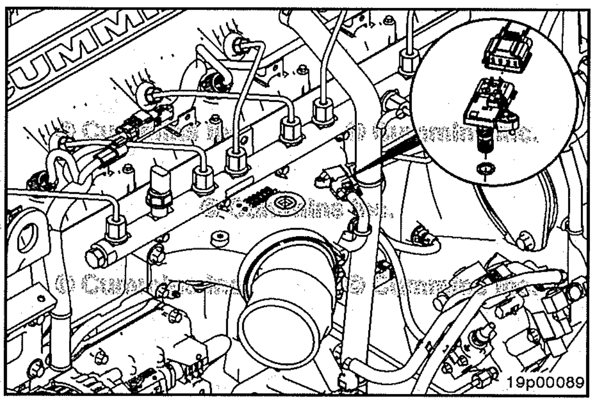
- Cracked or broken shell
- Missing or damaged connector seals
- Dirt, debris, or moisture in or on the connector pins
- Corroded, bent, broken, pushed back, or expanded pins.





Inspect the intake manifold pressure/temperature sensor for the following:

- Swollen o-ring
- Nicks or cuts in or on the o-ring.



Install

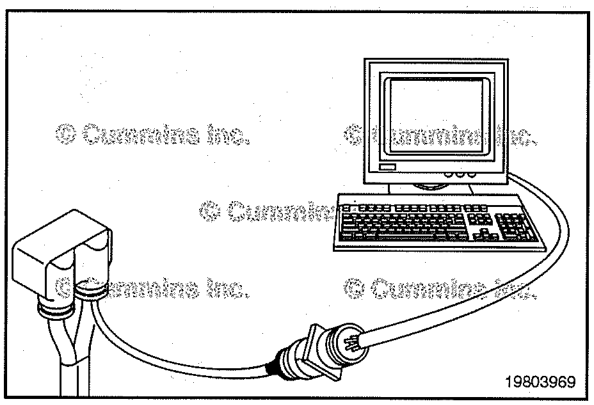
Make sure the new sensor has an o-ring.

Install the new sensor into the engine.

Tighten the capscrew.

Torque Value: 3 N•m [27 in-lb]

Push the connectors together until they lock. An audible click will be heard as the connectors lock in place.



Data Link Circuit, SAE J1939 (019-165)

General Information

The OEM J1939 datalink circuit is located in the OEM wiring harness.

The purpose of this datalink is to allow communication with vehicle control-operated systems such as transmission controllers, traction control system, etc.

The traditional OEM J1939 datalink circuit is described as a shielded twisted pair and includes the wires connected to the J1939 datalink positive (+) pin, the J1939 datalink negative (-) pin, and the J1939 (shield) pin in the OEM harness.

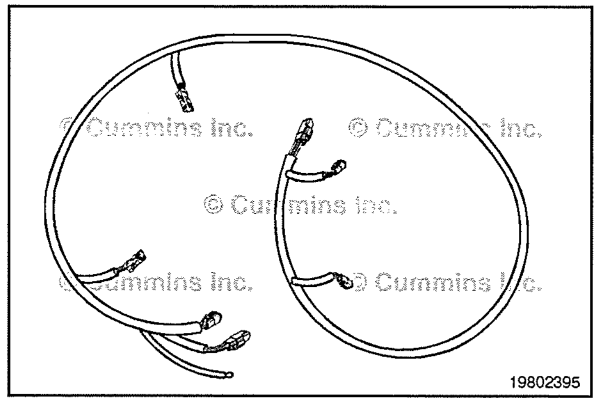
On newer vehicles and equipment, OEM's can utilize an OEM J1939 datalink circuit that is described as an unshielded twisted pair (UTP). The unshielded twisted pair (UTP) J1939 datalink does **not** include the J1939 (shield) pin and **only** includes the J1939 datalink positive (+) pin and the J1939 datalink negative (-) pin in the OEM harness.

With the keyswitch in the ON position, public datalink messages will be broadcast on the OEM J1939 datalink. The broadcast will stop when the keyswitch is turned to the OFF position.

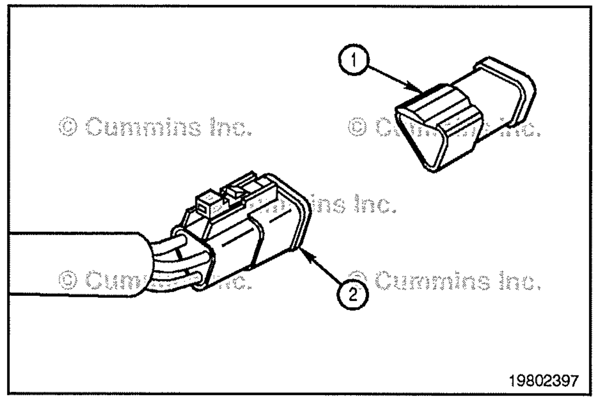
The Society of Automotive Engineers (SAE) J1939 has strict guidelines that **must** be followed for successful communication. Understanding some fundamentals about SAE J1939 will help make sure these guidelines are followed.

The main component of an SAE J1939 system is a backbone harness. The harness can be up to 40 meters [131 feet] in length. The backbone harness is terminated at each end with a 120 ohm resistor.

A maximum of thirty different devices can be attached to the SAE J1939 backbone at once. Each device, such as the datalink adapter, is connected to the backbone through a stub, which can be up to 1 meter [3.3 ft] in length. The stub connector is a 3-pin plug.



The terminating resistor caps (1) **must** be in place on the OEM backbone harness plugs (2) to maintain proper communication. Each resistor is 120 ohms and can be located in a removable cap.



Some OEMs will choose to provide a complete SAE J1939 backbone harness. If this is supplied, connection to the electronic service tool is accomplished by a 9-pin datalink connector (1), Part Number 3162848.

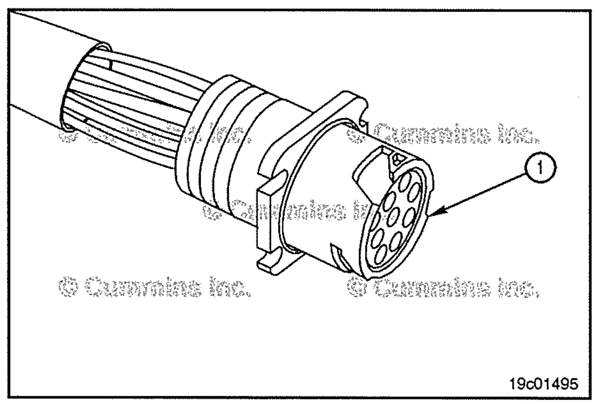
NOTE: Some OEM's place a 9-pin connector in the cab, but do **not** connect all of the pins to support J1939 protocol.

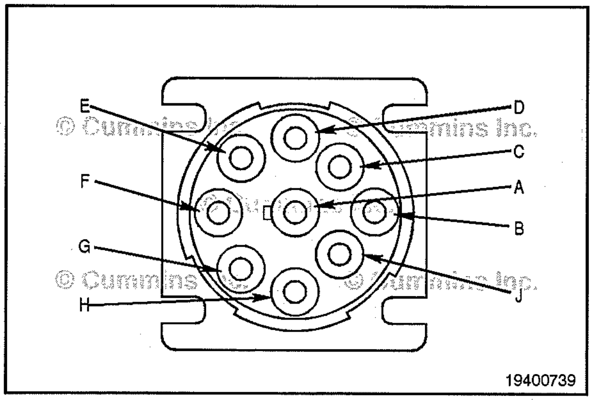
To check for the OEM J1939 backbone, turn the keyswitch to the OFF position. Measure the resistance from the SAE J1939 datalink positive (+) pin to the SAE J1939 datalink negative (-) pin of the 9-pin Deutsch™ connector.

The multimeter **must** read between 50 and 65 ohms for the electronic service tool to be able to establish communication.

If the OEM does **not** supply the J1939 backbone harness to the 9-pin connector, the **only** way to establish J1939 communication is through either the bench communication setup or for the Engine Control Module through the engine communication setup. Refer to Procedure 022-999.

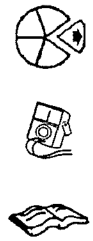
NOTE: The typical SAE J1939 connector will be a 9-pin connector.

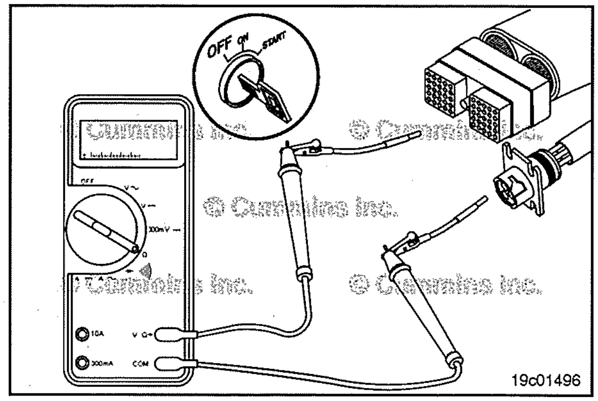




Pin	Signal
A	Ground
B	Unswitched Battery
C	J1939 datalink (+)
D	J1939 datalink (-)
E	J1939 datalink (shield) (if available)
F	J1708 datalink (+)
G	J1708 datalink (-)
H	Open
J	Open

Resistance Check





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

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Turn the keyswitch to the OFF position.

Disconnect the batteries.

Disconnect the OEM harness connector from the ECU.

Insert a test lead into the SAE J1939 datalink positive (+) pin of the OEM harness connector, and connect it to the multimeter probe. Insert the other test lead into the SAE J1939 datalink positive (+) pin of the 9-pin Deutsch™ connector, and connect it to the multimeter.

Measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual for the procedures.

Insert the multimeter lead into the SAE J1939 datalink negative (-) of the OEM harness connector. Touch the other lead to the SAE J1939 datalink negative (-) pin of the 9-pin Deutsch™ connector. Measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less)

If the circuit is **not** closed, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual for the procedures.

If the values are correct, the circuit **must** still be checked for a short circuit to ground and a short circuit from pin to pin.

Remove the lead from the SAE J1939 datalink negative (-) pin of the OEM harness connector and insert it into the SAE J1939 datalink (shield) pin, if the shield pin is available.

If the J1939 datalink circuit is an unshielded twisted pair (UTP), the shield pin will **not** be provided.

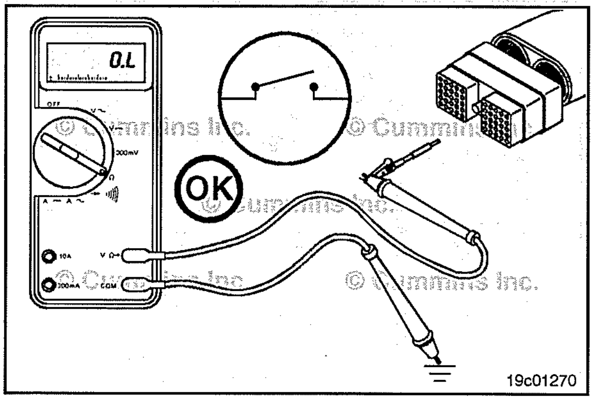
If the shield pin is provided, measure the resistance from the SAE J1939 datalink (shield) pin of the OEM harness connector to the SAE J1939 datalink (shield) pin of the 9-pin Deutsch™ connector.

The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual for the procedures.

If the (shield) pin is provided, measure the resistance from the SAE J1939 datalink (shield) pin of the 9-pin Deutsch™ connector to the engine block or chassis ground. The SAE J1939 datalink shield **must** be grounded to the vehicle battery ground. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, refer to the OEM troubleshooting and repair manual for repair instruction.

If more than 10 ohms are measured in any of these steps, there can be an open circuit in the SAE J1939 datalink positive (+) pin, the SAE J1939 datalink negative (-) pin, or the SAE J1939 (shield) pin, or the polarity is **not** correct. There can also be an open circuit from the datalink (shield) pin to vehicle battery ground.

If the values are correct, the SAE J1939 datalink positive (+) pin and the datalink negative (-) pin **must** still be checked for a short circuit to ground. The SAE J1939 datalink positive (+) pin, the datalink negative (-) pin, and the datalink (shield) pin **must** still be checked for a short circuit from pin to pin.



Check for Short Circuit to Ground

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

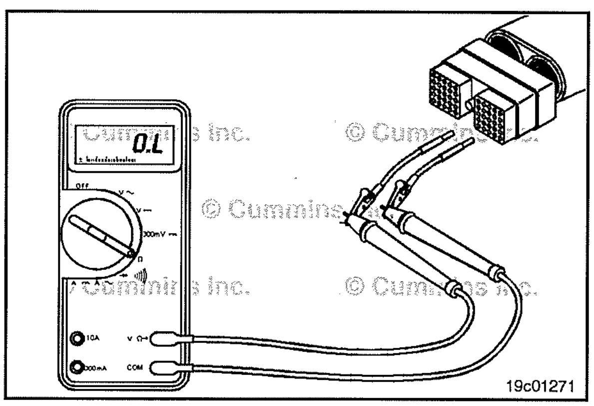
Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.Insert a test lead into the SAE J1939 datalink positive (+) pin of the OEM harness connector and connect it to a multimeter probe. Touch the other multimeter probe to the engine block or chassis ground.

Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Remove the test lead from the SAE J1939 datalink positive (+) pin and insert it into the SAE J1939 datalink negative (-) pin. Measure the resistance from the SAE J1939 datalink negative (-) pin of the OEM harness connector to the engine block or chassis ground. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



Check for Short Circuit from Pin to Pin

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

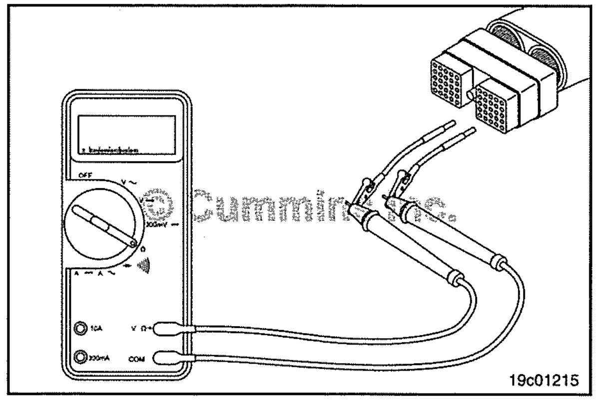
Insert a test lead into the SAE J1939 datalink positive (+) pin of the OEM harness connector and connect it to the multimeter probe. Insert the other test lead into another pin in the connector of the OEM harness and connect it to the other multimeter probe.

Measure the resistance from the SAE J1939 datalink positive (+) pin to the first pin in the connector. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Measure the resistance from the SAE J1939 datalink positive (+) pin of the OEM harness connector to all other pins in the connector, one at a time. The multimeter **must** show an open circuit (100k ohms or more) at all pins, except the J1939 datalink negative (-).

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



19c01215

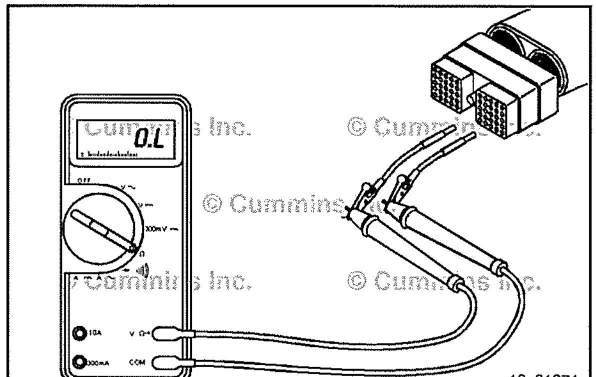
Remove the test lead from the J1939 datalink positive (+) pin and insert it into the J1939 datalink (shield) pin of the OEM harness connector, if the shield pin is available

NOTE: If the J1939 datalink circuit is an unshielded twisted pair (UTP), the (shield) pin will **not** be provided. If the shield pin is **not** provided, the datalink negative (-) pin **must** still be checked for a short circuit to the other pins.

Insert the other test lead into another pin in the connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

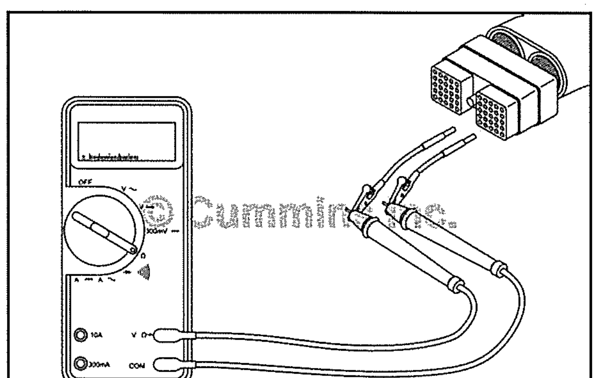
If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



19c01271

Measure the resistance from the SAE J1939 datalink (shield) pin, if available, to all other pins in the connector, one at a time. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

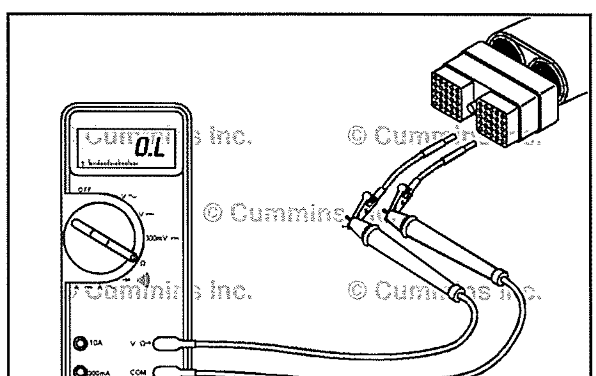


19c01215

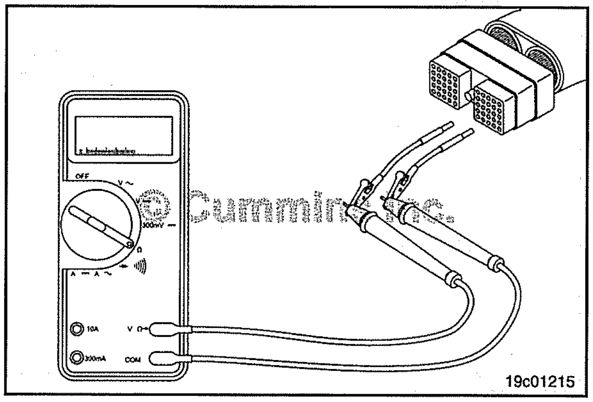
Remove the test lead from the SAE J1939 datalink (shield) pin and insert it into the SAE J1939 datalink negative (-) pin of the OEM harness connector. Insert the other test lead into another pin in the connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



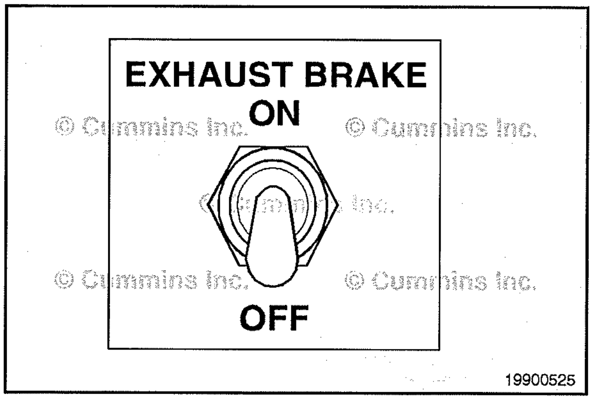
19c01271


19c01215

Measure the resistance from the SAE J1939 datalink negative (-) pin of the OEM harness connector to all other pins in the connector. The multimeter **must** show an open circuit (100k ohms or more) at all pins, except the J1939 datalink positive (+) pin.

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Connect all the components after the repair is complete.

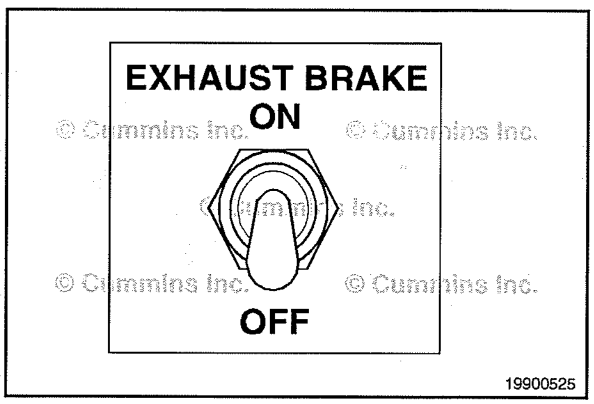


19900525

Exhaust Brake ON/OFF Switch (019-193)

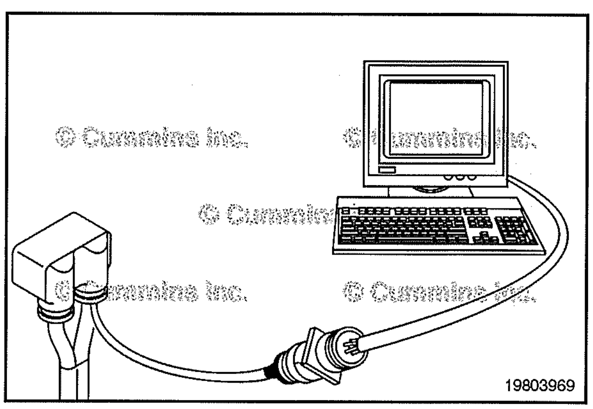
General Information

The exhaust brake on/off switch circuit signals the system that the operator is requesting the exhaust brake system to be activated.



19900525

After the ECM receives the signal from the exhaust brake on/off switch, the ECM will supply 12 VDC to the exhaust brake signal pin in the engine harness, provided the engine speed is **not** below 1000 rpm and the driver is **not** in cruise control or depressing the accelerator or clutch pedals.


19803969

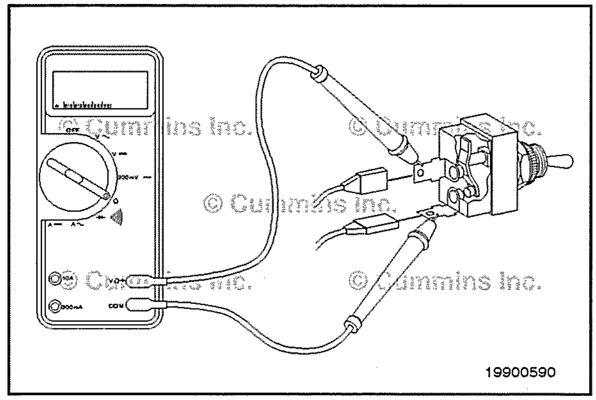
Resistance Check

If an electronic service tool is available, monitor the exhaust brake select switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Label the wires with the location on the switch or the wire number. Remove the electrical connectors from the switch.

Set the multimeter to measure resistance.

Touch one multimeter probe to the center terminal of the switch. Touch the other multimeter probe to the bottom terminal of the switch.



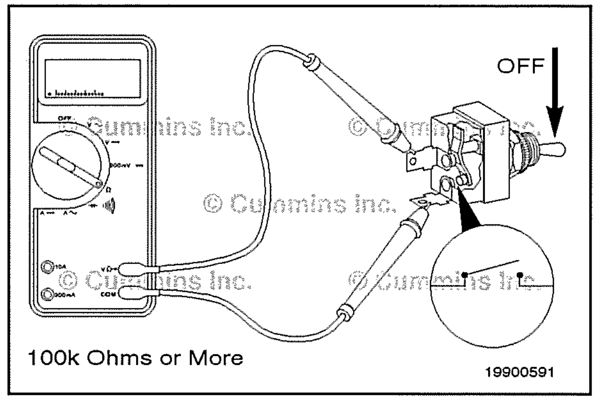
19900590

Set the switch to the OFF position.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Replace the switch.

Refer to the OEM repair manual for replacement instructions.



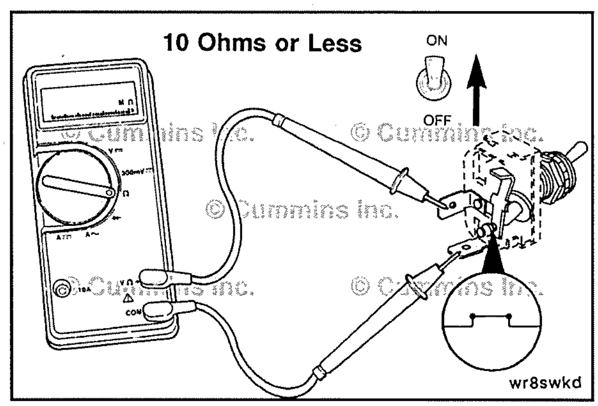
19900591

Set the switch to the ON position.

The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

Refer to the OEM troubleshooting and repair manual for replacement instructions.



wr8swkd

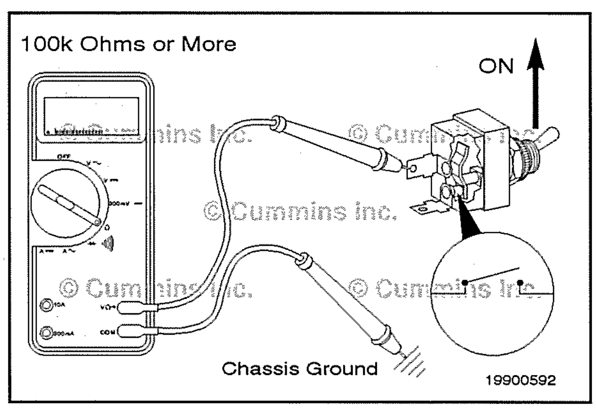
Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position, and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Replace the switch. Refer to the OEM troubleshooting and repair manual for replacement instructions.

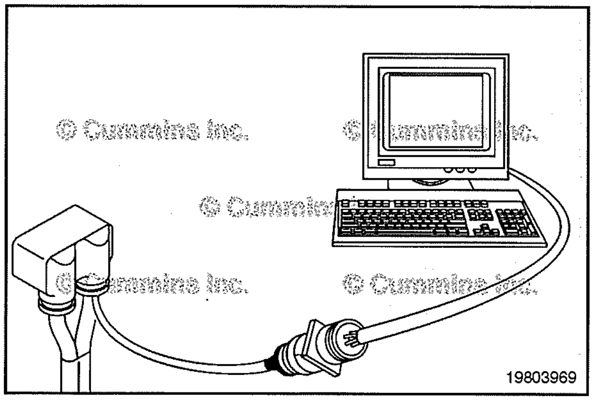
If the switch passes all of the previous checks, the circuit **must** be checked for open circuits, short circuits to ground, short circuits from pin to pin, and short circuits to an external voltage source.



19900592

Exhaust Brake ON/OFF Switch Circuit (019-194)

Resistance Check

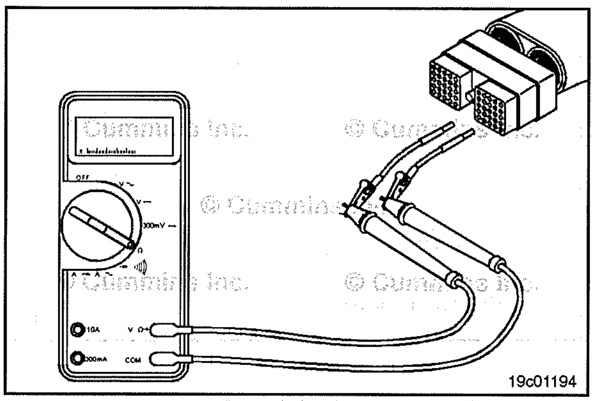


⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If electronic service tool is available, monitor the exhaust brake switch circuit for proper operation.

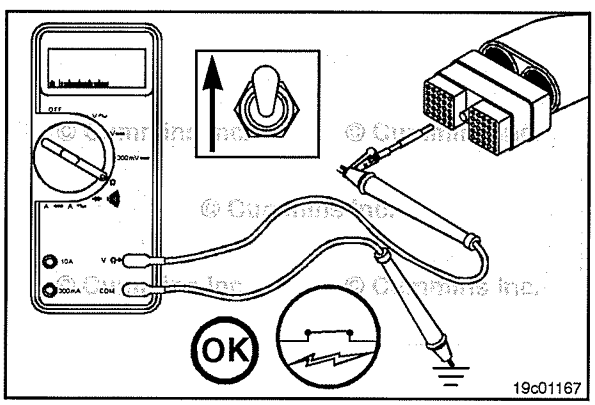
If **not**, follow the troubleshooting procedures in this section.



Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Insert the appropriate test lead into exhaust brake ON/OFF switch input pin of the OEM harness connector.

Insert the other appropriate test lead into switch return pin of the connector.

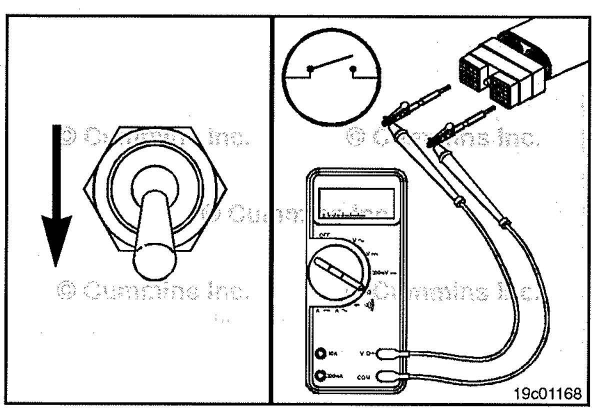


Set the exhaust brake switch to the ON position.

The multimeter **must** show a closed circuit (10 ohms or less).

Set the exhaust brake switch to the OFF position.

The multimeter **must** show an open circuit (100k ohms or more).



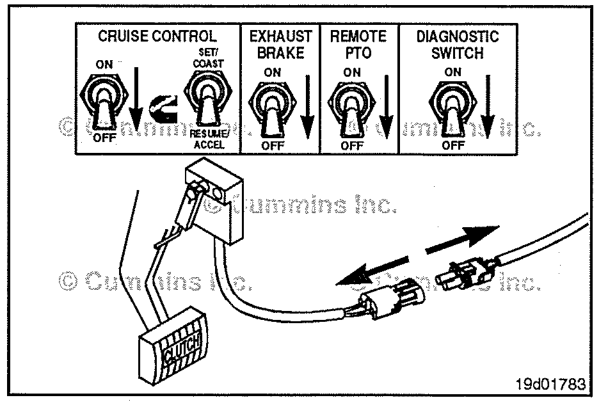
If the resistance values are **not** correct, make sure exhaust brake ON/OFF switch input pin and the battery positive (+) bus to switch return pin are properly installed on the switch.

If both wires are correctly installed, inspect exhaust brake ON/OFF switch input pin and the battery positive (+) bus to switch return pin for open circuits to ground and short circuits to other pins, provided the switch has been previously checked.

If the resistance values are correct in the previous checks, exhaust brake ON/OFF switch input pin and switch return pin **must** still be checked for short circuits to ground and short circuits from pin-to-pin.

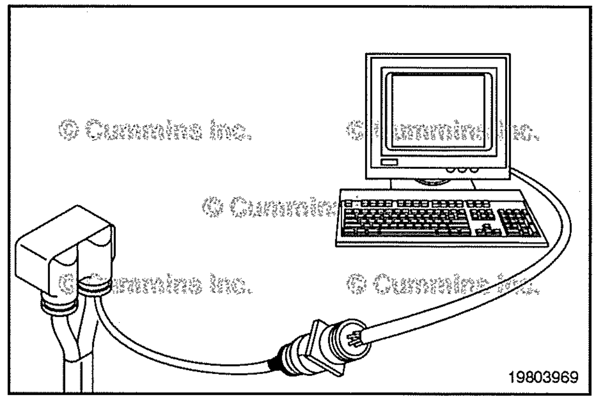
Check for Short Circuit to Ground

To isolate the exhaust brake circuit when checking for an electrical short, turn all cab switches to the OFF or NEUTRAL position.



If electronic service tool is available, monitor the engine brake ON/OFF switch circuit for proper operation.

If **not**, follow the troubleshooting procedures in this section.



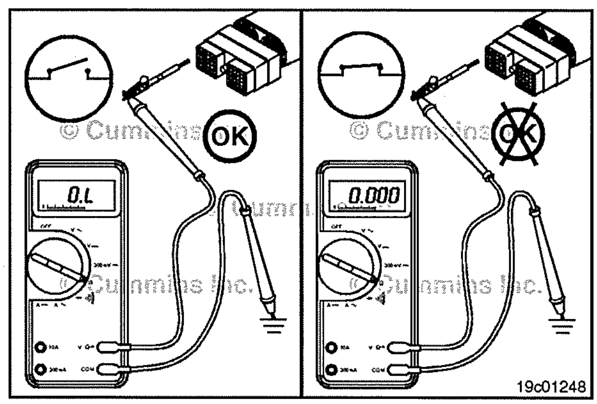
Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Insert the appropriate test lead into exhaust brake ON/OFF switch input pin of the OEM harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the resistance value is **not** correct, there is a short circuit to ground in the harness.

Repair or replace the OEM harness. Refer to Procedure 019-071.

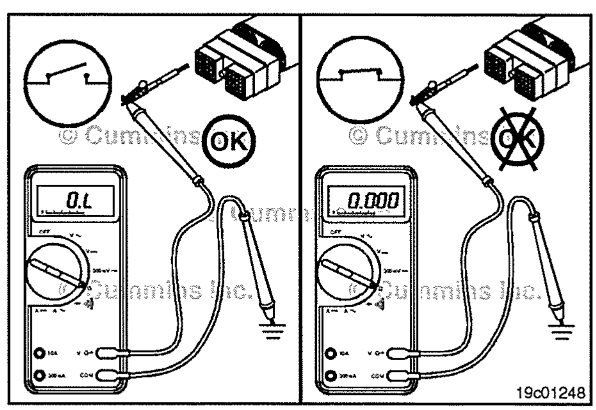


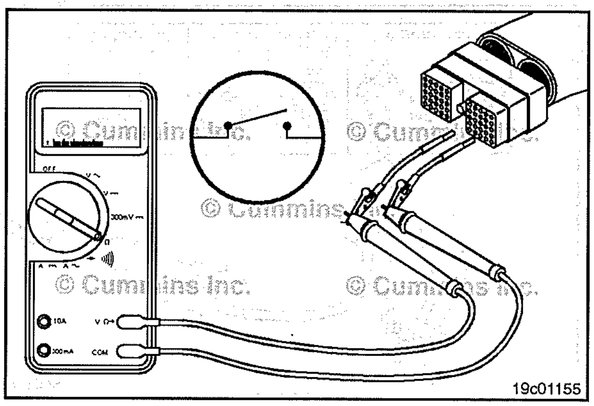
Touch one multimeter probe to the engine block. Insert the other multimeter probe with attached appropriate test lead into switch return pin of the OEM harness connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the resistance value is **not** correct, there is a short circuit to ground in the harness. Repair or replace the OEM harness. Refer to Procedure 019-071.

If the resistance value is correct in the previous checks, the exhaust brake ON/OFF switch input pin **must** still be checked for short circuits from pin-to-pin.





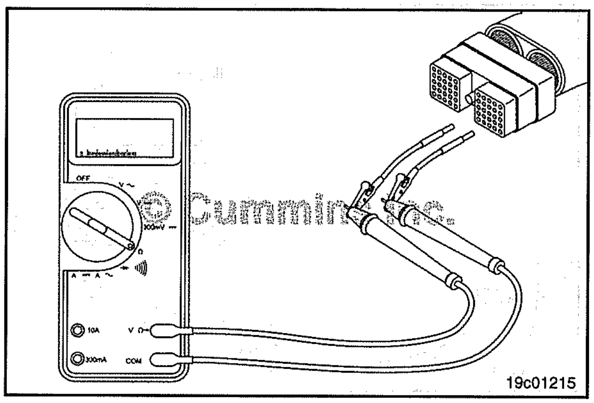
Check for Short Circuit from Pin to Pin

Isolate the switch circuit as in the previous section.

Insert the appropriate test lead into exhaust brake ON/OFF switch input pin of the OEM harness connector.

Insert the other appropriate test lead into pin 1 of the connector. Connect the alligator clips to the multimeter probes. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

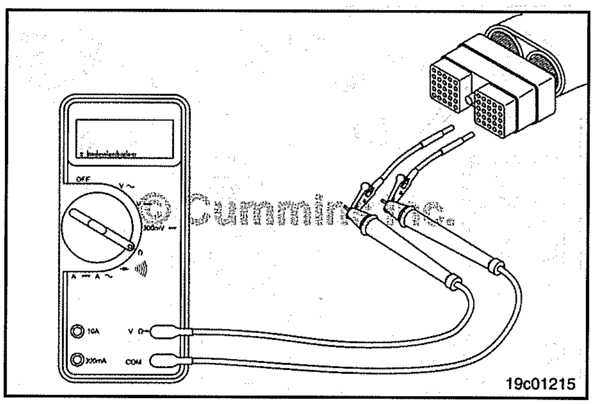


Remove the lead and check all other pins.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the wire connected to exhaust brake ON/OFF switch input pin and any pin that measured less than 100k ohms.

Repair or replace the OEM harness. Refer to (Procedure Refer to Procedure 019-071).



Insert the test lead into switch return pin of the OEM harness connector. Check all pins of the harness connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more) at all pins.

If the circuit is **not** open, there is a short circuit to ground in the positive switch supply bus, provided the switch has been previously checked.

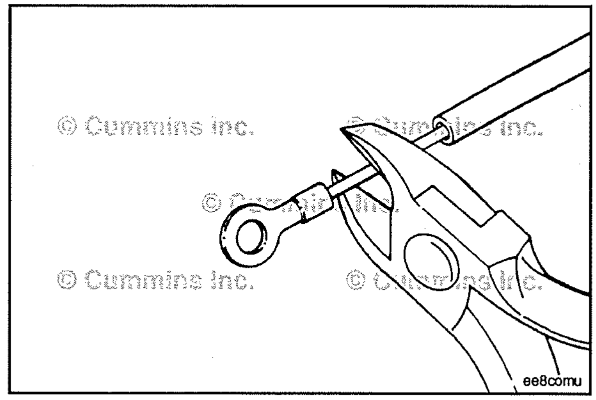
Repair or replace the wiring connected to switch return pin in the OEM harness. Refer to Procedure 019-071.

Ring Terminal (019-197)

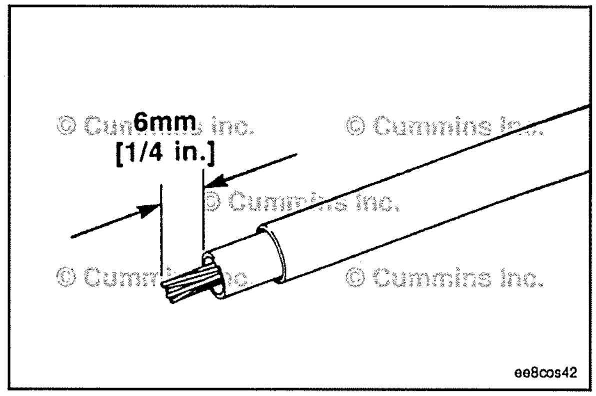
Connector Replacement

Terminals are used for various connections including grounds and fuel shutoff valve supply.

Use wire crimp tool, Part Number 3822930, to cut and remove the ring terminal connector as shown.

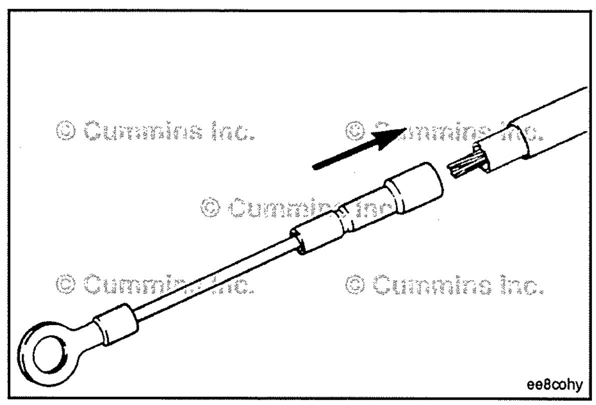


Use wire crimp tool, Part Number 3822930, to remove 6 mm [1/4 in] of insulation from the harness wire.



Install the proper-size ring terminal on the bare wire. The ring terminals that are included in the wiring repair kit, Part Number 3164572, are as follows:

Ring Terminal Size	Part No.
No. 10	3823760
1/2 inch	3823761

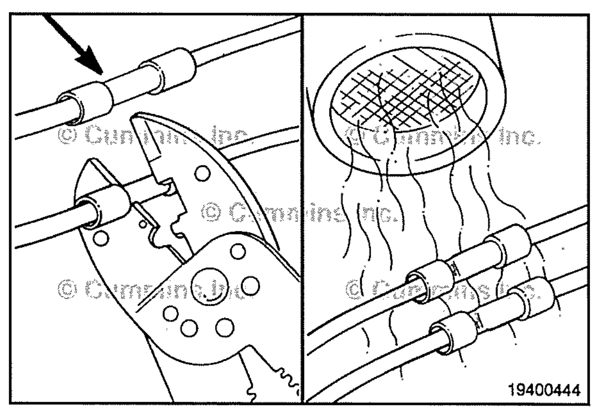


⚠CAUTION⚠

Only use wire crimping pliers, Part Number 3822930, when repairing electrical terminals.

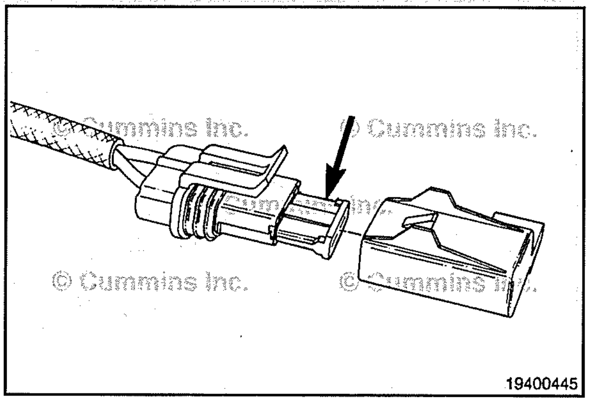
Crimp the repair wire on the bare wire.

Use a heat gun, Part Number 3822860, or open flame to heat the shrink tubing. The tubing will shrink and make the connection waterproof.

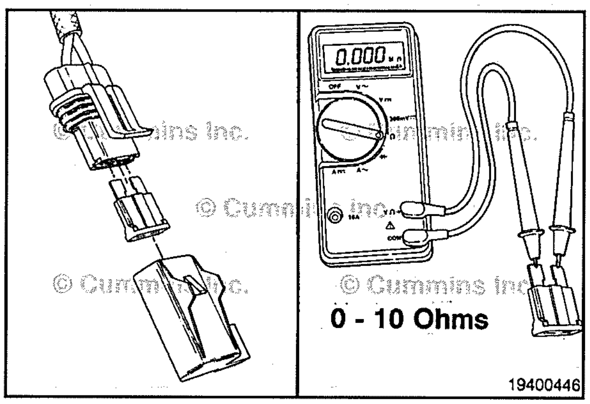


Fuse, Harness In-Line (019-198)

Inspect



Remove the fuse protective covers from the fuse(s) that are being checked. Check to make sure the fuse is installed in the fuse holder correctly.



If the fuse is installed correctly, check for a blown fuse.

Remove the fuse(s) to be checked.

Touch each one of the multimeter leads to each fuse terminal. Measure the resistance.

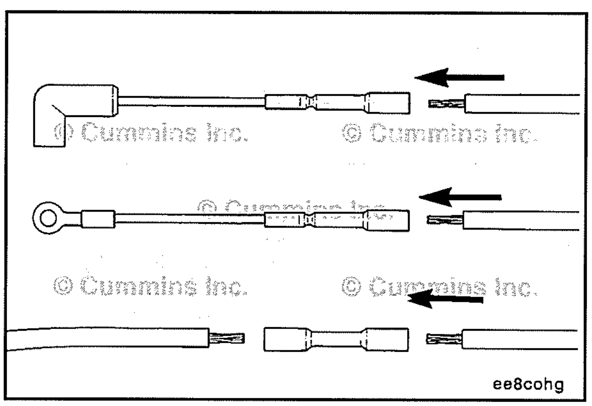
The multimeter **must** show less than 10 ohms, which is a closed circuit. If the circuit is closed then put the fuse back into the holder and connect the fuse cover.

Connector, Butt Splice (019-199)

Select Service Tools

The following Cummins Service Tools or equivalent are required to complete this procedure:

1 Wire Stripping Tool, Part Number 3400045, or equivalent.
2 Wire Crimping Tool, Part Number 3163109, or equivalent.
3 Heat shrink tube installer (butane), Part Number 5298996, or equivalent.



General Information

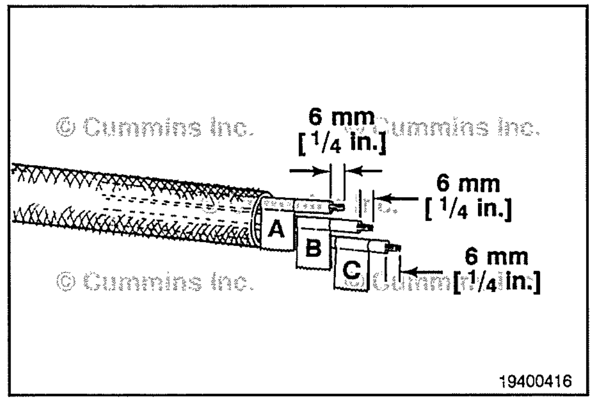
Butt splice connectors are used when repairing wiring harnesses or damaged wires.

This procedure **only** covers butt splice connectors provided by Cummins Inc. Installation procedures for other butt splice connectors may be different.

Repair

Crimp Splice

Strip 6 mm [¼ in] of insulation from the end of the wires. Use Cummins® service tool, Part Number 3400045, wire stripping tool or equivalent.



WARNING
To reduce the possibility of personal injury, wear goggles and protective clothing.

CAUTION
Connect the repair connector wires to the correct harness wires or electrical problems will occur.

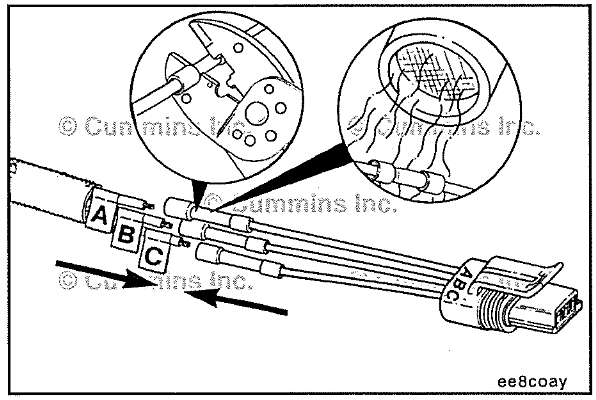
Install the wire end(s) into the end(s) of the crimp butt splice connector.

Crimp the butt splice connector. Use Cummins® service tool, Part Number 3163109, wire crimping tool or equivalent.

Heat the butt splice connector. Use Cummins® service tool, Part Number 5298996, heat shrink tube installer (butane) or equivalent.

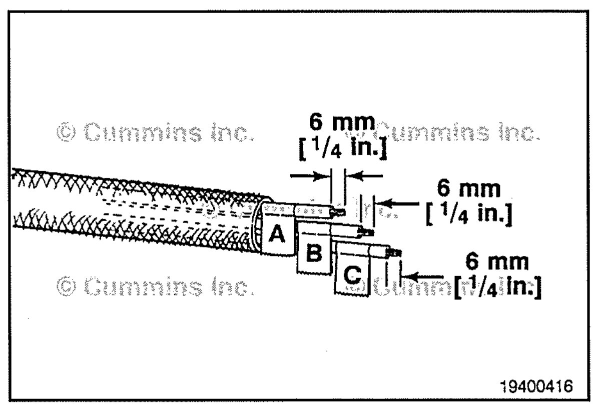
Apply heat evenly over the entire butt splice connector.

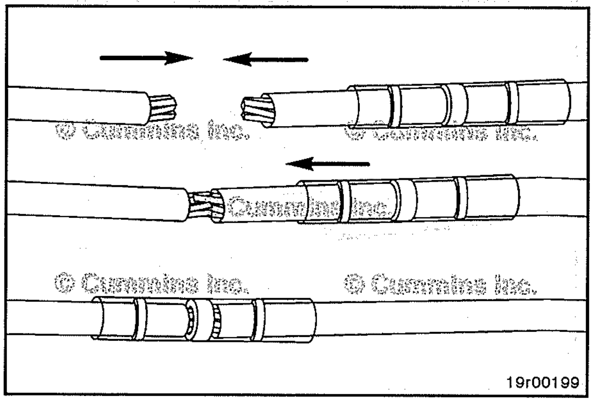
Apply heat until the shrink tube portion of the butt splice connector has sealed the joint.



Solder Splice

Strip 6 mm [¼ in] of insulation from the end of the wires. Use Cummins® service tool, Part Number 3400045, wire stripping tool or equivalent.





⚠CAUTION⚠

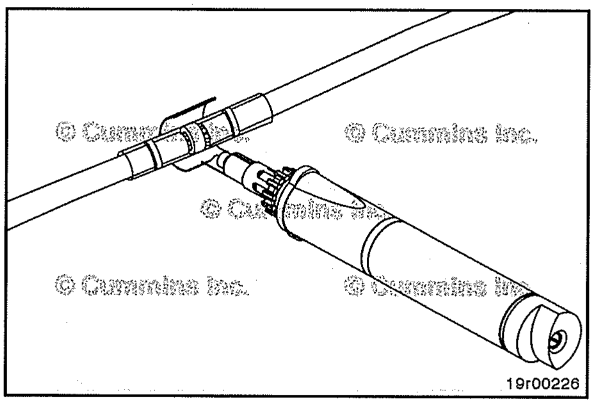
Connect the repair connector wires to the correct harness wires or electrical problems will occur.

Slide the solder butt splice connector on the repair wire.

Engage the stripped end of the wires to be connected.

Slide the solder butt splice connector over the bare wires until the solder is centered over the bare wires.

Rotating the solder butt splice connector will assist with installation.



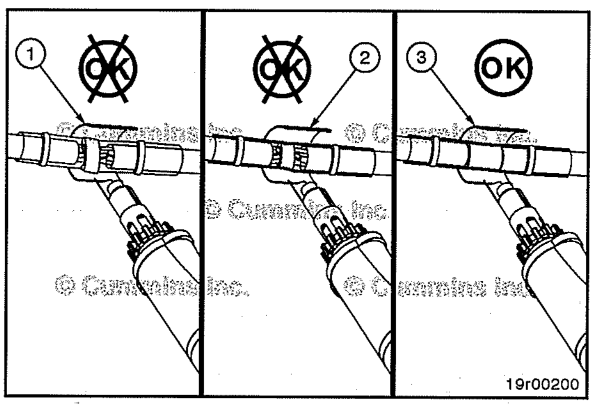
⚠WARNING⚠

To reduce the possibility of personal injury, wear goggles and protective clothing.

Heat the solder of the butt splice connector. Use Cummins® service tool, Part Number 5298996, heat shrink tube installer (butane) or equivalent.

Apply heat evenly over the entire butt splice connector.

Apply heat until the solder of the butt splice connector has flowed into the wire strands.



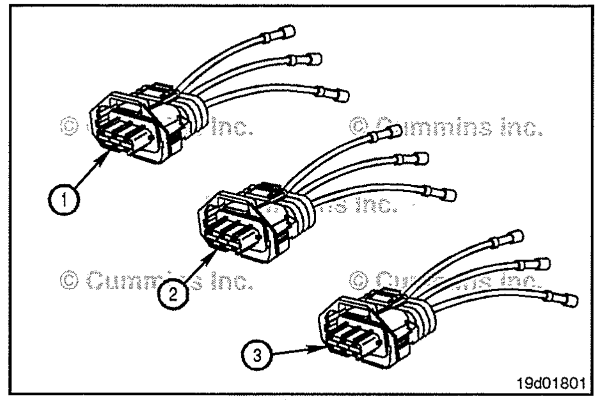
Verify the solder butt splice connector has been installed correctly.

1 Incorrect.
   - Insufficient heat.
   - Shrink tube not sealed.
   - Solder not melted.
2 Incorrect.
   - Insufficient heat on solder.
   - Uneven solder distribution.
3 Correct.
   - Shrink tube sealed.
   - Colored seal bands sealed and flattened.
   - Even solder distribution.

Metripack Connector Series (019-202)

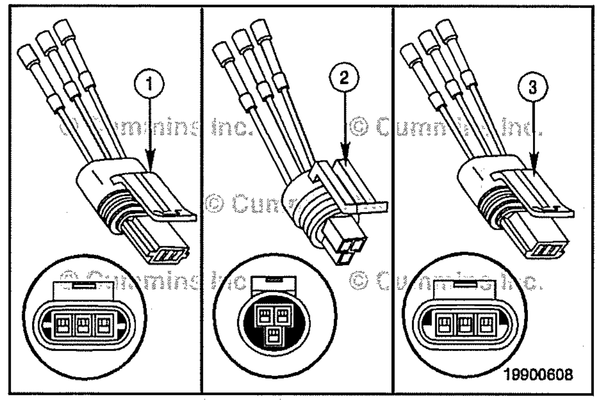
Pin Replacement

The connector can have multiple pin configurations. All types of connectors are repaired in the same manner.



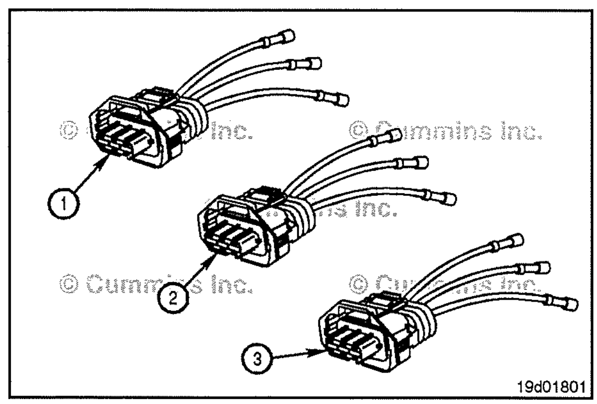
The connector pins can **not** be repaired or replaced. The connector **must** be replaced as a unit.

Refer to the connector replacement procedure for replacement instructions.



Connector Replacement

The connector can have multiple pin configurations. All types of connectors are repaired in the same manner.



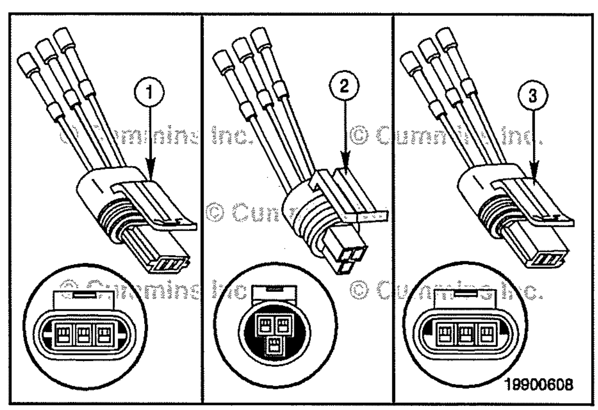
The connectors have different keying and can **not** be interchanged with each other.

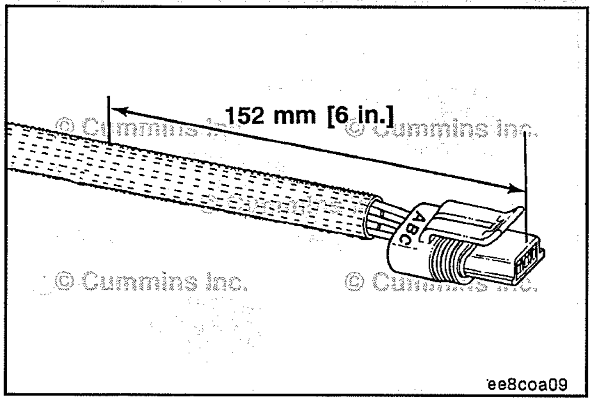
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

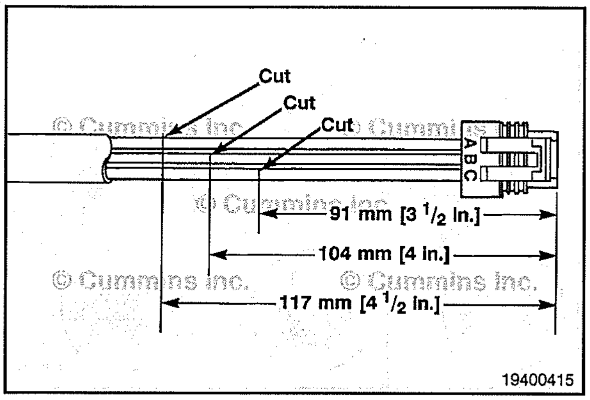
Refer to the wiring diagram in Section E for pin locations.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.





Measure 152 mm [6 in] back from the face of the connector, and remove the wiring harness protective cover.

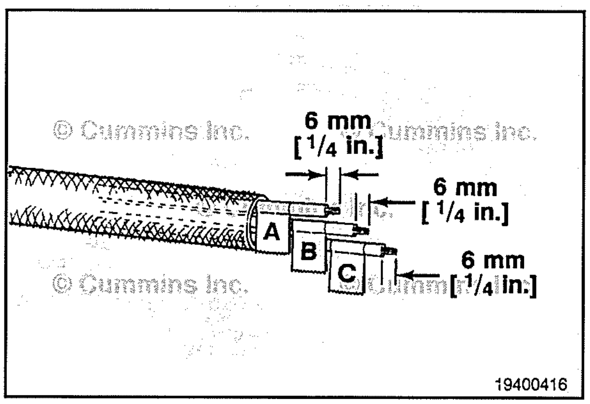


Before cutting the wires, measure and tag the wires.

Use wire cutters to cut wire A 117 mm [4-½ in] from the face of the connector.

Use wire cutters to cut wire B 104 mm [4 in] from the face of the connector.

Use wire cutters to cut wire C 91 mm [3-½ in] from the face of the connector.



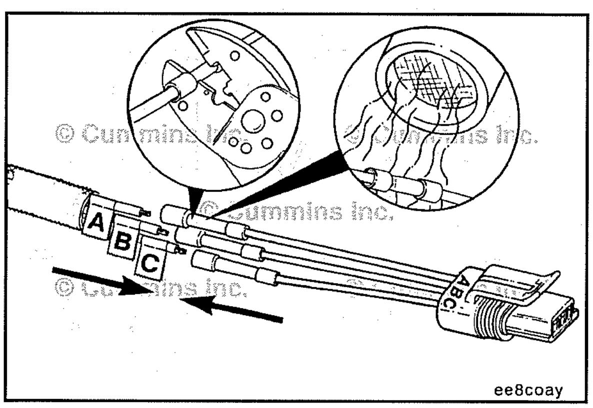
Use crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from all electrical wires.

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to Section E for pin locations.

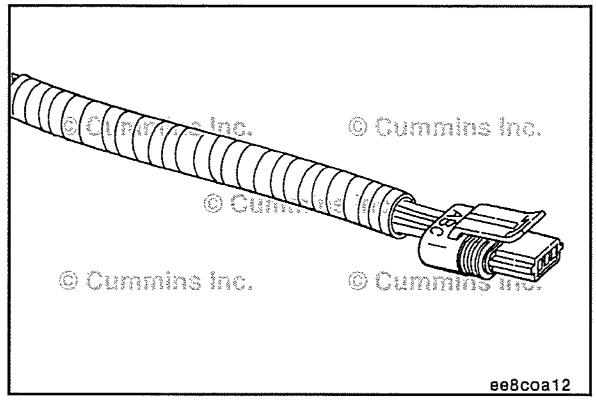
Replace one contact at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.



Install the terminal repair wires on the bare wires and use wire crimping tool, Part Number 3822930, to crimp the terminals.

Use heat gun, Part Number 3822860, to heat the shrink tubing. The tubing will shrink and make the connection waterproof.

Wrap the wires with tape, for added protection to complete the repair.



ee8coa12

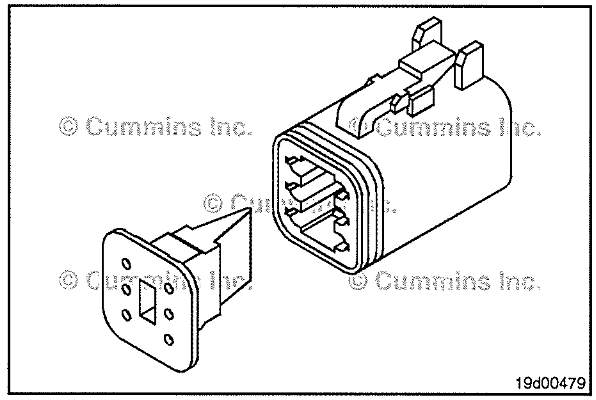
Deutsch DT Connector Series (019-205)

Pin Replacement

The connector can have multiple pin configurations. All type of connectors are repaired in the same manner.

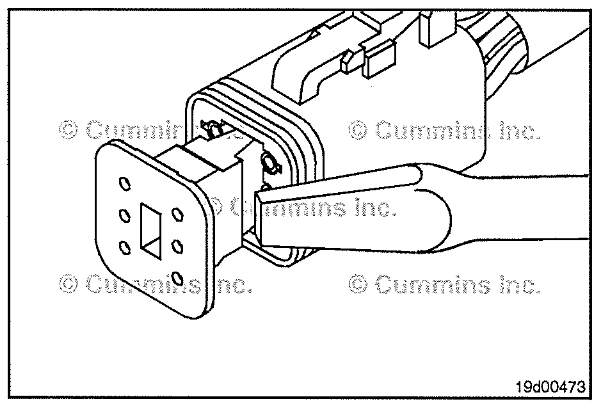
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.



19d00479

To replace the pin in the receptacle connector, remove the orange wedge using needle nose pliers or a hook-shaped wire to pull the wedge straight out.

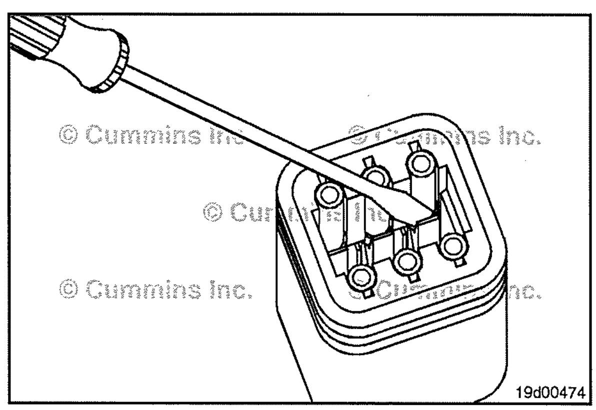


19d00473

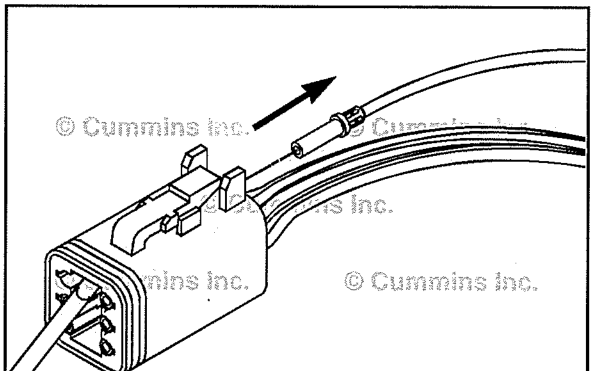
⚠CAUTION⚠

Locking finger can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

To remove the contact out of the connector body, gently pull wire backward, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.



19d00474

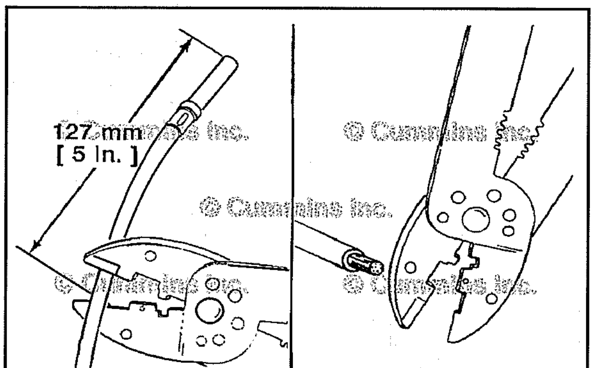


19d00475

⚠CAUTION⚠

If more than one wire is being repaired, tag each wire and install it in the original location. Electrical damage can occur if wire is installed in the incorrect location.

Pull the wire and the terminal out of the connector body.



19r00197

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

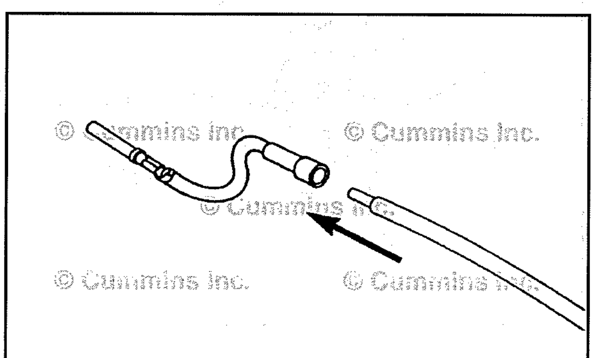
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

Use wire crimping tool, Part Number 3163109 or equivalent, to cut 127 mm [5 in] off the wire and pin.

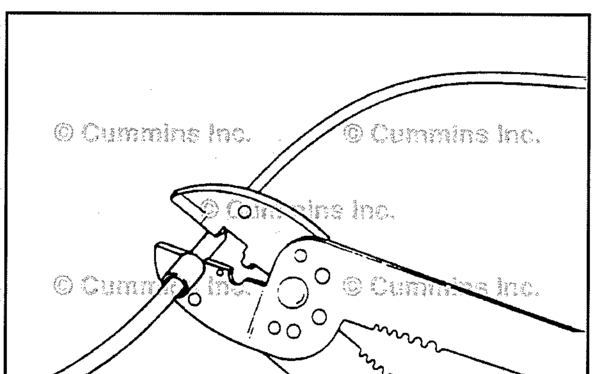
Use wire crimping tool, Part Number 3163109 or equivalent, to remove 6 mm [¼ in] of insulation from the wire.



ee8coaj

Install the correct repair wire on the bare wire.

Make sure the bare wire extends into the splice connector.

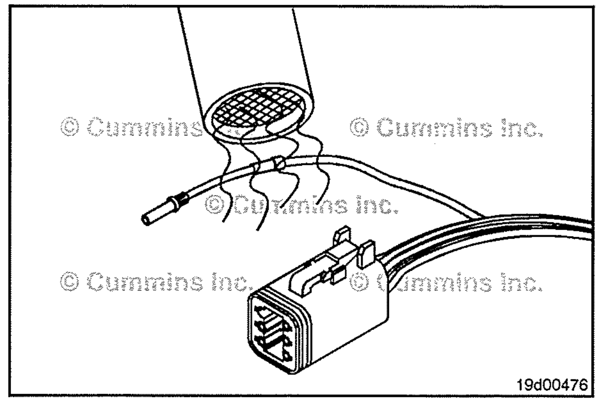


ee8cohv

Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.

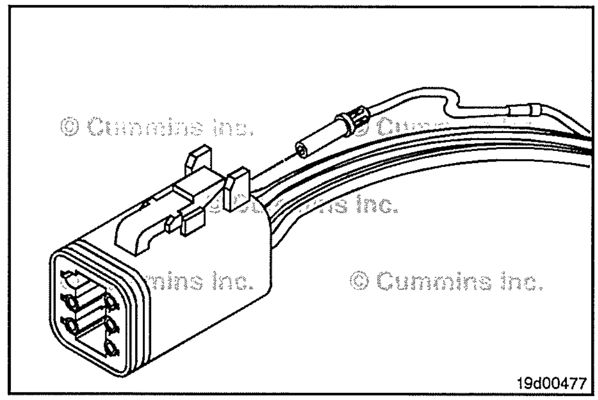
Use heat gun, Part Number 3822860, to heat shrink the tubing around the wire.

The tubing will shrink and make the connection waterproof.



⚠CAUTION⚠
If more than one wire is repaired or if the connector body is replaced, make sure to insert wires into the same locations as they are in the original connector. If wires are not in the original location electrical damage can occur.

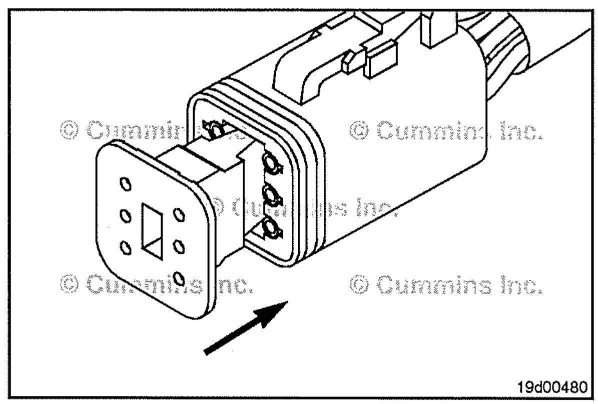
Replace the connector and install the wire and terminal into the connector body. Push the wire and terminal into the seal at the back of the connector. Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.



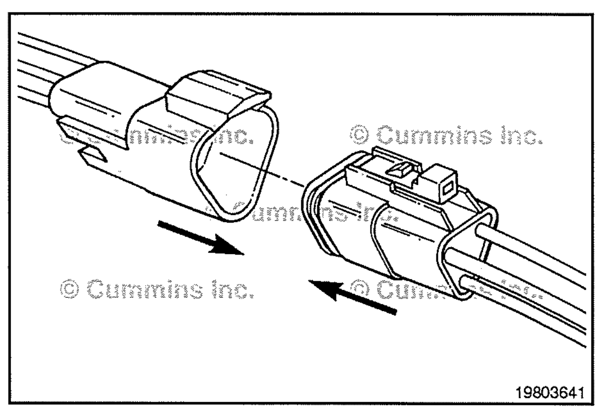
Once the wires are in place, insert the orange wedge with arrow pointing toward the exterior locking mechanism.

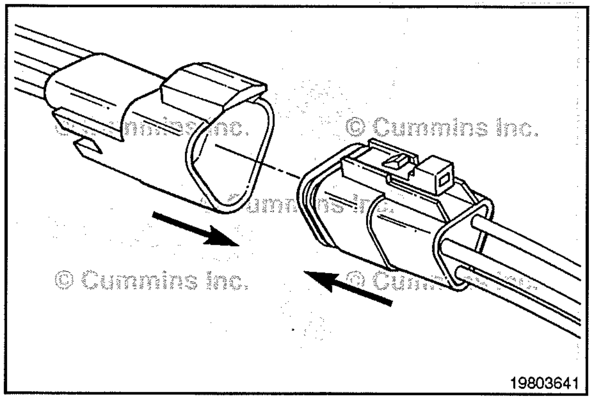
Push the orange wedge in until it snaps in place.

Make sure both seals are in place and the back of the connector plug and receptacle. Be sure the rubber seal has been installed on the connector plug.



Push the connector plug into the connector receptacle until the external locking clip snaps into place.





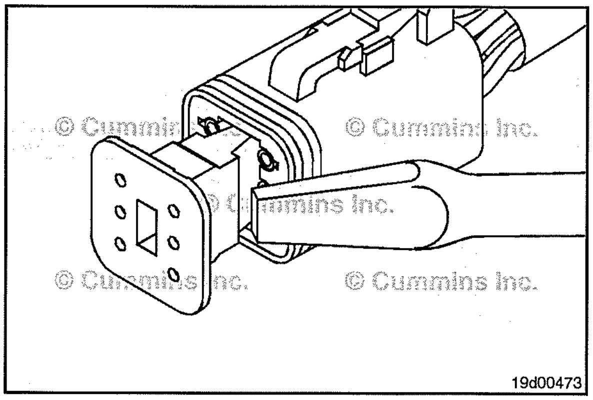
Connector Replacement

The connector can have multiple pin configurations. All types of connectors are repaired in the same manner.

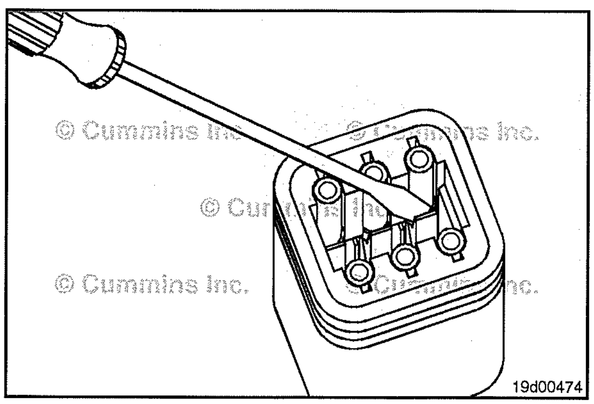
Before installing the new connector perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.



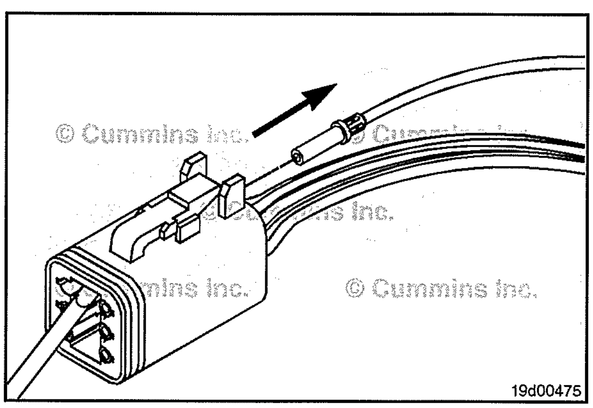
To replace the pin in the plug connector, grasp the orange wedge and pull the wedge straight out.



CAUTION

Locking finger can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

To remove the contact out of the connector body, gently pull wire backward, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.



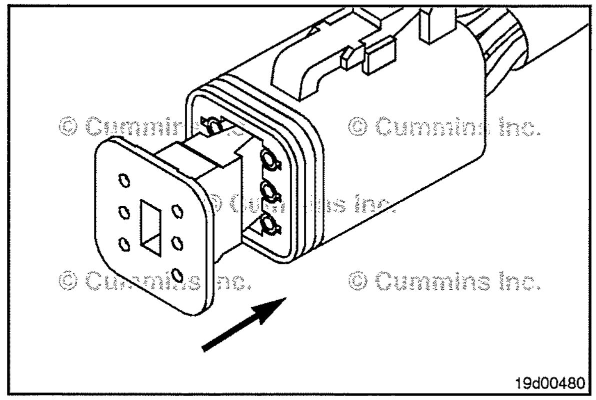
CAUTION

If more than one wire is repaired or if the connector body is replaced, be sure to insert the wires into the same location as they were in the original connector. If wires are not in the original location electrical damage can occur.

Replace the connector and install the wire and terminal into the seal at the back of the connector. Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.

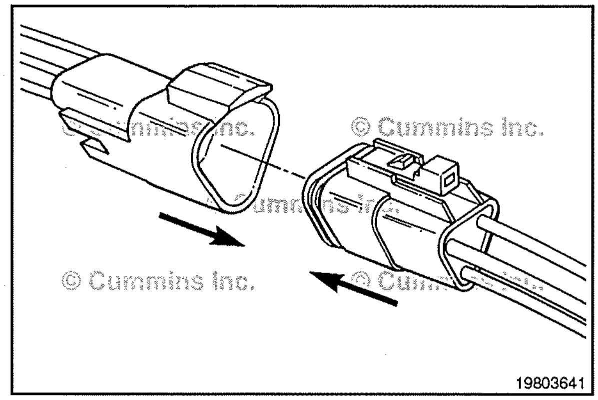
Once the wires are in place, insert the orange wedge with arrow pointing toward the exterior locking mechanism. Push the orange wedge in until it snaps in place.

Make sure both seals are in place at the back of the connector plug and receptacle. Make sure the rubber seal has been installed on the connector plug.



19d00480

Push the connector plug into the connector receptacle until the external locking clip snaps into place.



19803641

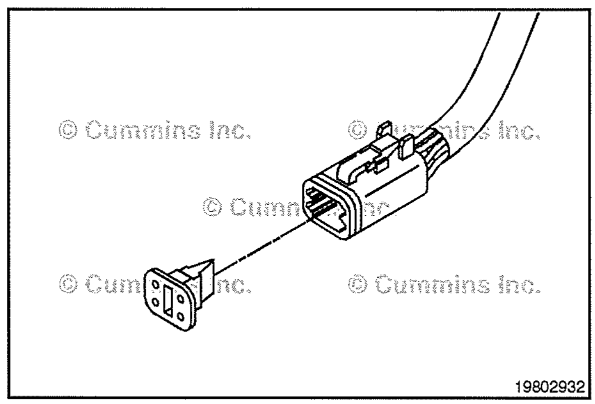
Deutsch DTM and DTP Connector Series (019-206)

Pin Replacement

The connector can have multiple pin configurations.

The connector pins can **not** be repaired or replaced. The connector **must** be replaced as a unit.

Refer to the connector replacement procedure for replacement procedures.



19802932

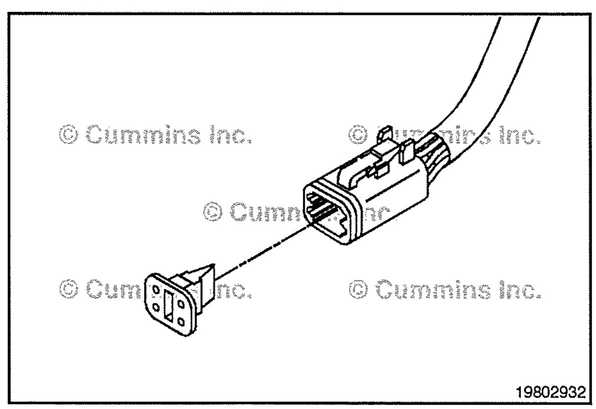
Connector Replacement

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

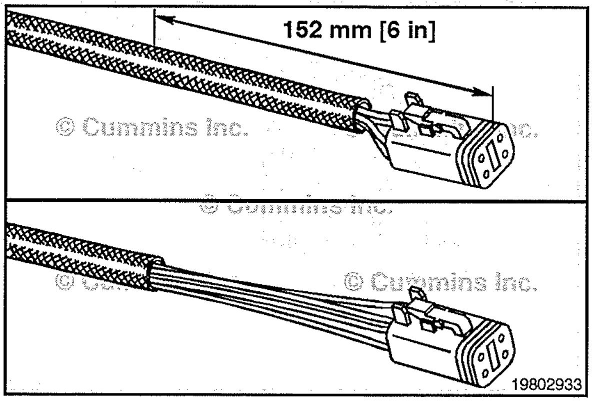
Refer to the appropriate wiring repair kit in the service tool table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.

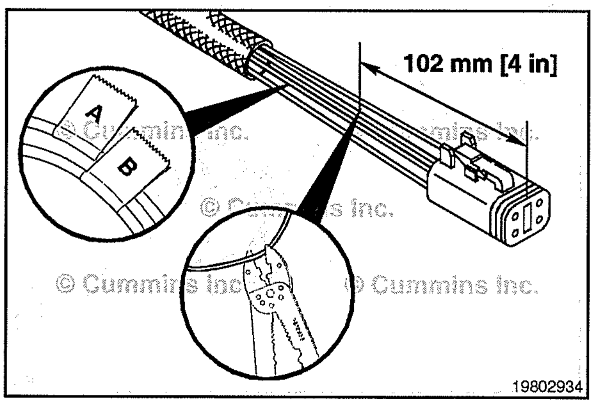
The replacement connector shown in the following procedure is a 4-pin Deutsch series. All sizes of DTM connectors are replaced in the same manner.



19802932



Measure 152 mm [6 in] back from the face of the connector and remove the wiring harness protective cover.

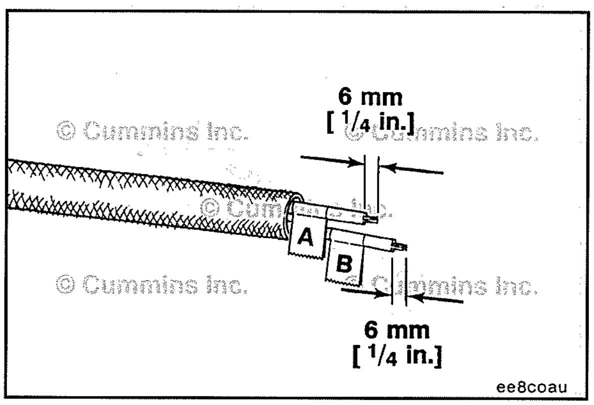


Before cutting the wires, measure and tag all wires.

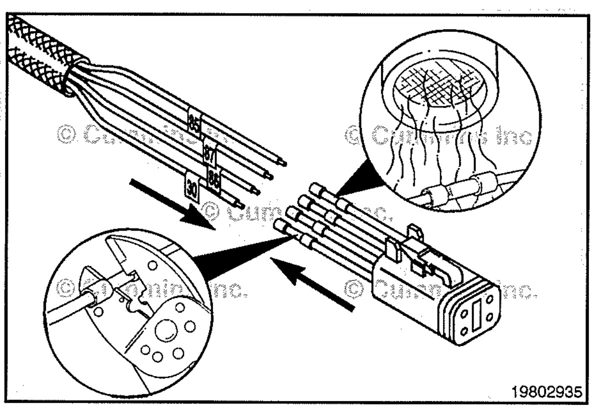
Use wire crimping tool, Part Number 3822930.

Cut wire A 102 mm [4 in] from the face of the connector.

Cut wire B 102 mm [4 in] from the face of the connector.



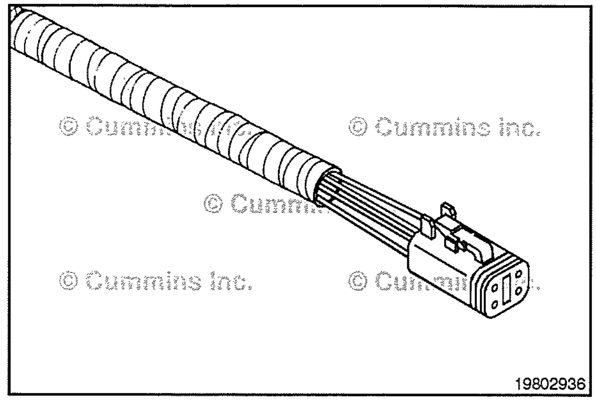
Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from both electrical wires.



Install the connector repair wires and use wire crimping tool, Part Number 3822930, to crimp the terminals.

Use heat gun, Part Number 3822860, to heat the shrink tubing. The tubing will shrink and make the connection waterproof.

Wrap the wires with tape, for added protection, to complete the repair.



Deutsch HD10 Connector Series (019-207)

Pin Replacement

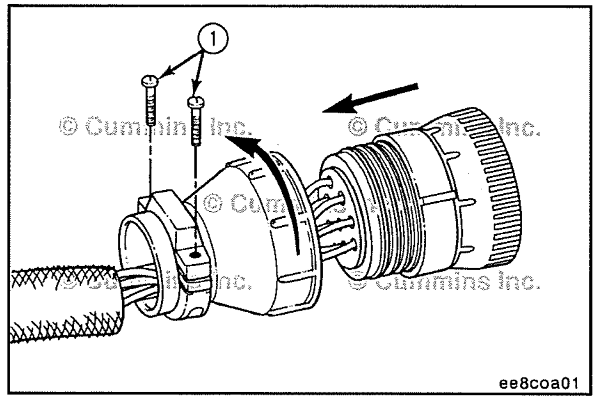
These connectors are available with multiple pin configurations.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire. Replace one contact at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

Unlock the connector. Rotate the locking tab **counterclockwise** by hand. Do **not** use pliers; they can damage the connector.

Remove the two clamp capscrews (1) from the rear of the connector. Turn the rear support of the connector **counterclockwise** until the two pieces are separated.



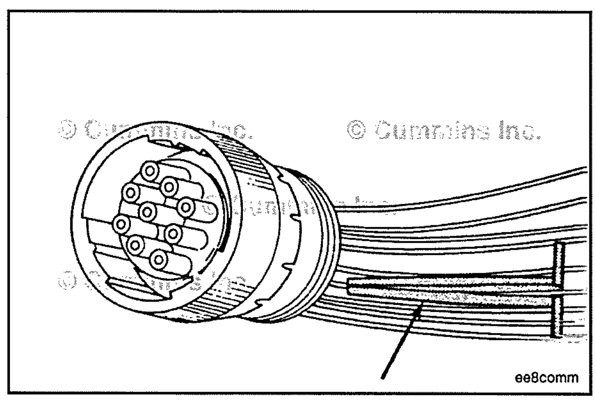
These connectors are available with multiple pin configurations.

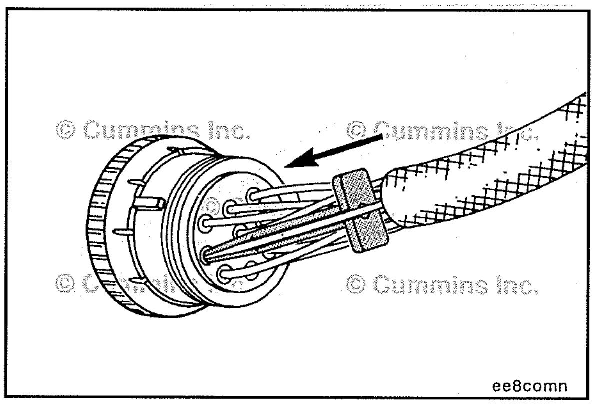
Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.

Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

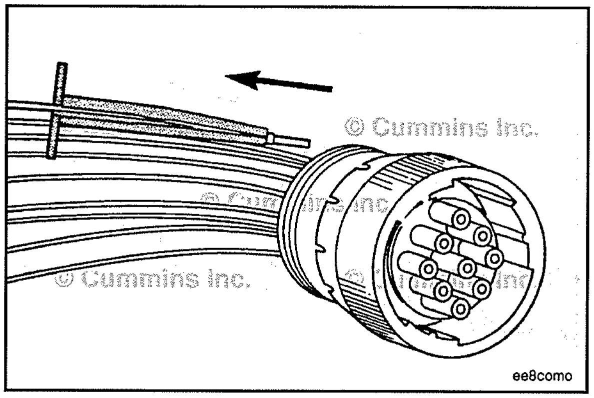
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

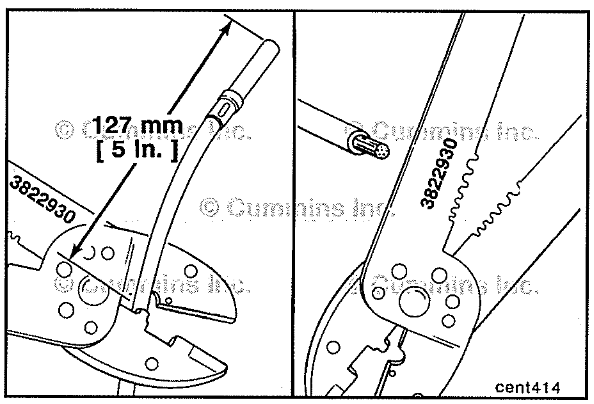




Push the tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange.



Hold the tool on the terminal flange and pull the wire and the connecting pin out of the connector. Note and record the hole from which the pin is removed.



NOTE: The repair wire is 127 mm [5 in] long.

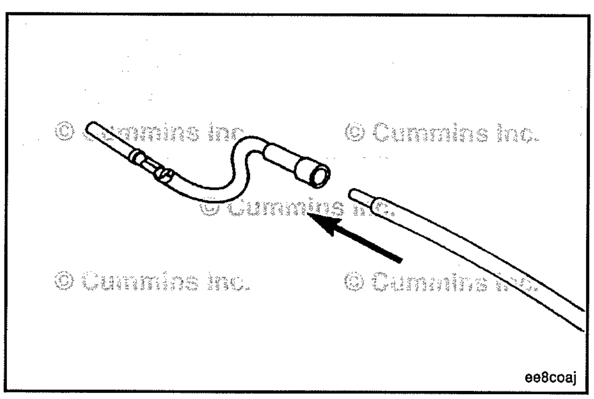
Remove about 6 mm [¼ in] of insulation from the wire.

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

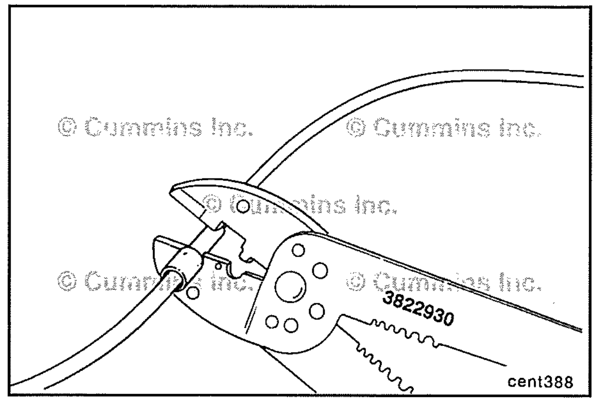
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.



Install a repair wire on the bare wire. Make sure the bare wire extends into the splice.

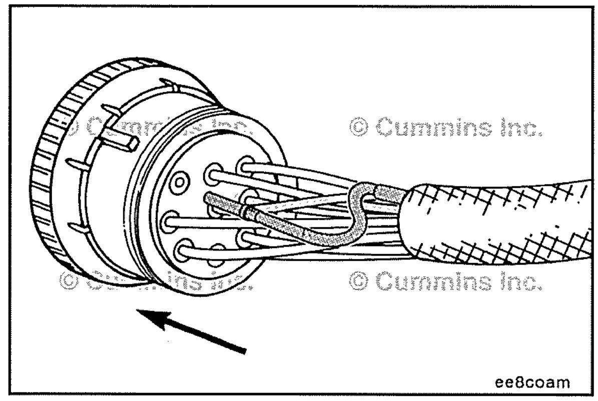
Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



Insert the pin into the correct hole of the connector.

The pin **must** lock into place and hold the wire in the connector.

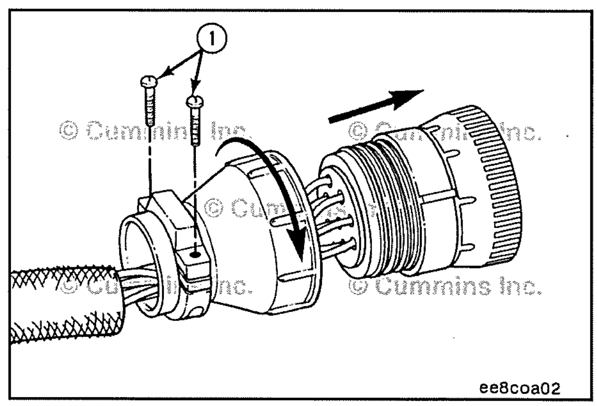
Pull the wire gently to make sure it is seated in the connector.

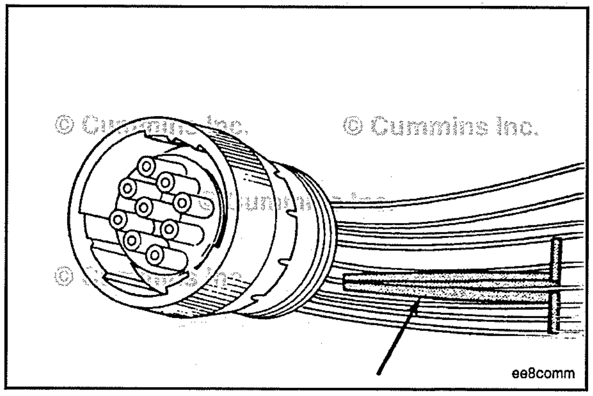


Install the rear connector support.

Tighten the two wire clamp capscrews.

Torque Value: 1 N•m [9 in-lb]





Connector Replacement

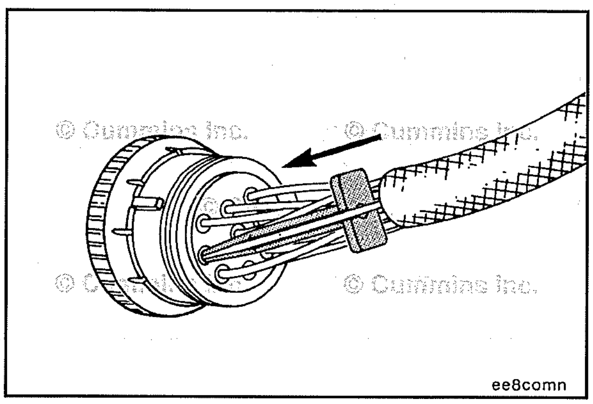
These connectors are available with multiple pin configurations.

Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.

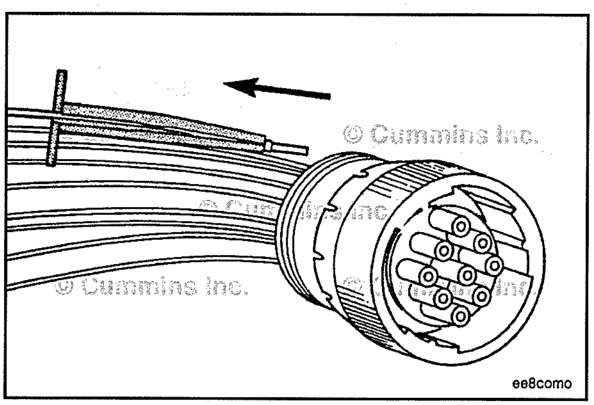
Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.



Push the tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange.

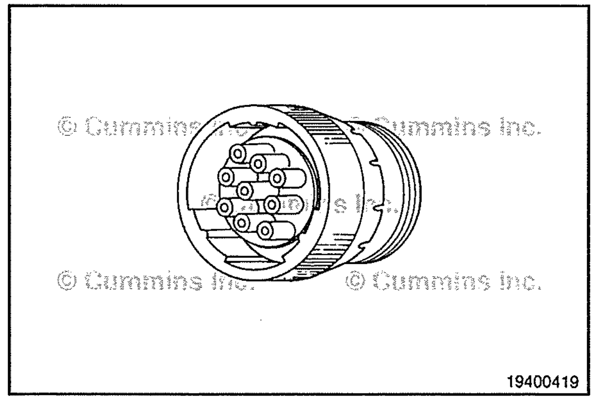


Hold the tool on the terminal flange and pull the wire and the connecting pin out of the connector. Note and record the hole from which the pin is removed.

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

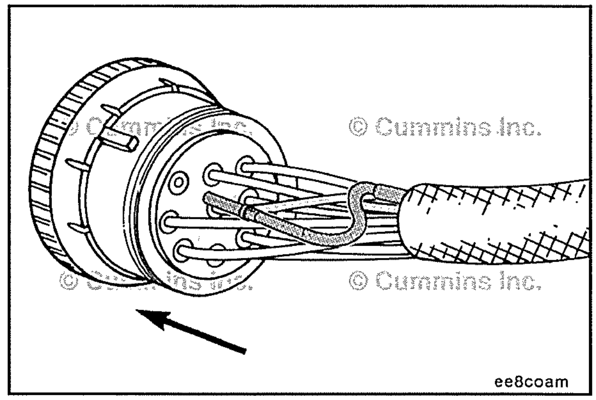
Refer to the wiring diagram in Section E for pin locations.



Insert the pins into the correct holes of the replacement connector.

The pin **must** click into place and hold the wire in the connector.

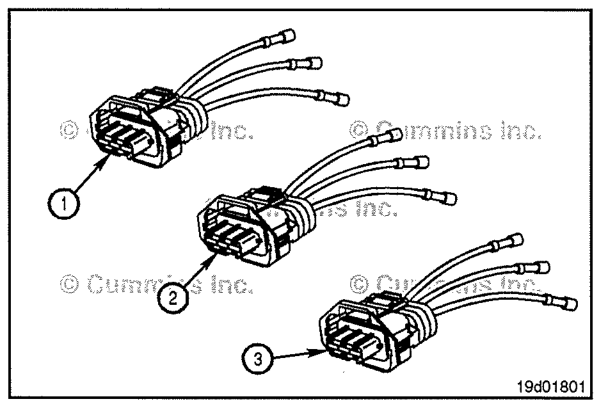
Pull the wire gently to make sure it is seated in the connector.



Bosch™ Actuator and Sensor Connector Series (019-214)

Pin Replacement

The connector is **not** repairable. If any part of the connector becomes damaged, replace the connector with the appropriate repair connector.



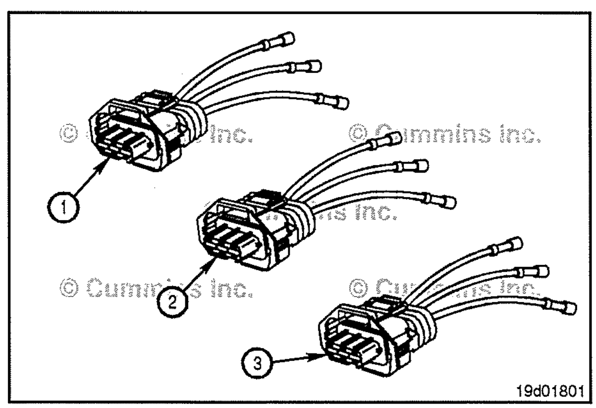
Connector Replacement

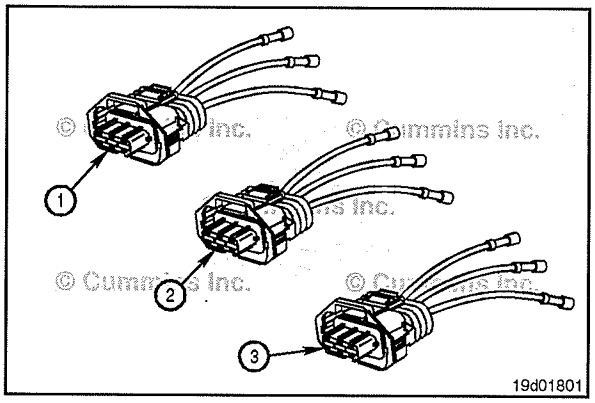
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.

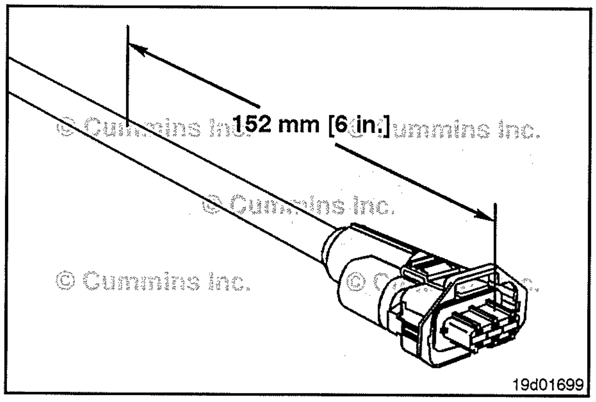
The connector is **not** repairable. If any part of the connector becomes damaged, replace the connector with the appropriate repair connector.



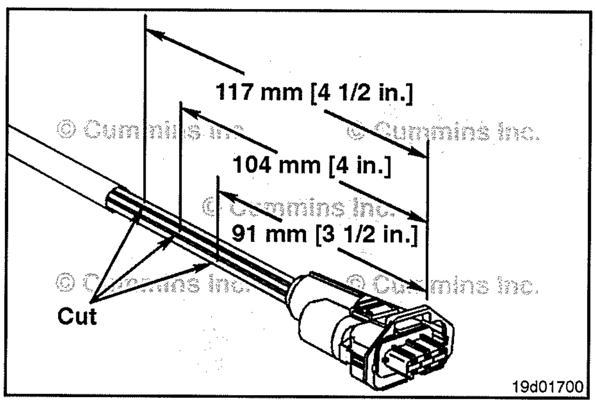


The connectors have different keying and can **not** be interchanged with each other.

Make sure the correct wires are connected to pin 1, pin 2, and pin 3, when replacement is necessary.



Measure 152 mm [6 in] back from the face of the connector, and remove the wiring harness protective cover.

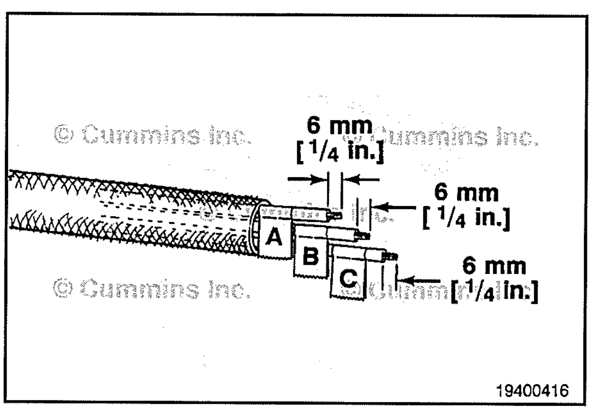


Before cutting the wires, measure and tag the three wires.

Use wire cutters to cut wire 1 117 mm [4-½ in] from the face of the connector.

Use wire cutters to cut wire 2 104 mm [4 in] from the face of the connector.

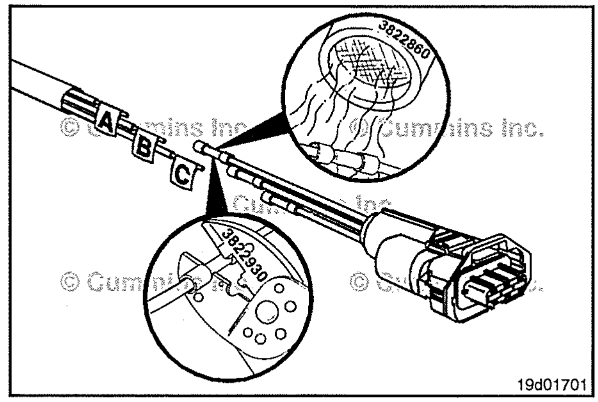
Use wire cutters to cut wire 3 91 mm [3-½ in] from the face of the connector.



Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from all electrical wires.

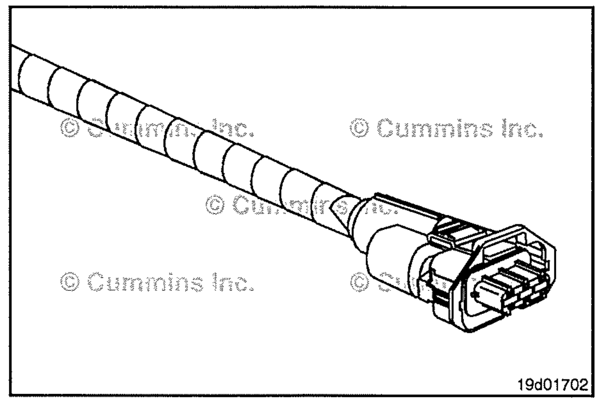
Install the pin repair wires and connector onto the bare wires of the harness and use the wire crimping tool to crimp each repair wire onto the harness.

Use heat gun, Part Number 3822860, to shrink the tubing. The tubing will shrink and make the connection waterproof.



19d01701

Wrap the wires with tape, for added protection, to complete the repair.



19d01702

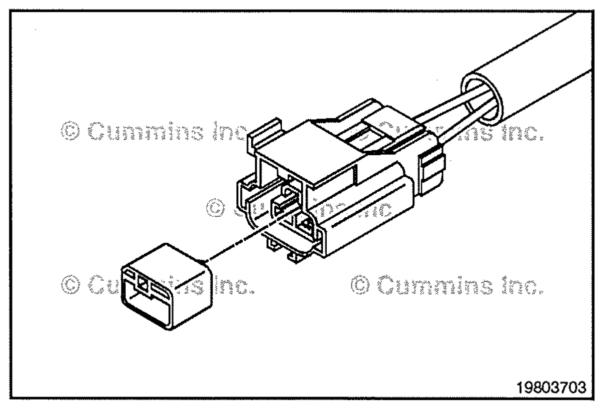
Framatome Connector Series (019-218)

Pin Replacement

The connector can have multiple pin configurations. All type of connectors are repaired in the same manner.

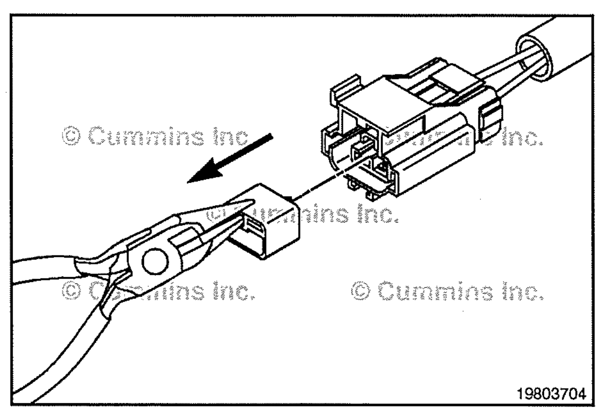
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

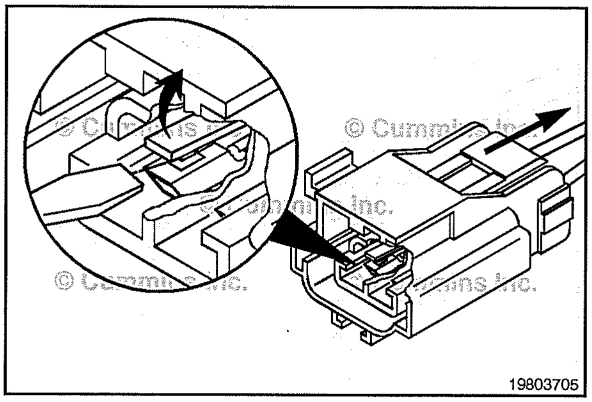


19803703

To replace the pin in the receptacle connector, remove the blue inter connector lock using needle nose pliers.



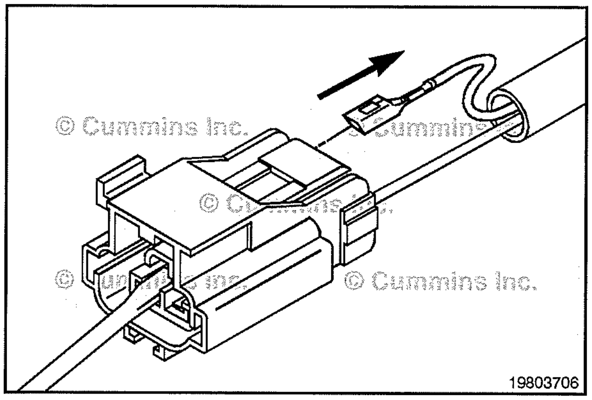
19803704



CAUTION

The locking finger can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

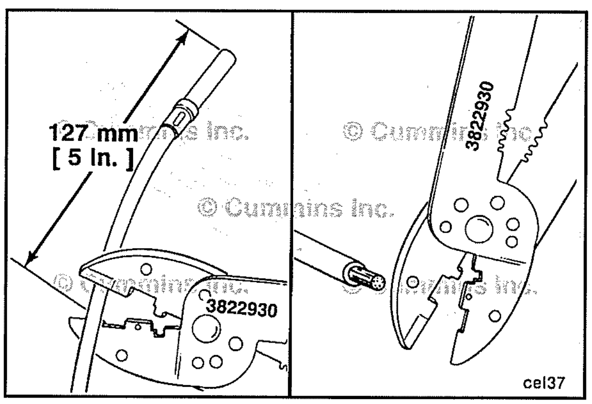
To remove the contact out of the connector body, gently pull wire backward, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.



CAUTION

If more than one wire is being repaired, tag each wire and install it in the original location. Electrical damage can occur if a wire is installed in the incorrect location.

Pull the wire and the terminal out of the connector body.



Refer to the appropriate wiring repair kit in the service tools table in the front of this section for the correct repair wire.

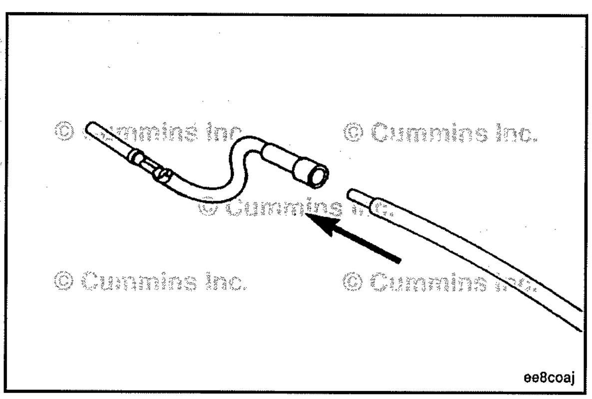
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

Use wire crimping tool, Part Number 3822930, to cut 127 mm [5 in] off the wire and pin.

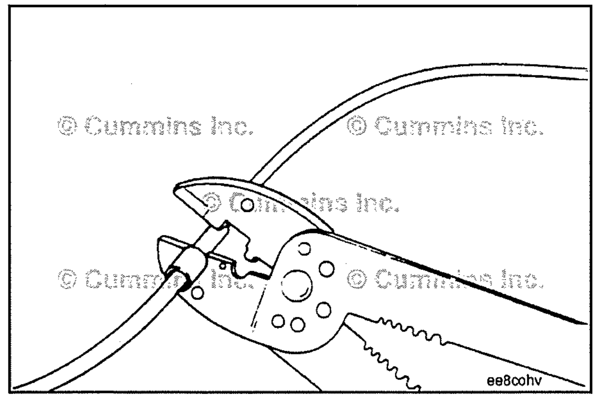
Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from the wire.



Install the correct repair wire on the bare wire.

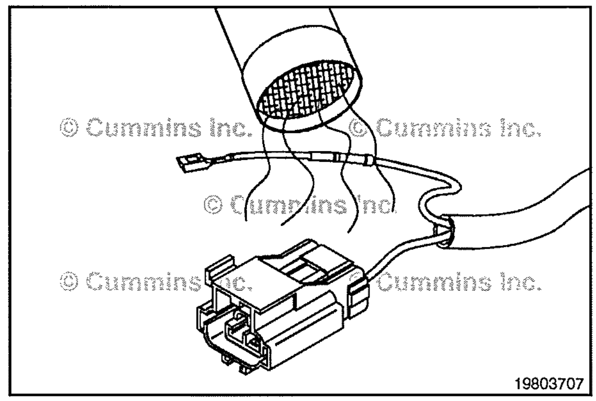
Make sure the bare wire extends into the splice connector.

Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



Use heat gun, Part Number 3822860, to heat shrink the tubing around the wire.

The tubing will shrink and make the connection waterproof.

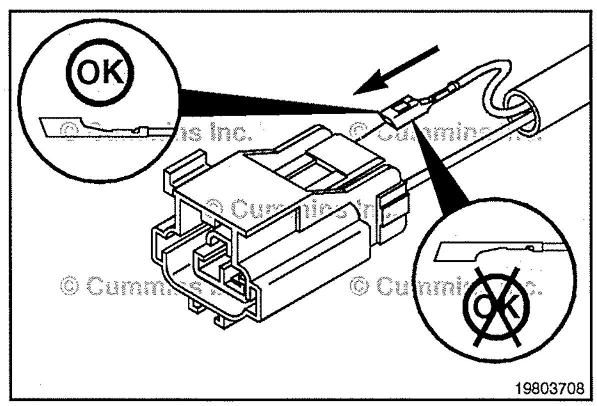


CAUTION

If more than one wire is repaired or if the connector body is replaced, make sure to insert wires into the same locations as they are in the original connector. If wires are not in the original location, electrical damage can occur.

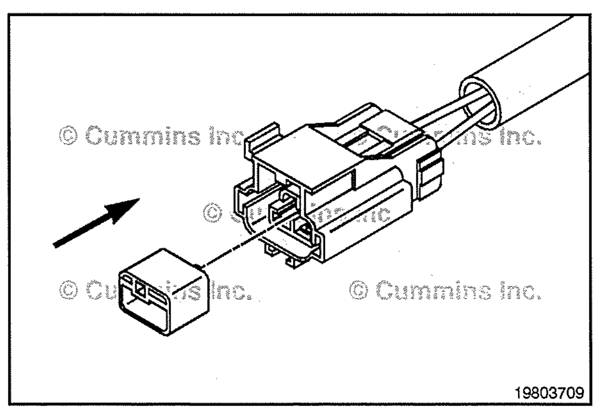
Install the wire and terminal into the connector body. Push the wire and terminal into the seal at the back of the connector. Install the replacement terminal and wire so that the longest point of the terminal is closest to the connector locking tab.

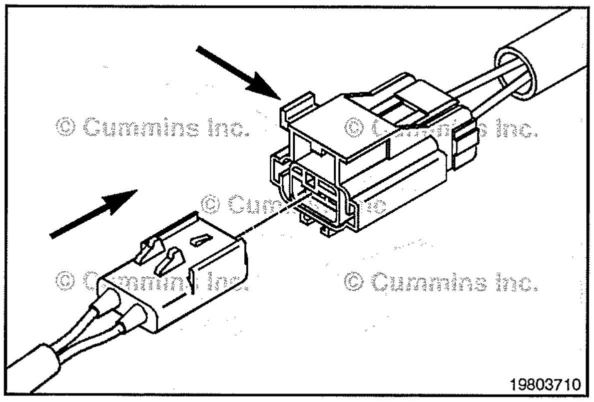
Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.



Once the wires are in place, insert the blue inter connector lock with the locking tab positioned towards the connector locking tab.

Push the blue inter connector lock in until it snaps in place.

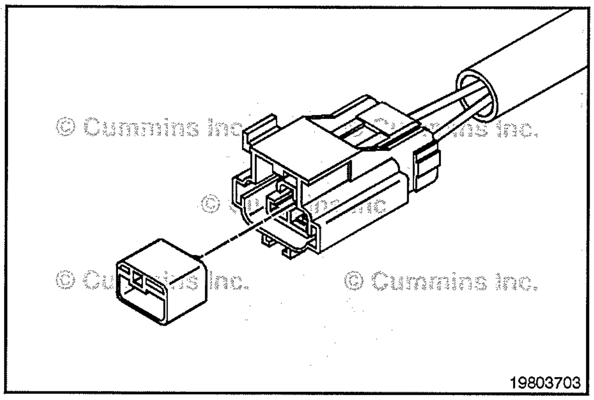




19803710

Push the connector plug into the connector receptacle until the external locking clip snaps into place.

Slide the connector locking tab to the locked position.



19803703

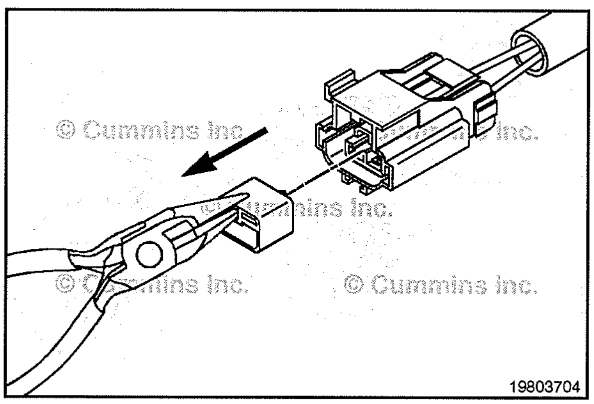
Connector Replacement

The connector can have multiple pin configurations. All types of connectors are repaired in the same manner.

Before installing the new connector perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of this section for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.

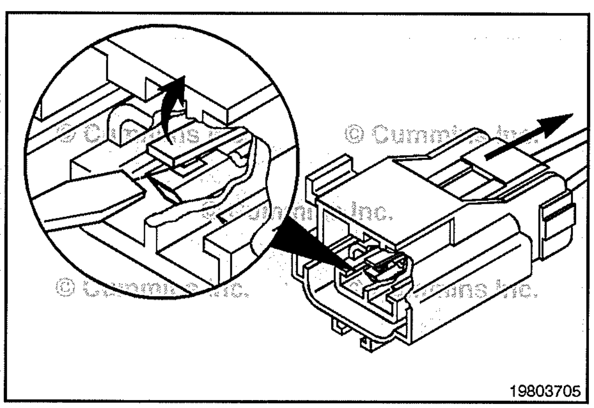


19803704

⚠CAUTION⚠

If more than one wire is repaired or if the connector body is replaced, be sure to insert the wires into the same location as they were in the original connector. If the wires are not in the original location, electrical damage can occur.

To replace the connector, grasp the blue inter connector and pull it straight out.



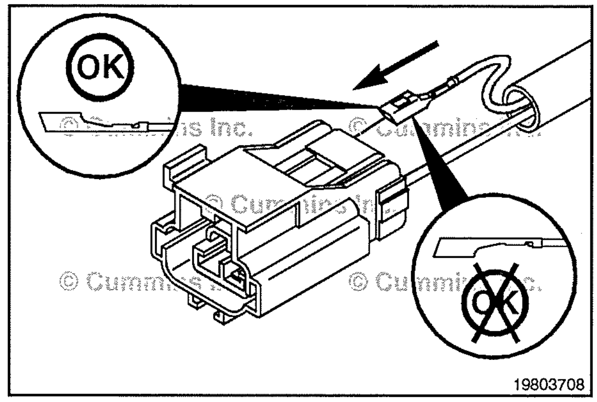
19803705

⚠CAUTION⚠

The locking finger can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

To remove the contact out of the connector body, gently pull wire backward, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.

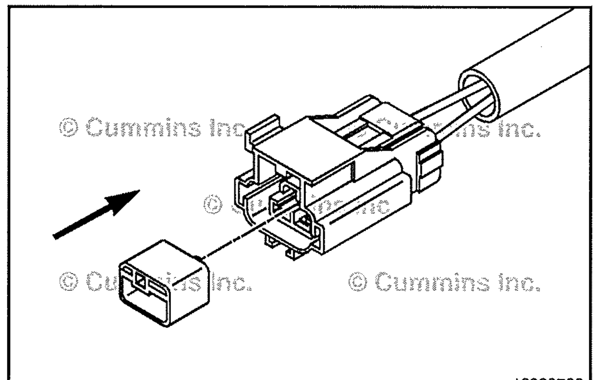
Replace the connector and install the wires and terminals into the seal at the back of the connector. Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.



19803708

Once the wires are in place, insert the blue inter connector lock with the locking tab positioned towards the connector locking tab.

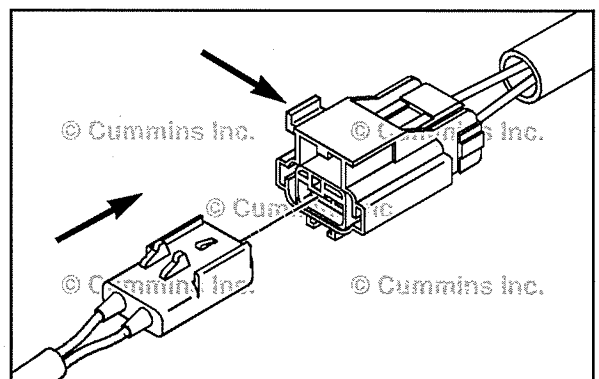
Push the blue inter connector lock in until it snaps in place.



19803709

Push the connector plug into the connector receptacle until the external locking clip snaps into place.

Slide the connector locking tab to the locked position.

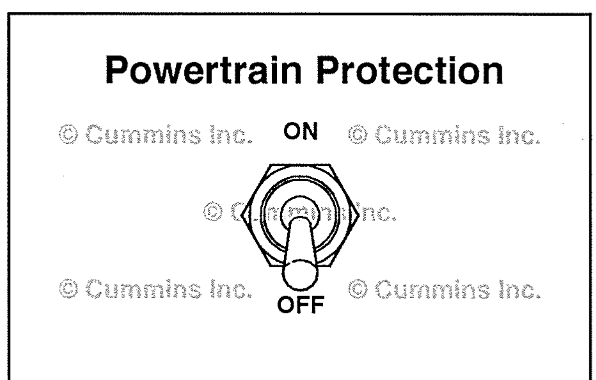


19803710

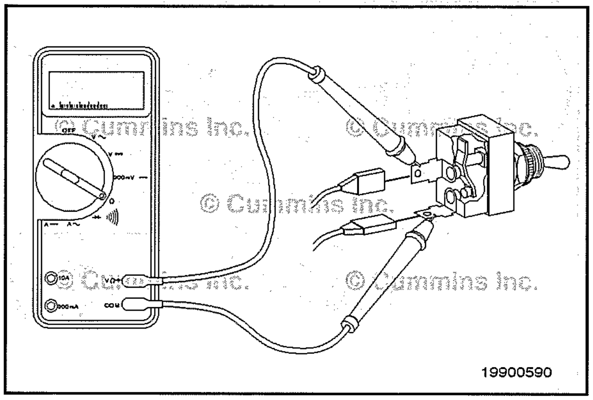
Power Train Protection Switch (019-253)

General Information

The powertrain protection switch circuit signals the system to protect the drivetrain when lower gears are engaged. The powertrain protection feature can limit engine output torque depending upon transmission gear ratio. Engine torque limits based on transmission gear ratio can be adjusted using the INSITE™ electronic service tool.



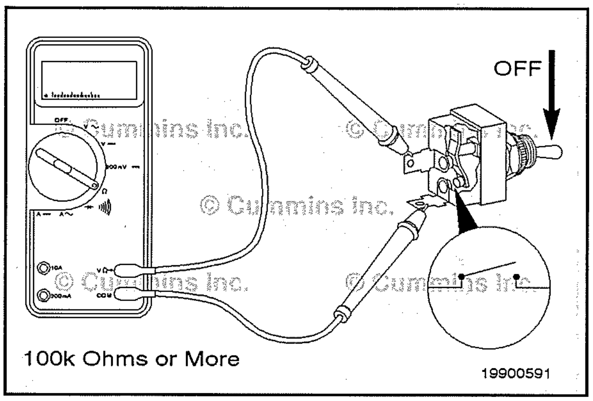
19d00838



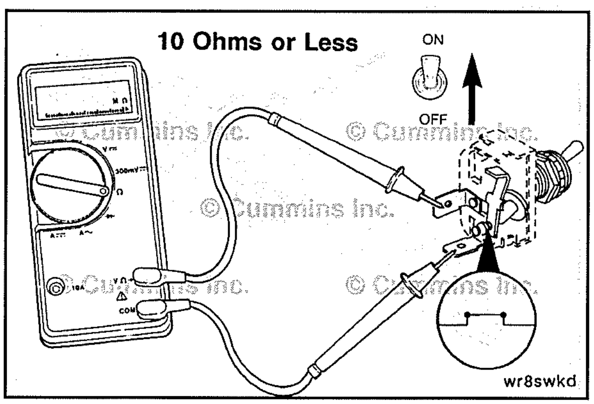
Resistance Check

If an electronic service tool is available, monitor the powertrain protection switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate the powertrain protection switch. Remove and tag the two connectors from the terminals on the switch. Touch the multimeter probes to the terminals on the switch.

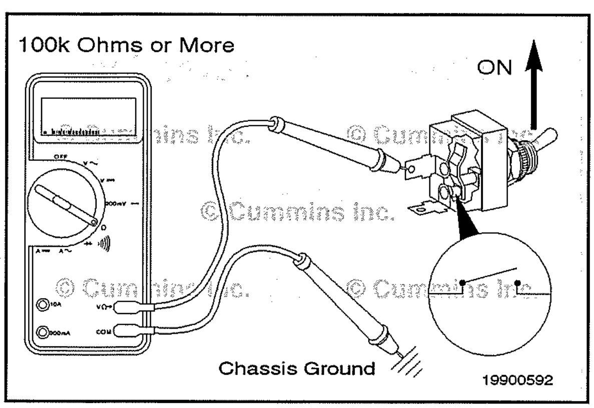


Move the switch to the OFF position, and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual for the replacement instructions.



Move the switch to the ON position, and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement instructions.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

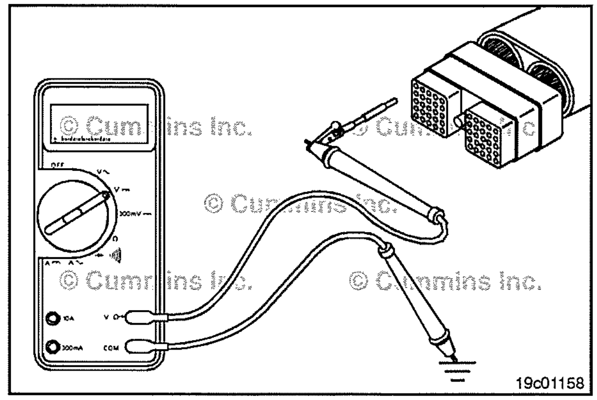


Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position, and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.

Check for Short Circuit to External Voltage Source



⚠CAUTION⚠

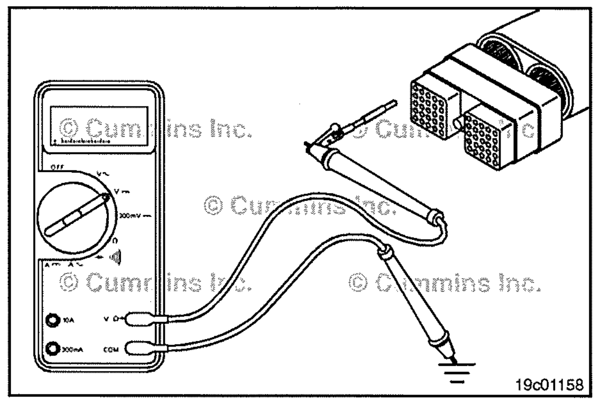
The leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

Isolate the powertrain protection switch circuit. Turn the vehicle keyswitch to the ON position. Adjust the multimeter to measure VDC.

Insert the test lead connected to the positive (+) multimeter probe into the powertrain protection switch signal pin of the OEM harness.

Disconnect the negative (-) multimeter probe from the test lead, touch it to the engine block ground, and measure the voltage. The voltage **must** be 1.5 VDC or less.

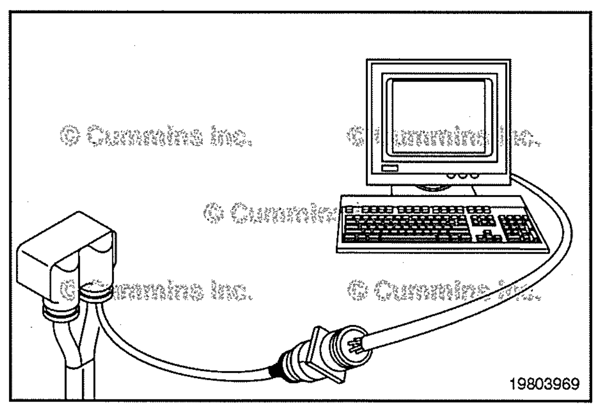
NOTE: An external voltage source is any wire in the OEM harness wiring that carries the voltage.



If the voltage value is more than 1.5 VDC, there is a short circuit between the wire connected to the powertrain protection switch signal pin and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.

Power Train Protection Switch Circuit (019-254)

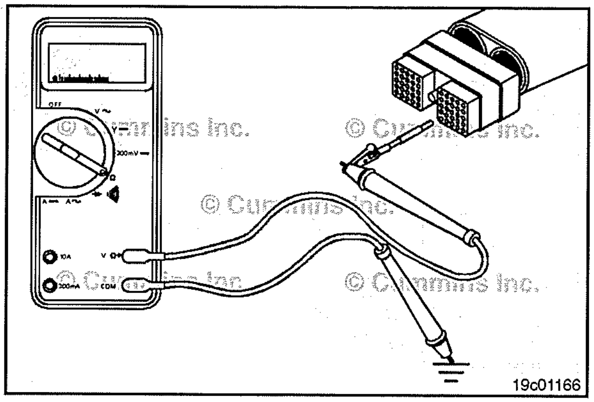
Resistance Check



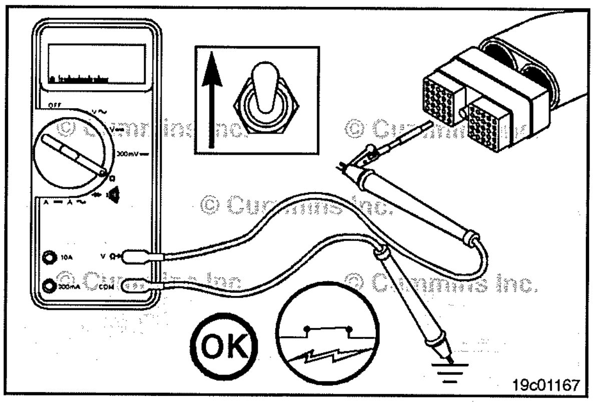
⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

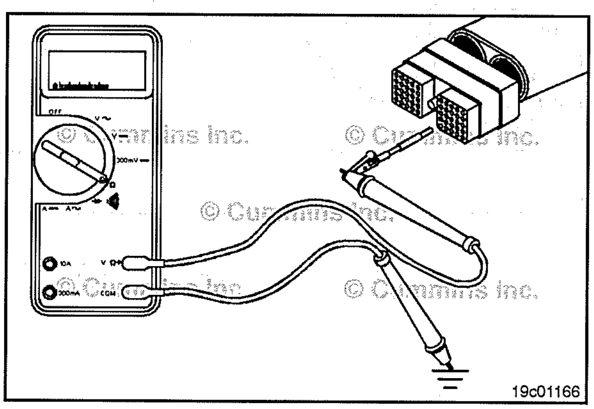
If electronic service tool is available, monitor the powertrain protection switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Insert the multimeter probe into powertrain protection switch signal pin in the OEM harness. Touch the other probe to the engine block ground.



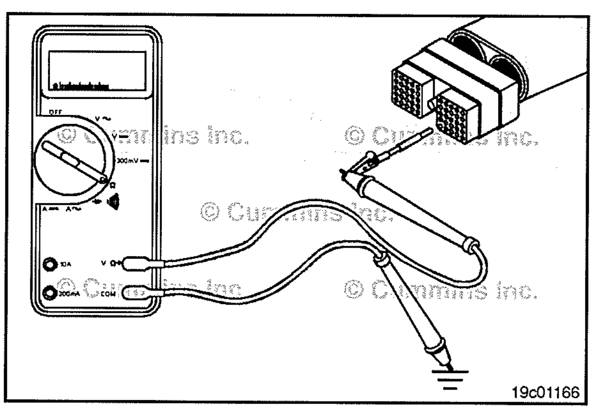
Move the powertrain protection switch to the ON position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the signal wire for an open circuit. Refer to the OEM troubleshooting and repair manual. If the resistance is within specification, the signal pin **must** be checked for a short circuit to ground, a short circuit from terminal to terminal, and a short circuit to an external voltage source.



Check for Short Circuit to Ground

Isolate the powertrain protection switch circuit.

Touch multimeter probe to the engine block. With the other electrical lead inserted into powertrain protection switch signal pin, measure the resistance.

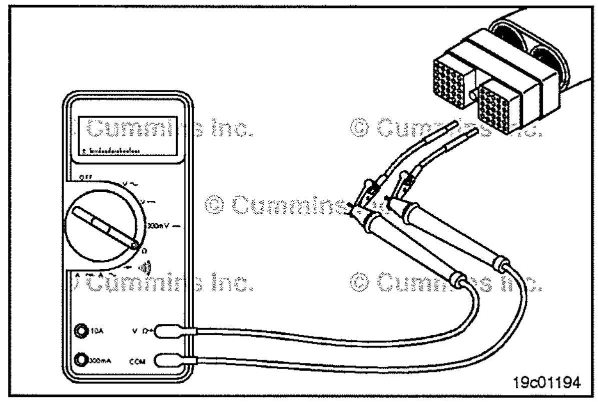


The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the powertrain protection switch circuit, provided that the switch has been previously checked. Repair or replace the wire connected to powertrain protection switch signal pin according to the vehicle manufacturer's instructions.

Check for Short Circuit from Pin to Pin

Isolate the powertrain protection switch circuit. Place one of the leads into power train protection switch signal pin. Insert the pin of the other lead into pin 1. Connect the alligator clips to the multimeter probes. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

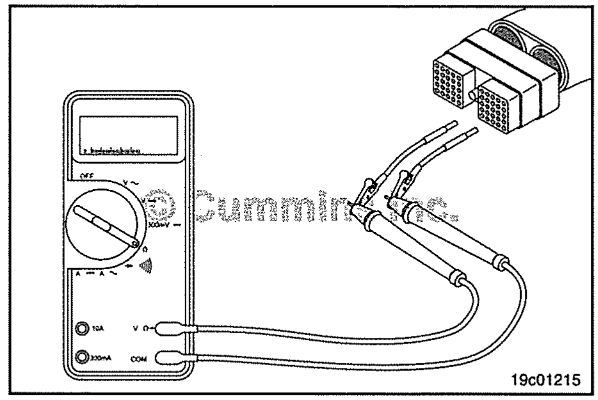


19c01194

Remove the lead from pin 1, and check all other pins. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit from the wire connected to powertrain protection switch signal pin and any pin that measured less than 100k ohms.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's instructions.



19c01215

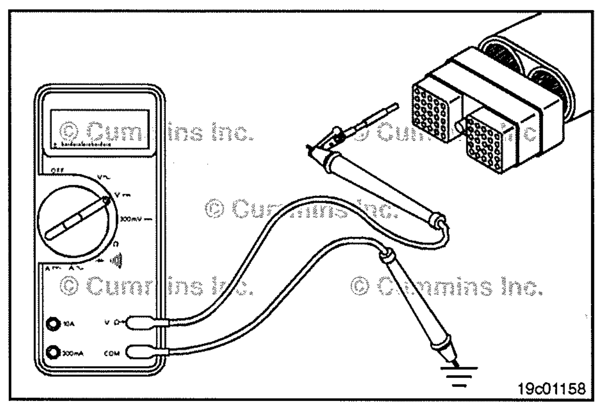
Check for Short Circuit to External Voltage Source

Isolate the powertrain protection switch circuit. Turn the vehicle keyswitch to the ON position. Set the multimeter to measure VDC.

Insert the test lead connected to the positive (+) multimeter probe into powertrain protection switch signal pin of the OEM harness.

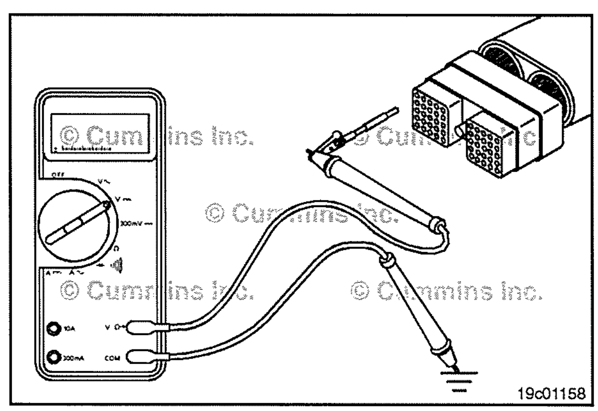
Disconnect the negative (-) multimeter probe from the test lead, touch it to the engine block ground, and measure the voltage. The voltage **must** be 1.5 VDC or less.

NOTE: An external voltage source is any wire in the OEM harness wiring that carries the voltage.



19c01158

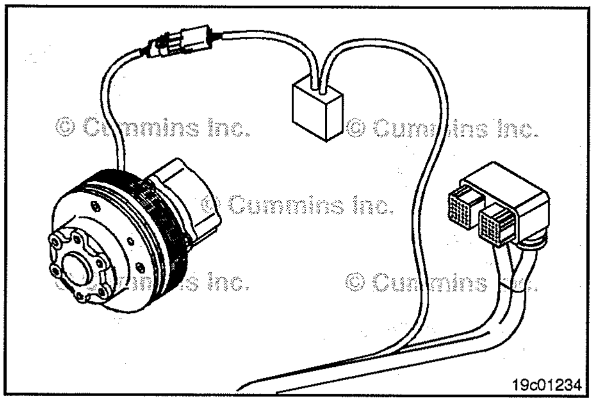
If the voltage value is more than 1.5 VDC, there is a short circuit between the wire connected to powertrain protection switch signal pin and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.



19c01158

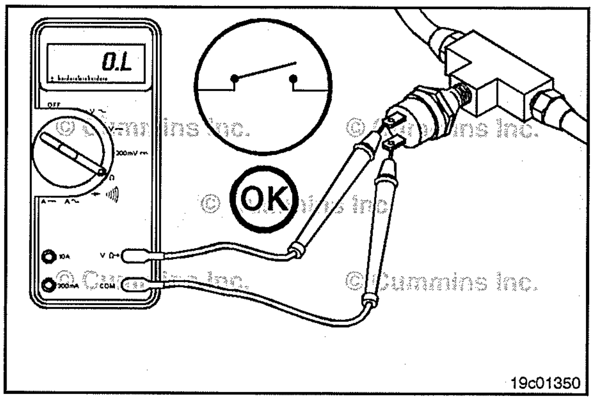
Air Conditioning Pressure Switch (019-261)

General Information



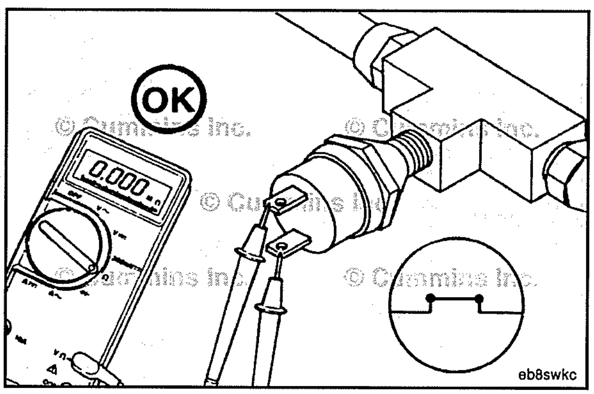
The air conditioning pressure switch circuit signals the system that the air conditioner head pressure is high and the engine fan **must** be engaged. The air conditioning pressure circuit consists of the air conditioning pressure switch signal pin and switch return pin. This circuit is considered “fail safe”, meaning when the circuit is open, the engine fan will be engaged by the electronic control module (ECM).

Resistance Check



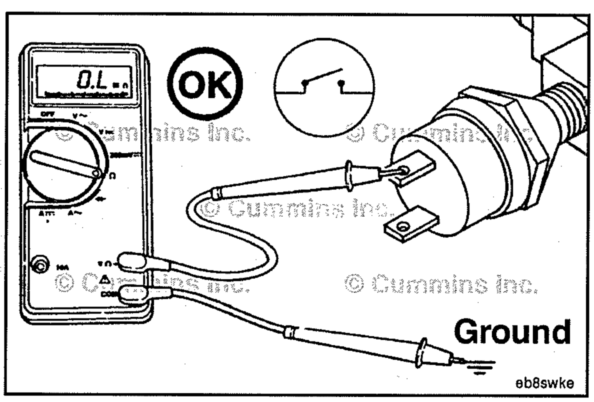
Locate the air conditioning pressure switch. Remove the electrical connection from the switch. Adjust the multimeter to measure resistance. Touch one multimeter probe to one of the terminals on the switch. Touch the other multimeter probe to the other terminal of the switch.

When the system head pressure is high, the multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual for replacement procedures.



When the system head pressure is low, the multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

Check for Short Circuit to Ground



When the system head pressure is low, touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.

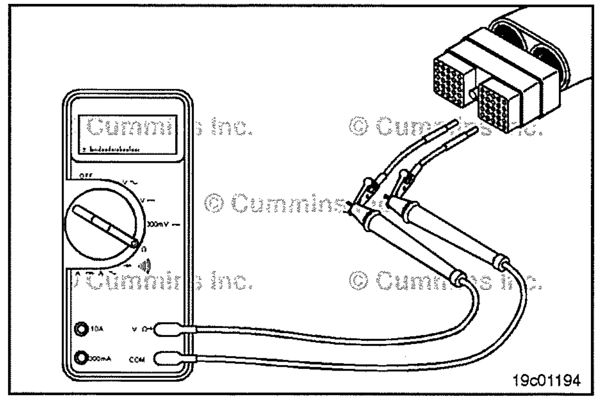
Air Conditioning Pressure Switch Circuit (019-262)

Resistance Check

⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Insert one of the test leads into the switch return of the OEM harness connector and connect the alligator clip to the multimeter probe. Insert the other lead into the air conditioning pressure switch signal pin of the harness connector and connect the alligator clip to the other multimeter probe.

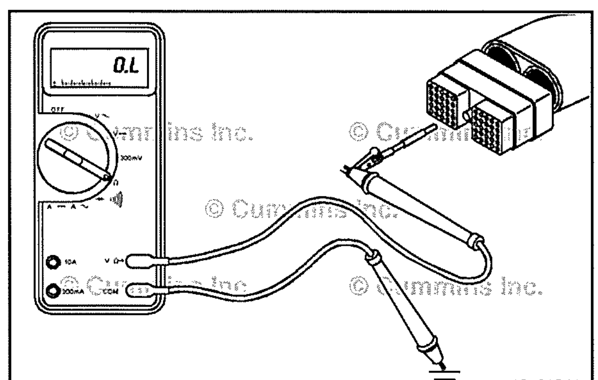


19c01194

When the system head pressure is low, the multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the switch return and the air conditioning pressure switch signal wire for an open circuit, provided that the switch has been previously checked. Refer to the OEM troubleshooting and repair manual for repair procedures. If the resistance is within the specification, the switch return and the air conditioning pressure switch wire **must** be checked for a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.

Check for Short Circuit to Ground

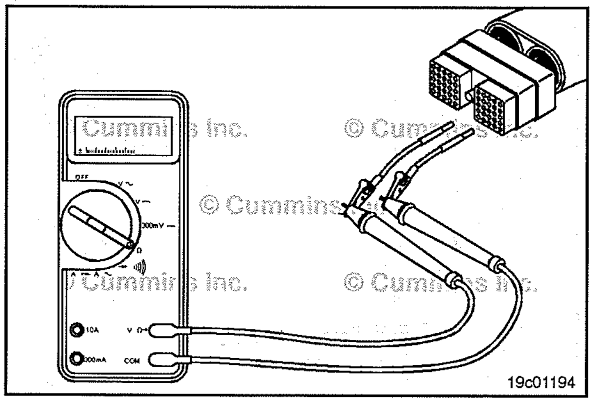
To isolate the air conditioning switch circuit when checking for an electrical short, disconnect the OEM harness engine interface connector.



19c01241

Adjust the multimeter to measure resistance. When the system head pressure is low, insert a test lead into the air conditioning pressure switch signal pin of the OEM harness connector and connect it to a multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the resistance.

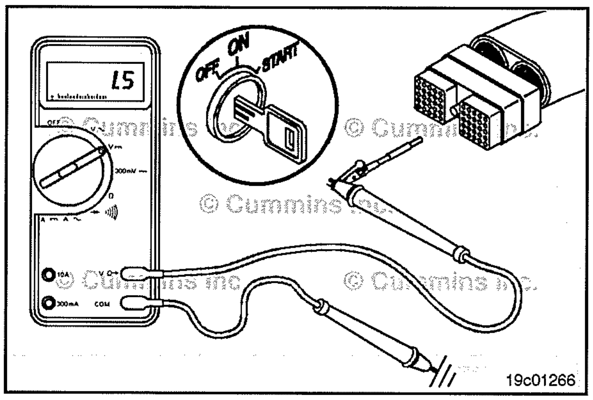
The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the air conditioning switch circuit, provided that the switch has been previously checked. Repair or replace the wire connected to the air conditioning pressure switch signal pin in the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit from Pin to Pin

Check for a short circuit from pin-to-pin. Isolate the air conditioning circuit by removing the OEM harness from the ECM. Insert the lead into the air conditioning pressure switch signal pin. Connect the alligator clip to the multimeter. With the other lead inserted into the switch return pin, measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

Allow the head pressure to drop and remove the lead from the air conditioning pressure switch signal pin and check all other pins. When the system head pressure is low, measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit between the air conditioning pressure circuit and any pin that shows a closed circuit. Repair or replace the wires in the engine harness. Refer to Procedure 019-043. Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to External Voltage Source

Turn the keyswitch to the ON position. When the system head pressure is low, adjust the multimeter to measure VDC. Insert a test lead into the air conditioning pressure switch signal pin of the OEM connector and attach it to a multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the voltage. The voltage **must** be 1.5 VDC or less. If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the air conditioning pressure switch circuit and a wire carrying power in the engine or OEM harness. Remove the voltage source, or repair or replace the wiring in the OEM harness. Refer to Procedure 019-071. Remove the voltage source or repair or replace the wires in the engine harness. Connect all components after completing the repair.

NOTE: If the air conditioning pressure switch circuit was approved in all of the previous tests, it is functioning properly.

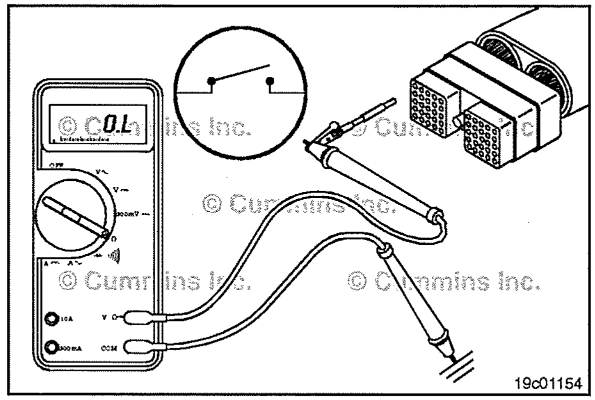
Accelerator Interlock Switch (019-264)

General Information

The accelerator interlock switch inhibits the operation of the cab accelerator and the remote accelerator. For example, busses inhibit the accelerator as passengers embark and disembark, to ensure the bus remains stationary. The accelerator interlock feature, available **only** on special transit and vocational calibrations, uses this switch. Installation varies; busses commonly use a door-actuated switch.

Accelerator Interlock Switch Circuit (019-265)

Resistance Check



19c01154

⚠CAUTION⚠

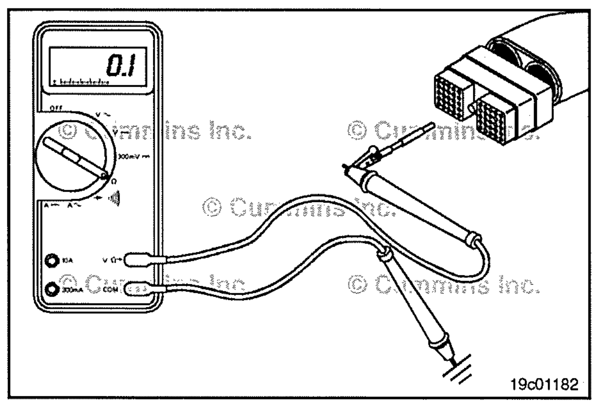
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

The accelerator interlock switch is programmable. Check the setting with INSITE™ electronic service tool before continuing with the troubleshooting steps.

If electronic service tool is available, monitor the accelerator interlock switch for proper operation. If **not**, follow the procedure below.

NOTE: The accelerator interlock signal input can also be used as the engine torque limit switch signal as well.

Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). Insert a test lead into the accelerator interlock switch signal pin. Touch the other multimeter probe to engine block ground. With the switch in the inhibit position, the multimeter **must** read an open circuit (100k ohms or more).

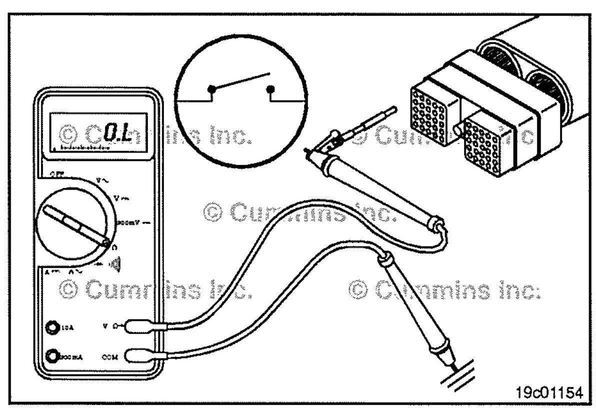


19c01182

With the switch in the normal position, the multimeter **must** read a closed circuit (10 ohms or less).

If the circuit is **not** closed, inspect the accelerator interlock switch signal line for an open circuit.

Check for Short Circuit to Ground

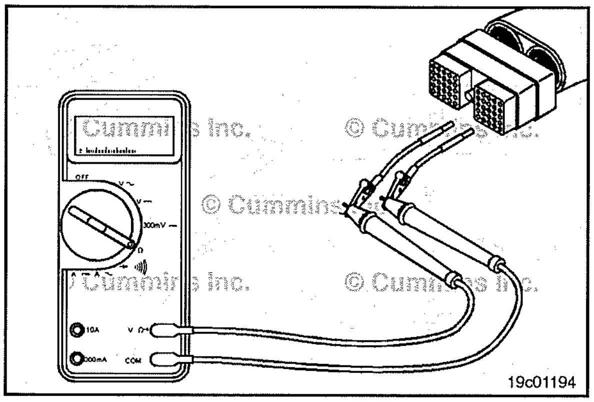


19c01154

Connect one of the multimeter probes to the accelerator interlock switch signal wire. Touch the other probe to chassis ground. Move the switch to the inhibit position and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more). If the circuit does **not** show an open circuit then there is a short to ground in the circuit somewhere.

Repair or replace the OEM harness. Refer to Procedure 019-071.

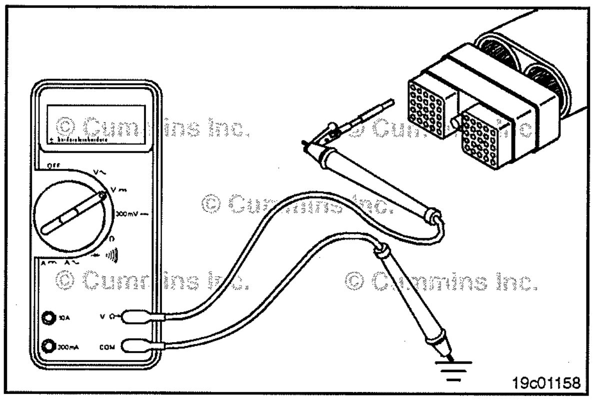


Check for Short Circuit from Pin to Pin

Check for a short circuit from pin-to-pin. Insert a test lead into the accelerator interlock switch signal pin. Insert the other test lead into the switch return pin. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

Remove the test lead from the switch return pin and test all other pins in the connector. The multimeter **must** show an open circuit on all pins.

Repair any pin circuits that show a closed circuit with the accelerator governor switch signal pin.

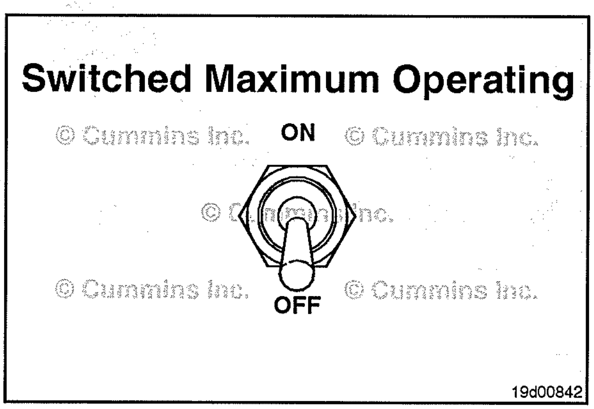


Check for Short Circuit to External Voltage Source

Set the switch to normal position and set the multimeter to read VDC. Insert one test lead into the accelerator interlock switch signal pin and connect a multimeter lead to it. Touch the other multimeter lead to engine block ground. Measure the voltage.

The voltage **must** read 1.5 VDC or less.

If the voltage is **not** correct, there is an external voltage source connected to the circuit. Repair or replace the OEM wiring. Refer to Procedure 019-071.

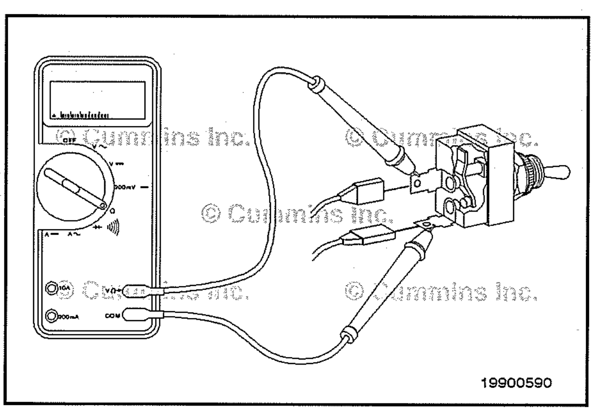


Switched Maximum Operating Speed Switch (019-268)

General Information

The maximum engine speed switch is an original equipment manufacturer (OEM) installed switch that allows a driver to select a lower, programmable maximum engine speed.

Certain applications, such as one that uses a hydraulic system, can possibly need to be protected from an overspeed condition. The operator can toggle this switch and limit the maximum engine rpm to a lower value in which the hydraulic system can safely operate.



Resistance Check

If an electronic service tool is available, monitor the switched maximum operating switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

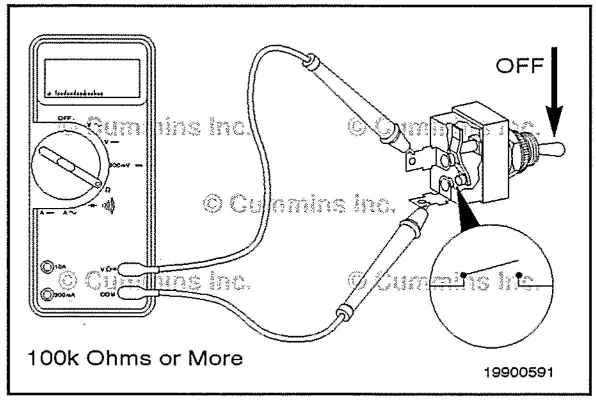
Locate the maximum engine speed switch. Label the wires with the location on the switch or the wire number.

Remove the electrical connectors from the switch.

Set the multimeter to measure resistance. Touch the other multimeter probe to the other terminal of the switch.

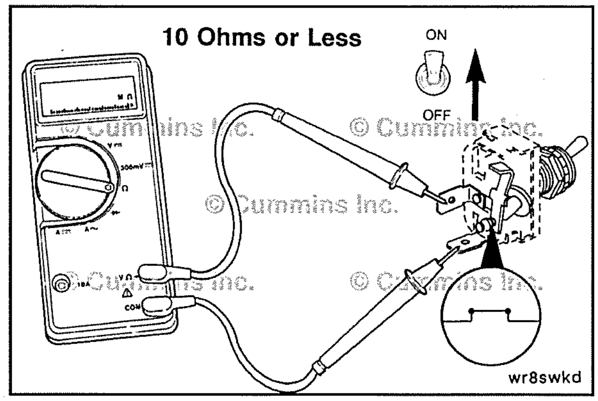
Place the switch in the OFF position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch is defective. Refer to the OEM troubleshooting and repair manual for replacement procedures.



Place the switch in the ON and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch is defective. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

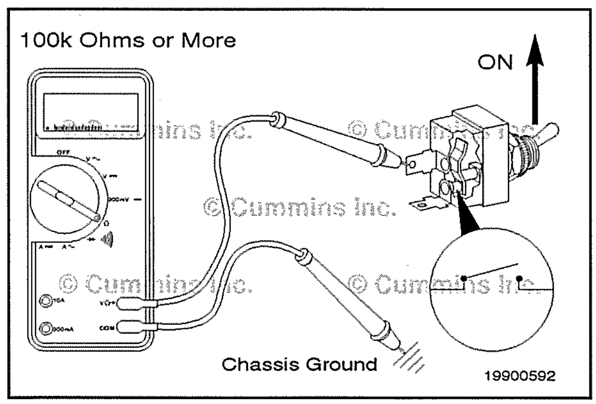


Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the normal position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.

If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.



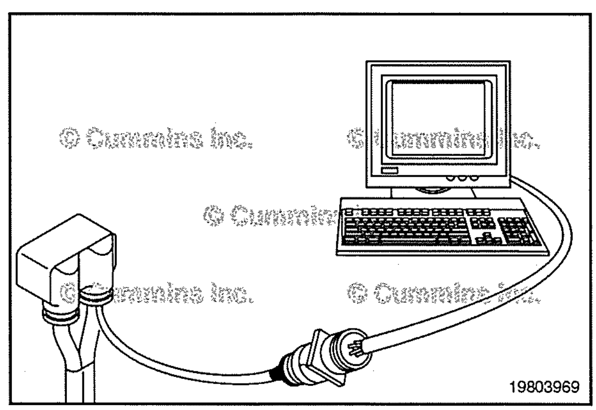
Switched Maximum Operating Speed Switch Circuit (019-269)

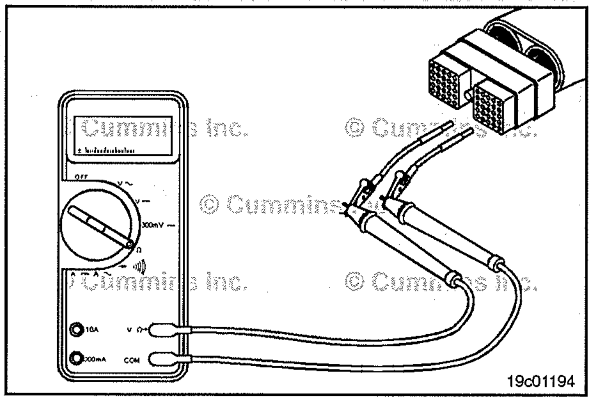
Resistance Check

CAUTION

Proper leads and/or a Cummins approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

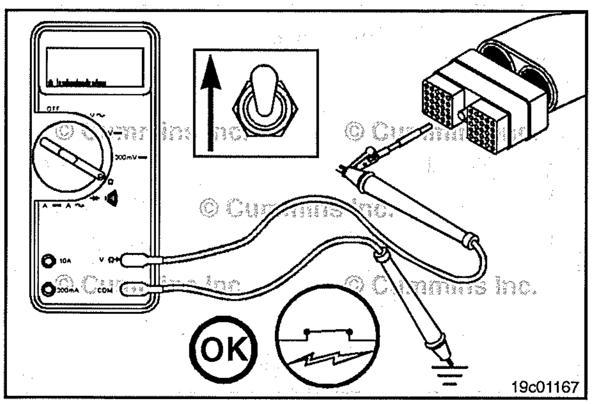
If electronic service tool is available, monitor the switched maximum operating speed switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.





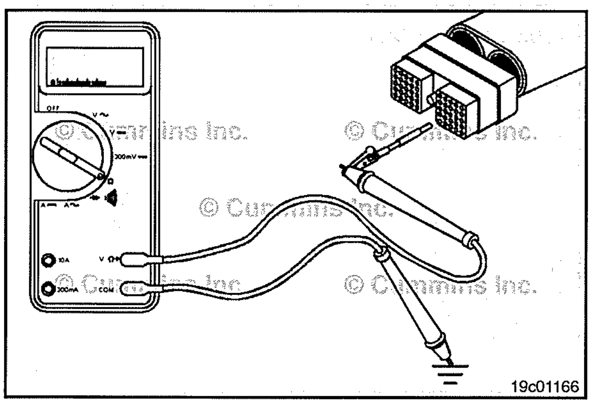
Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Set the multimeter to measure resistance.

Insert a test lead into the switched maximum operating speed switch return (-) pin of the OEM harness connector, and connect the alligator clip to the multimeter probe. Touch the other lead to the switched maximum operating speed switch input pin of the connector, and connect the alligator clip to the other multimeter probe.



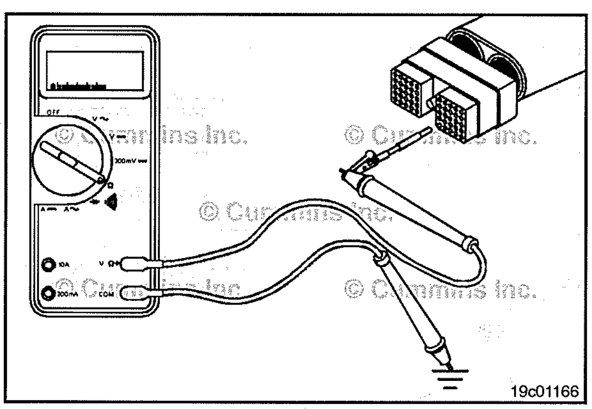
Move the switched maximum operating speed switch to the ON position. The multimeter **must** show 10 ohms or less (closed circuit). If the circuit is **not** closed, inspect both the return (-) wire and the input wire for an open circuit, provided that the switch has been previously checked.

Refer to the OEM troubleshooting and repair manual. If the resistance is within specification, both the return (-) wire and the input wire **must** be checked for a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.



Check for Short Circuit to Ground

Isolate the switched maximum operating speed switch circuit.



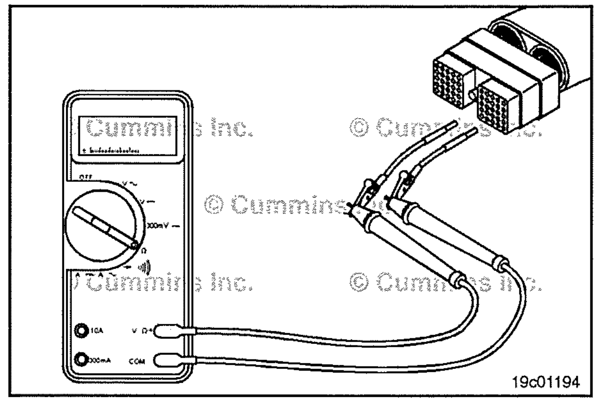
Insert one of the test leads into the switched maximum operating speed switch return (-) pin of the OEM harness connector, and connect the alligator clip to the multimeter probe. Touch the other multimeter probe to the engine block, and measure the resistance.

The multimeter **must** show 100k ohms or more (open circuit). If the circuit is **not** open, there is a short circuit to ground in the switched maximum operating speed switch circuit, provided that the switch has been previously checked.

Repair or replace the wire connected to the return (-) pin according to the vehicle manufacturer's instructions.

Check for Short Circuit from Pin to Pin

Isolate the switched maximum operating speed switch circuit. Disconnect the OEM harness connector from the ECM. Set the multimeter to measure resistance.

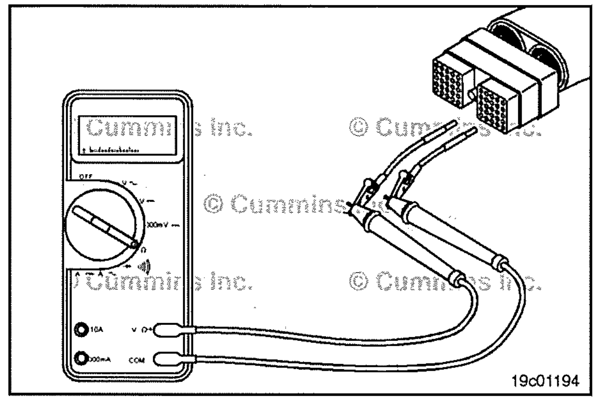


19c01194

Insert a test lead into the maximum operating speed switch input pin of the OEM harness connector. Insert the other test lead into the switch return pin of the connector. Connect the alligator clips to the multimeter probes.

Measure the resistance.

The multimeter **must** show 100k ohms or more (open circuit).

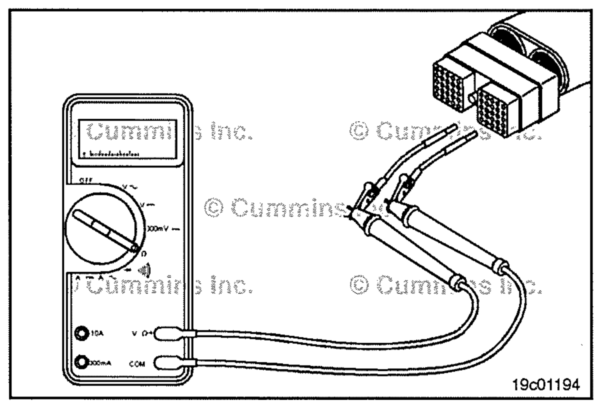


19c01194

Remove the lead from the maximum operating speed switch return pin, and check all other pins.

The multimeter **must** show 100k ohms or more (open circuit) at all pins. If the circuit is **not** open, there is a short circuit from the wire between the applicable pins that measured less than 100k ohms.

Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



19c01194

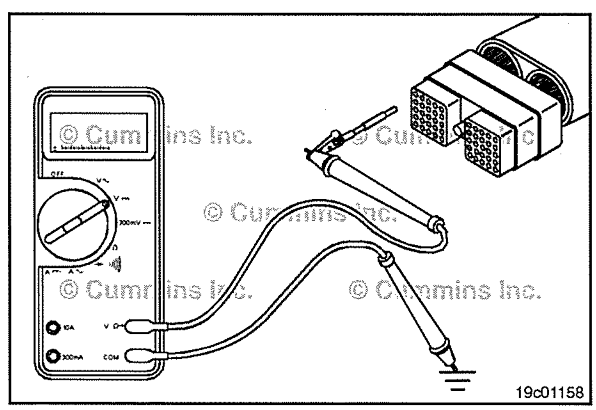
Check for Short Circuit to External Voltage Source

NOTE: An external voltage source is any wire in the OEM harness wiring that carries the voltage.

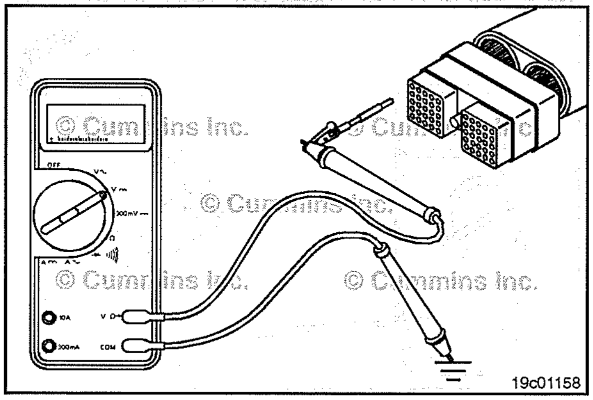
Set the switched maximum operating speed switch to normal. Disconnect the OEM harness connector from the ECM. Turn the vehicle keyswitch to the ON position. Set the multimeter to measure VDC.

Insert a test lead into the switched maximum operating speed switch input pin of the OEM harness connector. Connect the lead to the positive (+) multimeter probe.

Touch the negative (-) multimeter probe to the engine block ground, and measure the voltage. The voltage **must** be 1.5 VDC or less.

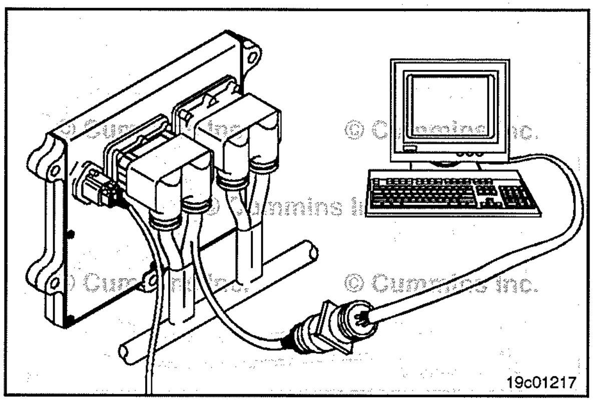


19c01158



If the voltage value is more than 1.5 VDC, there is a short circuit between the wire connected to the switched maximum operating speed switch input pin and a wire carrying power in the OEM harness. Repair the OEM harness. Refer to Procedure 019-071.

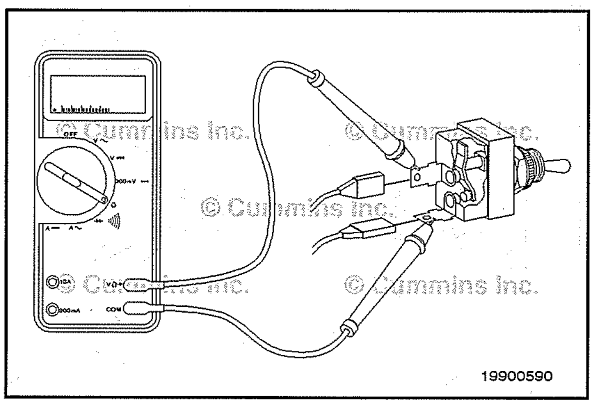
Connect all components after completing the repairs.



Remote Accelerator Switch (019-333)

General Information

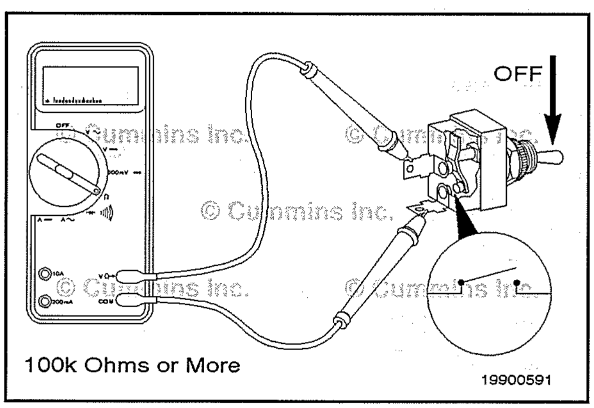
The remote accelerator switch enables and disables the remote accelerator feature. When enabled, the remote accelerator feature allows an operator to control the fueling of the engine from a remote location. Often, the remote accelerator switch is located on a remote panel very close to the remote accelerator sensor.



Resistance Check

If an electronic service tool is available, monitor the switch for proper operation. If an electronic service tool is **not** available, follow the troubleshooting procedures in this section.

Locate the remote accelerator switch. Remove and tag the two connectors from the terminals on the switch.



Touch the multimeter probes to the terminals on the switch.

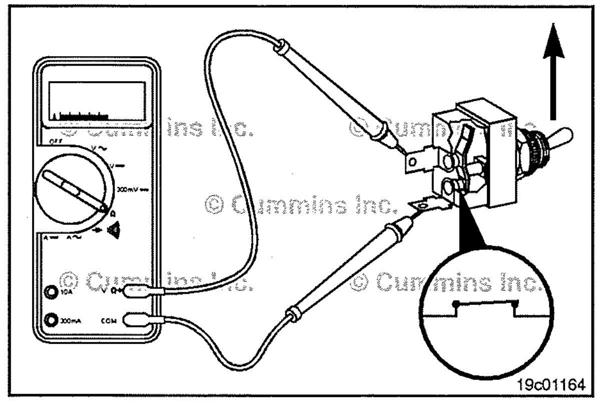
Move the switch to the OFF position and measure the resistance. The multimeter **must** show an open circuit (100K ohms or more).

If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

Move the switch to the ON position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.

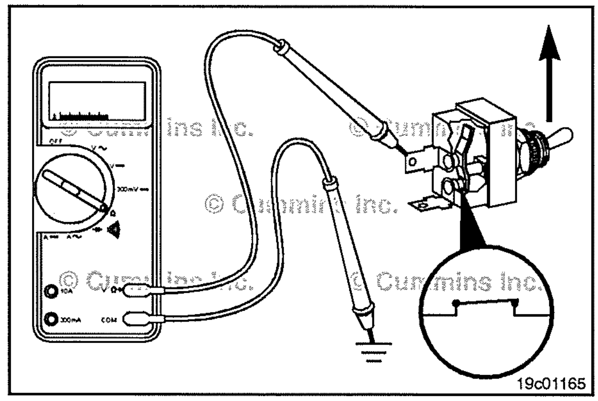
If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.



Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position and measure the resistance. The multimeter **must** show an open circuit (100K ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.

If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin to pin and a short circuit to an external voltage source.



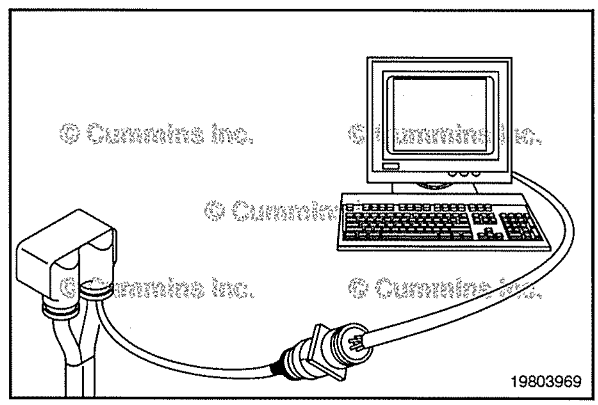
Remote Accelerator Switch Circuit (019-334)

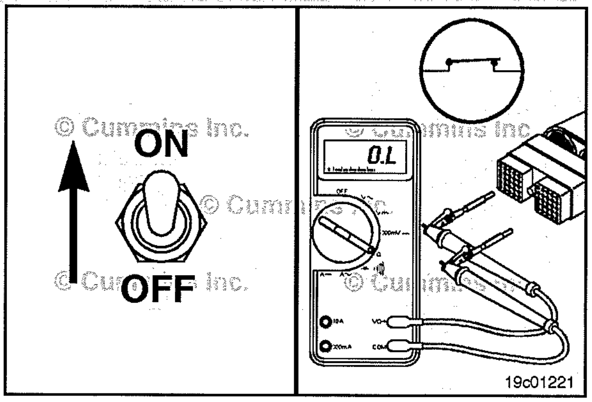
Resistance Check

⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If electronic service tool is available, monitor the switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



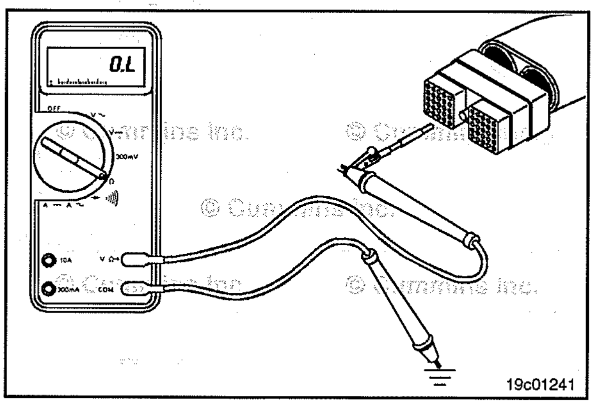


Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Insert a test lead into the remote accelerator switch signal of the OEM harness connector and attach it to the multimeter probe. Touch the other probe to engine block ground. Move the remote accelerator switch to the ON position. The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, inspect the remote accelerator switch signal line wire for an open circuit. Refer to the OEM troubleshooting and repair manual.

If the resistance is within specification, the remote accelerator switch signal wire **must** be checked for short circuit to ground, short circuit from pin-to-pin, and a short circuit to an external voltage source.



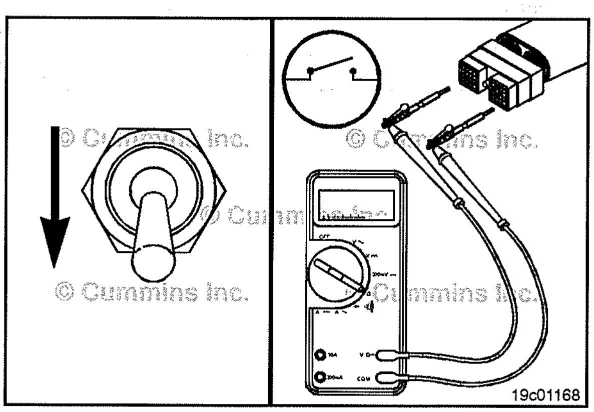
Check for Short Circuit to Ground

To isolate the remote accelerator switch circuit when checking for a short circuit, disconnect the OEM harness connector from the ECM and the OEM harness from the remote accelerator switch.

Adjust the multimeter to measure resistance. Insert a test lead into the remote accelerator switch signal wire of the OEM harness connector and attach it to a multimeter probe. Touch the other multimeter probe to engine block ground. Measure the resistance.

The multimeter **must** show an open circuit (100K ohms or more). If the circuit is **not** open, there is a short circuit to ground in the remote accelerator switch circuit, provided the switch has already been checked.

Repair or replace the wire connected to the remote accelerator switch signal. Refer to the OEM troubleshooting and repair manual.



Check for Short Circuit from Pin to Pin

Turn the remote accelerator switch to the OFF position. Insert a test lead into the remote accelerator switch signal wire at the OEM harness connector.

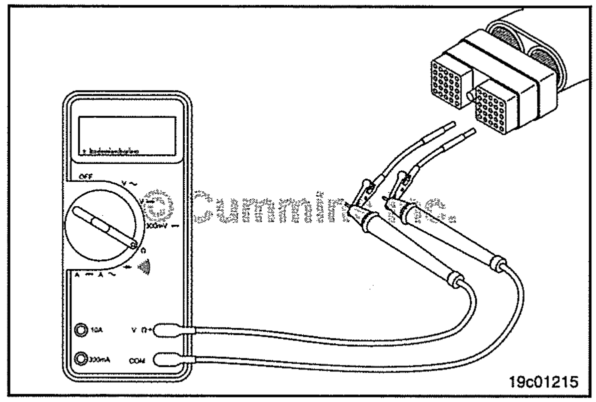
Connect the multimeter probe to the test lead. Insert the other multimeter probe with a test lead attached into the switch return wires within the OEM harness connector. Measure the resistance.

The multimeter **must** show an open circuit (100K ohms or more).

Remove the test lead from the remote accelerator switch signal wire and check all other pins. The multimeter **must** show an open circuit (100K ohms or more).

If the circuit is **not** open, there is a short circuit between the remote accelerator switch signal pin and any other pin that shows a closed circuit, provided the switch has previously been checked.

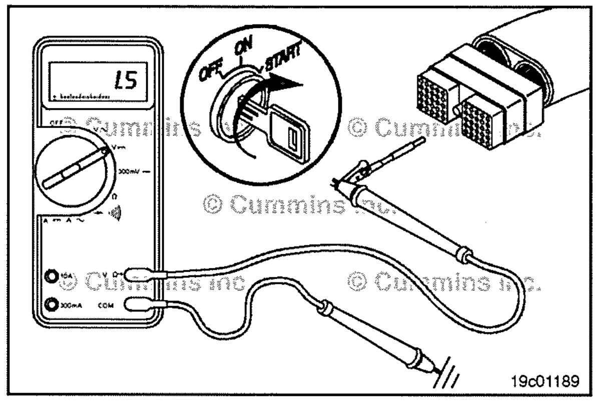
Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to External Voltage Source

Turn the vehicle keyswitch to the ON position. Set the remote accelerator switch to the ON position. Set the multimeter to measure VDC. Insert a test lead into the remote accelerator switch signal wire and attach it to a multimeter probe. Touch the other multimeter probe to engine block ground. Measure the voltage, the voltage **must** be 1.5 volts or less.

If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the remote accelerator switch circuit and a wire carrying power in the OEM harness. Repair or replace the OEM harness. Refer to Procedure 019-071.



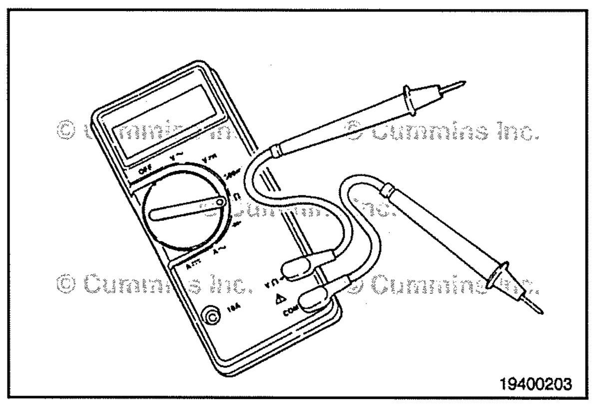
Multimeter Usage (019-359)

General Information

How to Use a Multimeter

On most meters, the negative (-), (black) meter probe **must** be plugged into the COM position and the positive (+), (red) meter probe **must** be plugged into one of the positions marked for amperage, resistance, or voltage. Refer to the manufacturer's procedures for more detail.

NOTE: When measuring to a block or chassis ground, use a clean, unpainted metal surface to make sure a good measurement exists.

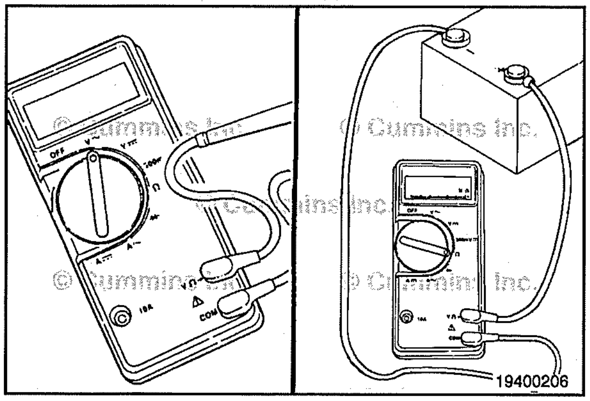


Use of Special Test Leads

⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

Refer to the appropriate wiring repair kit for specific test leads used on this application.



19400206

How to Measure Amperage

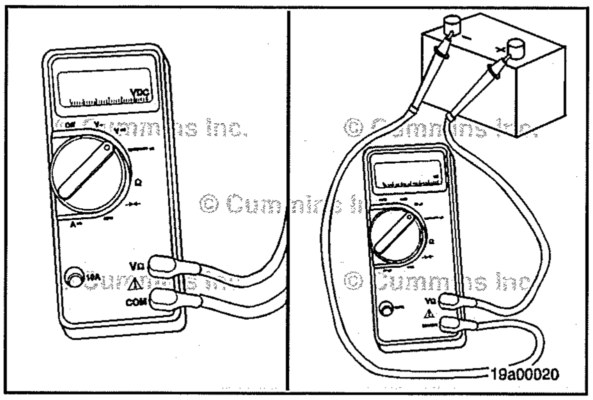
Make an open circuit at the place where the current is to be measured.

Select the AC current (A ˜) or DC current (A-) function on the meter.

Turn on the power in the circuit being measured.

Put the probes of the meter across the open circuit to measure the amperage.

Read the displayed measurement.



19a00020

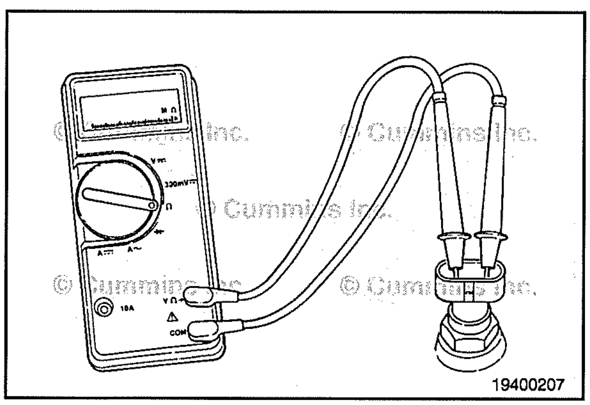
How to Measure Voltage

Select the AC voltage (V ˜) or DC voltage (V-) function on the meter.

Turn on the power in the circuit being measured.

Touch the positive (+) probe of the multimeter to the terminal or pin that is being measured for voltage. Touch the other probe to a clean, unpainted metal surface that is connected to battery ground or to the negative (-) post of the battery.

Read the displayed measurement.



19400207

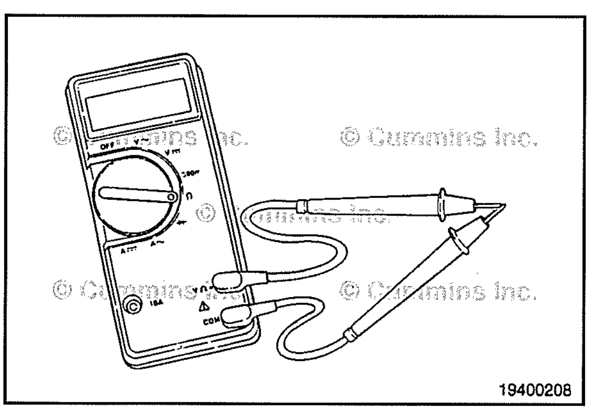
How to Measure Resistance

Select the resistance function on the meter.

Verify that there is no power to the components being tested.

Disconnect both ends of the circuit or component to be measured. Touch one probe to one end of the circuit or component terminal. Touch the other probe to the other end of the circuit or the other component terminal.

Read the displayed measurement.



19400208

How to Find the Internal Resistance of the Meter

It is important to know the internal resistance of the meter when measuring small resistances. To measure small resistances accurately, the internal resistance of the meter **must** be subtracted from the measured resistance.

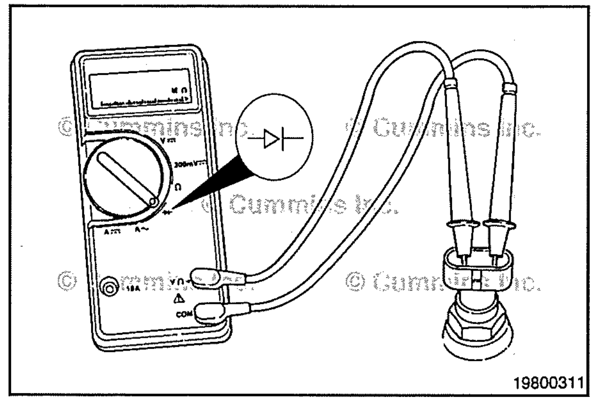
Turn the meter ON.

Set the meter to the lowest ohm scale.

Measure the resistance of the meter by touching the test probes together and reading the resistance value (including special test leads, if they are being used).

ZERO the meter or subtract this value when taking measurements.

How to Test for Continuity


19800311

Select the continuity function on the meter (usually marked with a diode symbol).

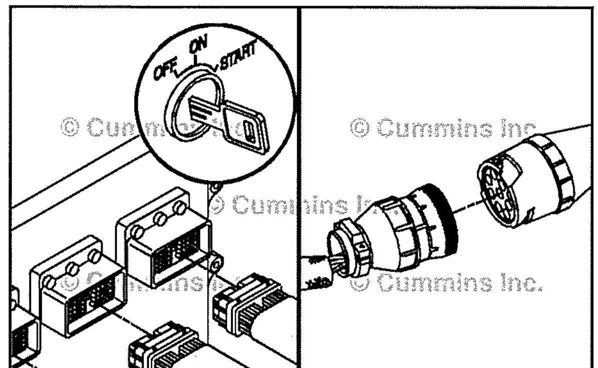
Make sure there is no power to the component being measured.

Disconnect both ends of the circuit or component to be measured. Touch one probe to one end of the circuit or component terminal. Touch the other probe to the other end of the circuit or the other component terminal.

Read the displayed measurement.

The meter will beep if the resistance is less than about 150 ohms. If there is an open circuit, the meter does **not** beep.

Short Circuit to Ground - Check

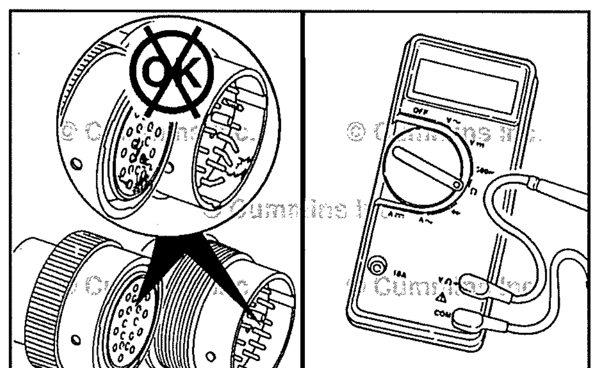


19200195

Short circuit to ground is a condition where a connection from a circuit to ground exists when it is **not** intended.

The procedure for checking for a short circuit to ground is as follows:

- Turn keyswitch OFF.
- Disconnect the connectors that are to be tested.



19800313

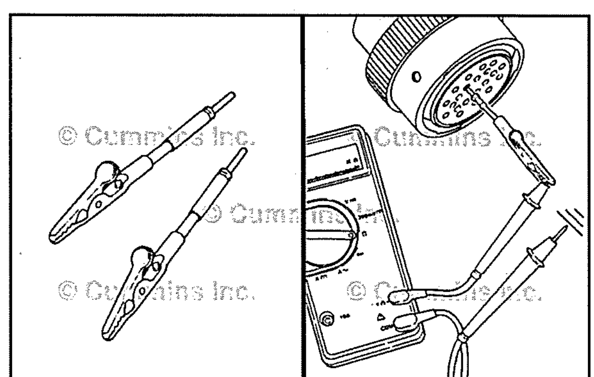
When testing a sensor, **only** the sensor connection is required to be disconnected.

When testing a harness, the harness connector at the electronic control unit and the connector at the sensor or multiple sensors should be disconnected.

Identify the pins that need to be tested.

Inspect the connector pins. 019-361.

Adjust the multimeter to measure resistance.


19800314

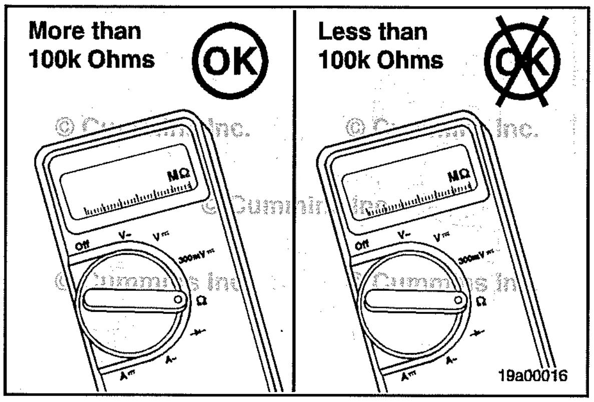
⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

Touch one of the multimeter probes to the correct pin to be tested.

Touch the other probe of the multimeter to a clean, unpainted surface on the engine block or chassis ground.

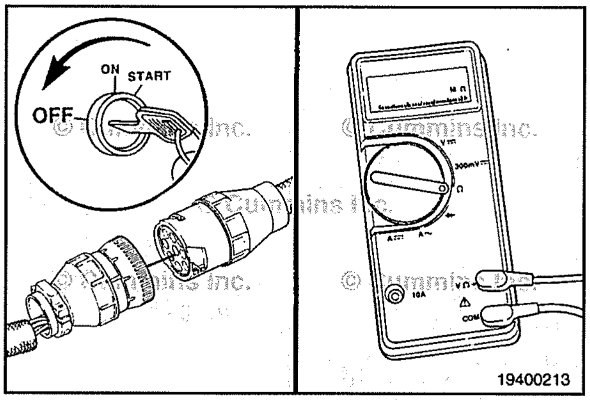
Read the value on the multimeter display.



The multimeter **must** read greater than 100k ohms, which is an open circuit.

If the circuit is **not** open, the wire being checked has a short circuit to ground, engine block or chassis ground.

Repair or replace the component or wire.

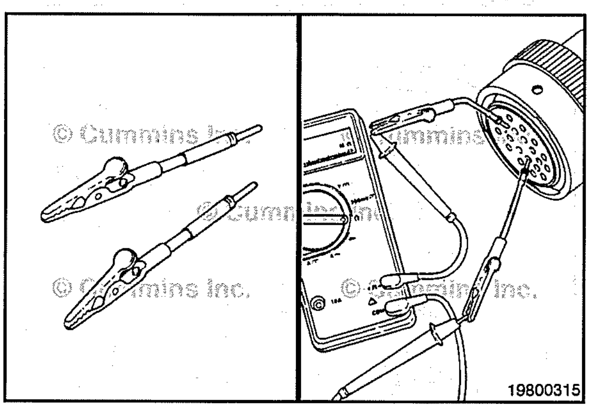


Short Circuit from Pin to Pin - Check

Short circuit from pin to pin is a condition in which an electrical path exists between two pins where it is **not** intended to exist.

The procedure for checking short circuit from pin to pin is as follows:

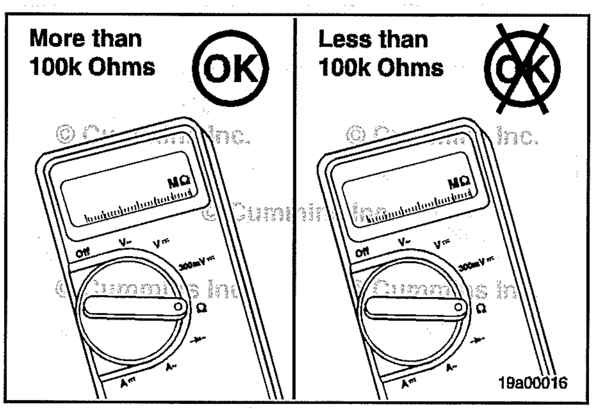
1 Turn keyswitch OFF.
2 Disconnect the connector that is to be tested.
3 Identify the pins that are to be tested.
4 Adjust the multimeter to measure resistance.



⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

1 Touch one of the multimeter probes to the correct pin to be tested on the harness side of the connector.
2 Touch the other probe of the multimeter to all other pins on the harness side of the connector.



1 Read the value on the multimeter display.
2 The multimeter **must** read greater than 100k ohms, which is an open circuit.
3 If the circuit is **not** open, the pins being checked are electrically connected.

NOTE: Refer to the wiring diagram to verify that the wires in question are **not** supposed to be connected.

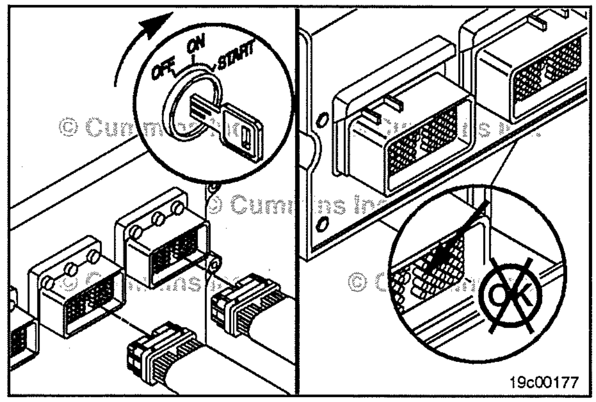
1 Inspect the harness connectors for moisture that can be the cause of an inappropriate electrical connection.
2 Repair or replace the harness.

Voltage Checking

Voltage check is a procedure to measure the difference in voltage potential between two points.

The procedure for checking voltage is as follows:

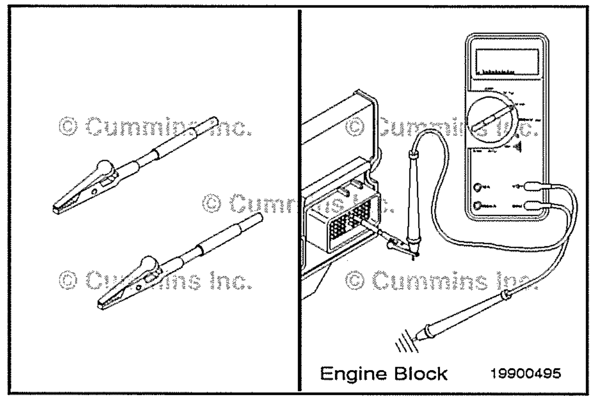
1. Disconnect the connectors that are to be tested.
2. Turn keyswitch ON.
3. Identify the pins that are to be tested.
4. Adjust the multimeter to AC voltage (V ~) or DC voltage (V-).



19c00177

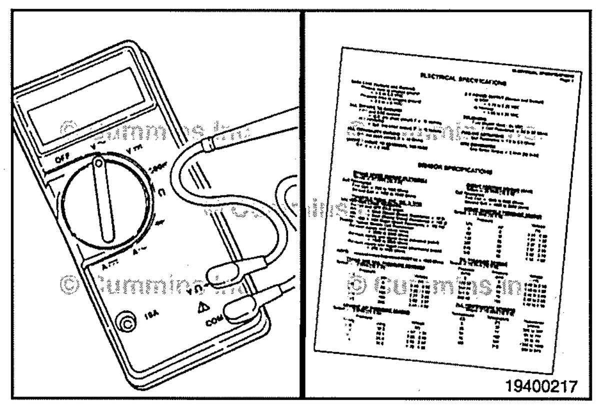
⚠CAUTION⚠
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

1. Touch one of the multimeter test probes to the correct lead to be tested.
2. Touch the other multimeter probe to a clean, unpainted surface on the engine block, chassis ground or to the appropriate return pin.



19900495

1. Read the value on the multimeter display. Compare the measured value to the range of voltage given in the specifications.
2. If the measured value falls outside of the specified range, check the repair procedure for the electrical system that is being checked for the appropriate action.

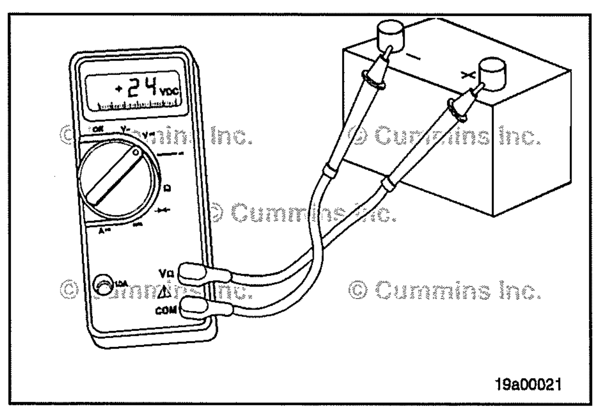


19400217

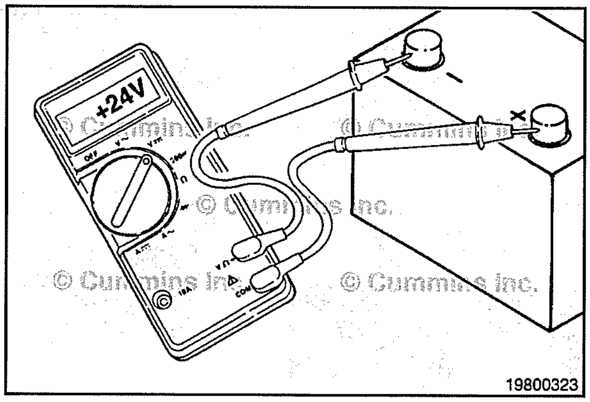
Polarity Check

A battery will be used as an example to check polarity of a circuit.

The terminals of a battery are marked for polarity. The multimeter displays the voltage difference of the positive (+) probe (red) to the negative (-) probe (black).



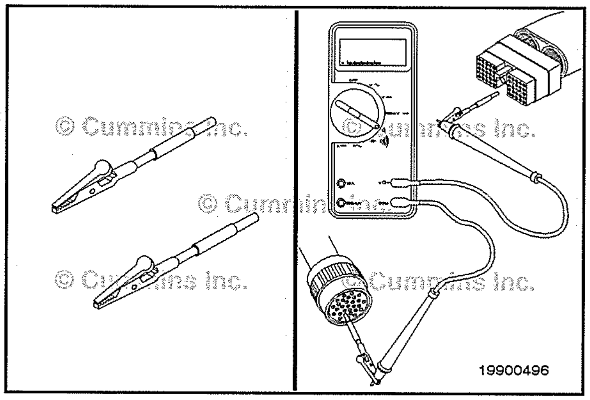
19a00021



The polarity is correct when the positive (red) probe of the multimeter is on the positive (+) terminal of the battery and the negative (black) probe of the multimeter is on the negative (-) terminal of the battery.

The multimeter will display positive voltage if the polarity is correct.

If the multimeter probes are reversed, the multimeter displays a negative voltage.

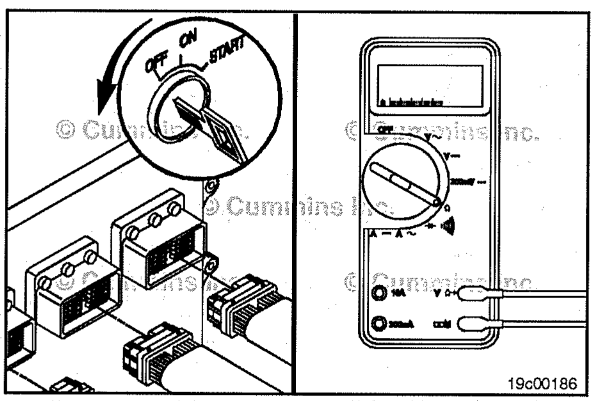


Continuity Check

⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

Continuity is an electrical connection between two pins that is less than a certain resistance value. For harness wires, the specification is less than 10 ohms.

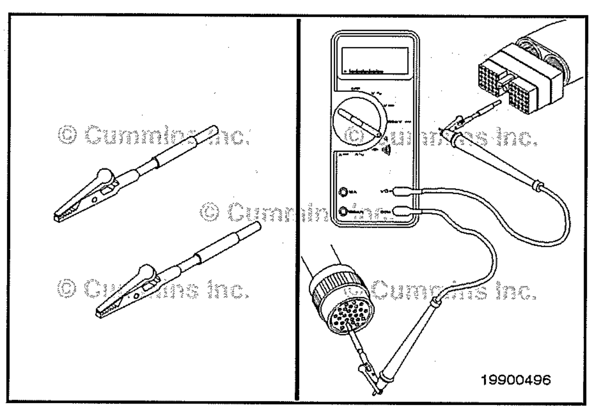


The procedure for checking continuity is as follows:

1 Turn keyswitch OFF.

2 Disconnect the harness connectors that are to be tested.

3 Adjust the multimeter to measure resistance.



⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

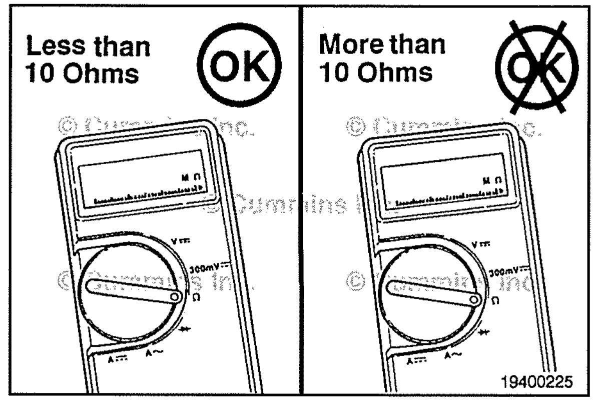
1 Insert test lead to the pin of the wire being tested and connect the alligator clip to the multimeter probe.

2 Insert the other test lead to the pin at the other end of the wire being tested and connect the alligator clip to the other multimeter probe.

3 Read the value on the multimeter display.

The multimeter **must** display less than 10 ohms for wire continuity.

If the multimeter displays greater than 10 ohms, the wire **must** be repaired or the harness replaced.



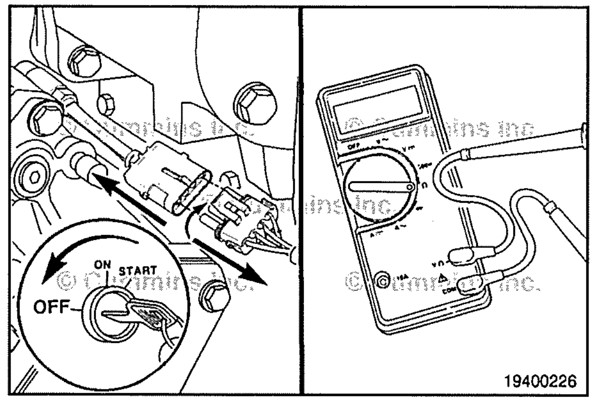
19400225

Resistance Check - Coil

Turn keyswitch OFF.

Disconnect the harness from the coil.

Adjust the multimeter to measure resistance.



19400226

⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

Insert test lead to the coil connector pin, and connect the alligator clip to the multimeter probe.

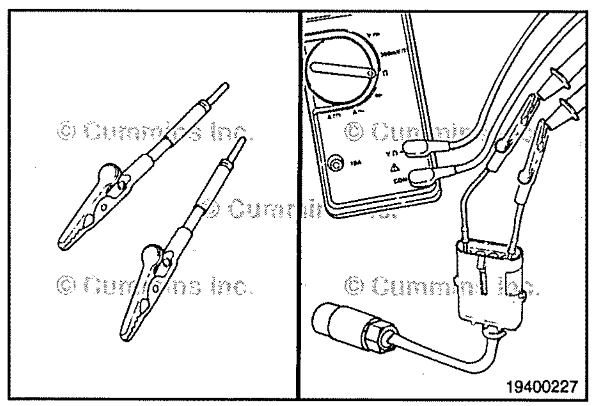
Insert the other test lead to the other coil connector pin, and connect the alligator clip to the other multimeter probe.

NOTE: For internally grounded coils, touch one multimeter lead to the coil terminal and the other multimeter lead to a clean, unpainted surface on the engine block.

Read the measured resistance on the multimeter display.

Check the measured resistance against the resistance specification for the coil.

NOTE: The internal resistance of the multimeter is significant in some coil resistance checks.



19400227

Resistance Measurement Using a Multimeter (019-360)

General Information

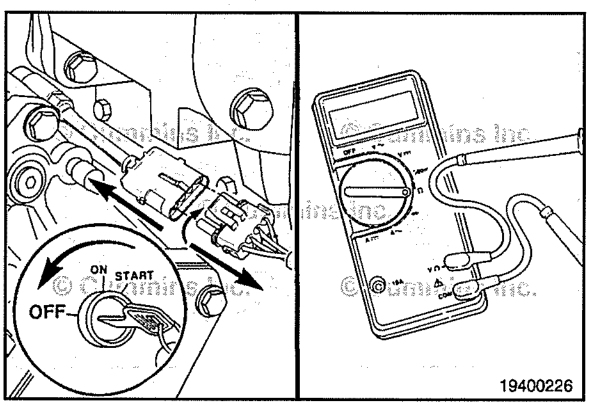
Use this procedure **only** if the harness or connector can be repaired.

After performing any of the checks below, and it is necessary to repair or replace a harness or connector, refer to the table of contents in section 19 for the appropriate repair or replacement procedure.

Fault code troubleshooting trees will refer to this procedure when it is necessary to measure resistance on a harness, connector, or component that the fault code applies to. Each fault code troubleshooting tree will troubleshoot a particular component and the associated circuitry such as a pressure sensor, wiring harness and connectors that connect the sensor to the electronic control unit.

When troubleshooting to determine if a short or open exists in a particular circuit, all of the associated connectors, pins, circuit names and connections that apply to this component can be viewed on the applicable wiring diagram.

Use the following procedures to determine how to make the necessary resistance checks on components, connectors and circuits that apply to the fault code that referred you to this procedure.



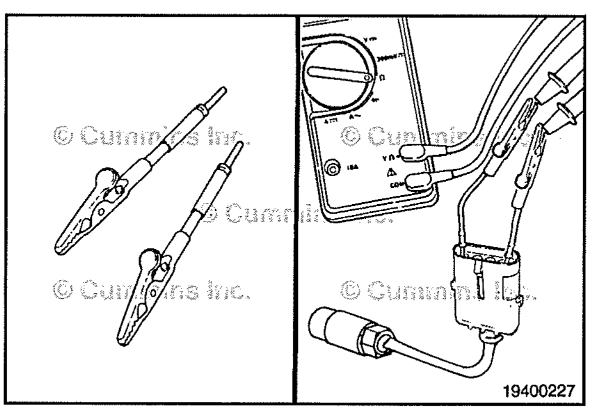
Resistance Check

Turn the key switch off.

Disconnect the appropriate connector from the component.

Adjust the multimeter to measure resistance.

Use the wiring diagram to determine the pins that apply to the component you are measuring.



⚠CAUTION⚠

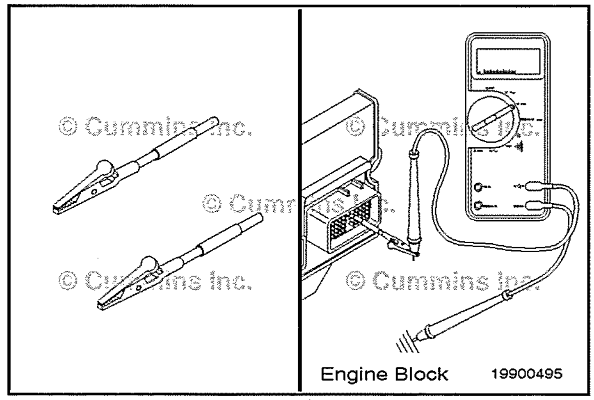
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit.

Connect the appropriate connector test leads to the connector pins and connect the alligator clips to the multimeter probe. Measure the resistance.

Compare this value to the applicable fault code specification or applicable Electrical or Sensor Specification on the wiring diagram. If the value is not correct, the component is malfunctioning. Refer to the applicable fault code procedure for instructions.

Continuity Check

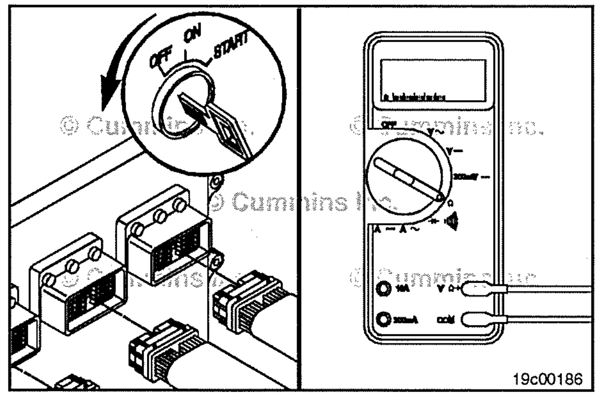
Continuity is an electrical connection between two pins that is less than a certain value. For harness wires, the specification is less than 10 ohms.



Turn the key switch to the OFF position.

Disconnect the harness connectors that are to be tested.

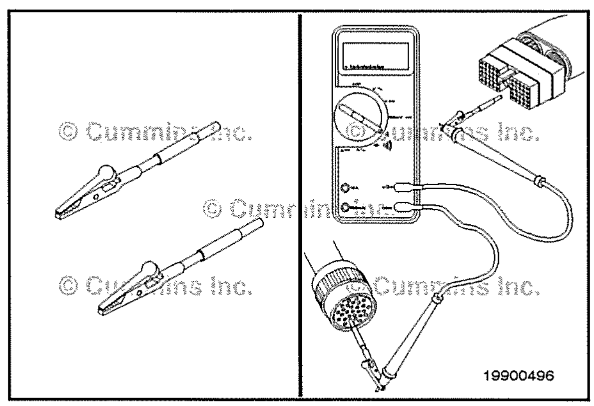
Adjust the multimeter to measure resistance.



⚠CAUTION⚠

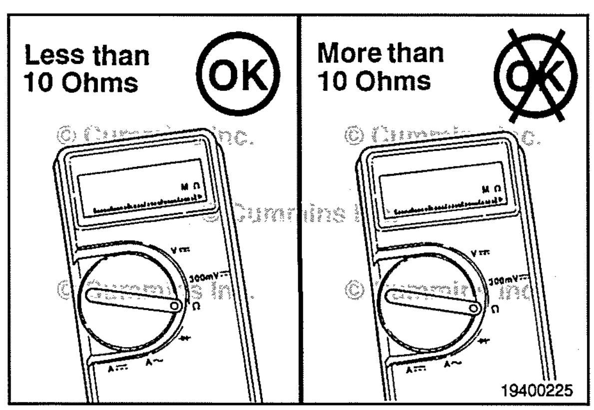
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit.

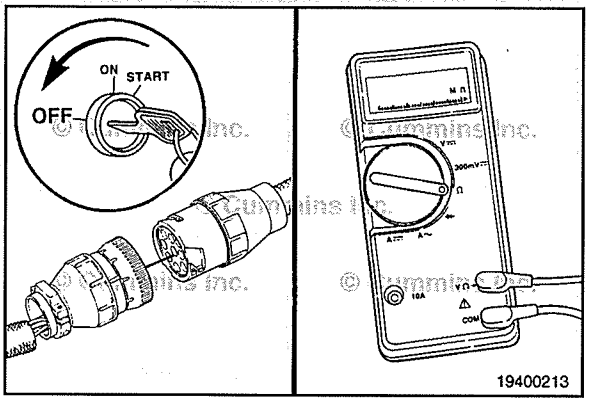
Connect the appropriate connector test leads to the connector pins and connect the alligator clips to the multimeter probe. Measure the resistance.



The multimeter **must** display less than 10 ohms for wire continuity. If the multimeter displays greater than 10 ohms, the wire **must** be repaired or the harness replaced.

Refer to the applicable fault code procedure for instructions.





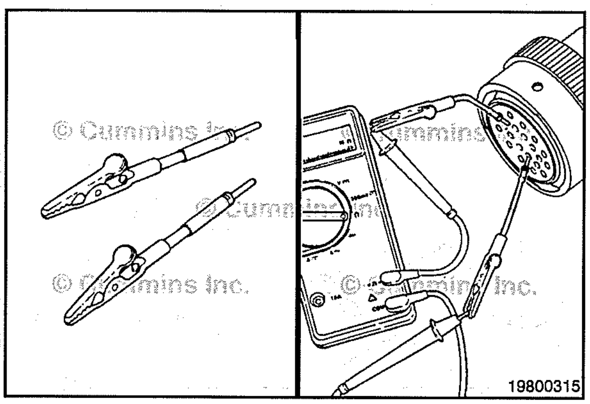
Check for Short Circuit from Pin to Pin

Short circuit from pin to pin check is a condition in which an electrical connection exists between two pins where it is **not** intended to exist.

Turn the key switch to the OFF position.

Disconnect the harness connectors that are to be tested.

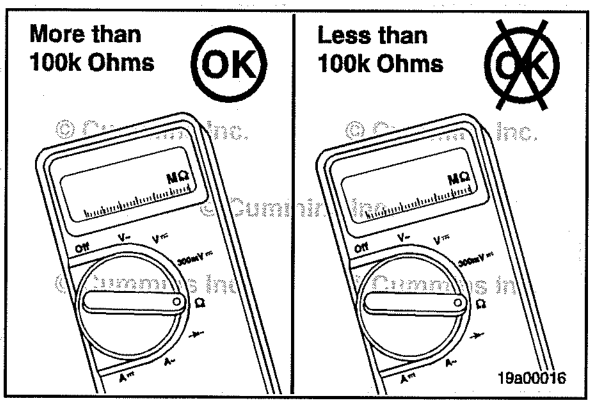
Adjust the multimeter to measure resistance.



⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit.

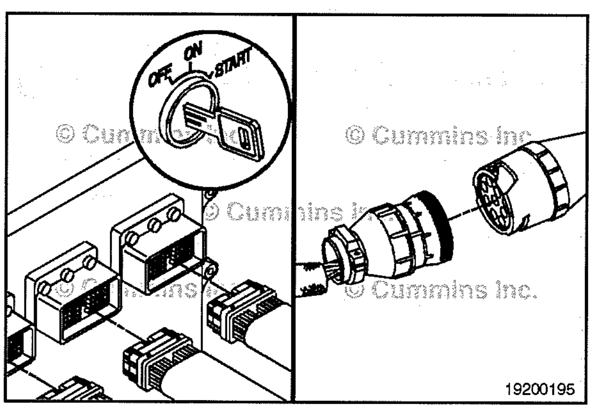
Connect the appropriate connector test leads to the connector pins and connect the alligator clips to the multimeter probes. Measure the resistance.



The multimeter **must** read greater than 100k ohms, which is an open circuit. If the circuit is **not** open, the pins being checked are electrically connected. Refer to the wiring diagram to verify that the wires are intended to be connected.

Inspect the harness connectors for moisture that can cause an inappropriate electrical connection.Refer to Procedure procedure 019-361.

Refer to the applicable fault code procedure for instructions.



Check for Short Circuit to Ground

Short circuit to ground is a condition where a connection from a circuit to ground exists when it is not intended.

Turn the key switch to the OFF position.

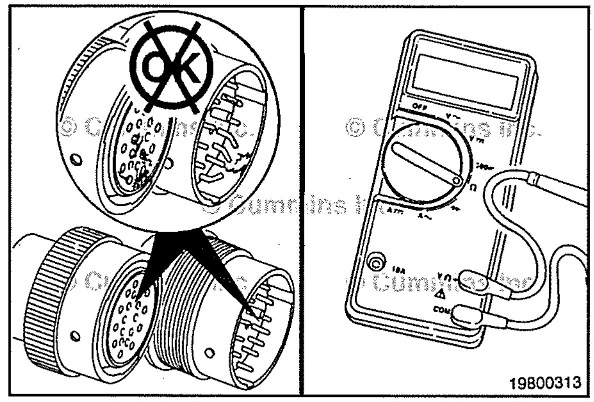
Disconnect the harness connectors that are to be tested.

When testing a sensor, **only** the sensor connection is required to be disconnected.

When testing a harness, the harness connector at the electronic control unit and the connector at the sensor or multiple sensors **must** be disconnected.

Identify the pins that need to be tested.

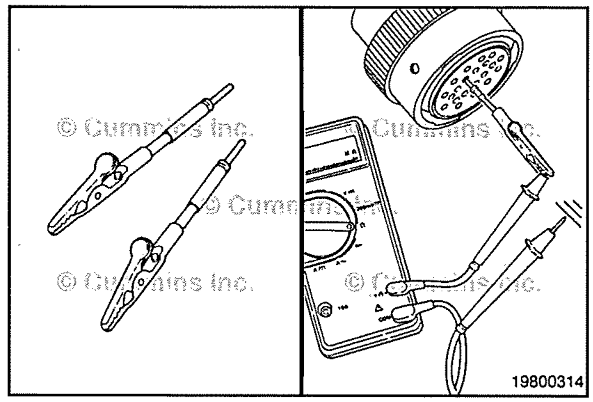
Inspect the connector pins.Refer to Procedure procedure 019-361.



⚠CAUTION⚠
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit.

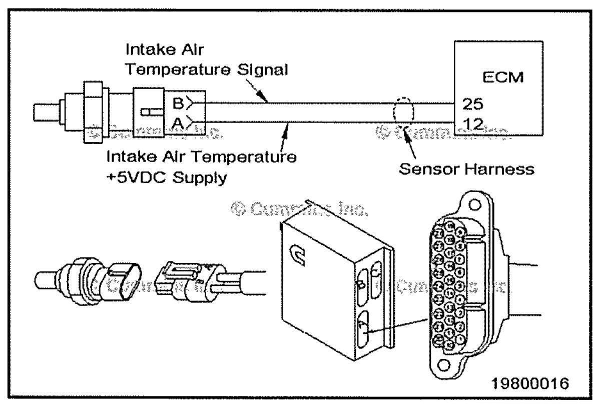
Connect the appropriate connector test lead to a connector pin and connect the alligator clip to the multimeter probe.

Touch the other multimeter probe to a clean, unpainted surface on the engine block or chassis ground. Measure the resistance.



The multimeter **must** read greater than 100k ohms, which indicates an open circuit. If the circuit is **not** open, the wire being checked has a short circuit to ground, the engine block or chassis ground.

Refer to the applicable fault code procedure for instructions.

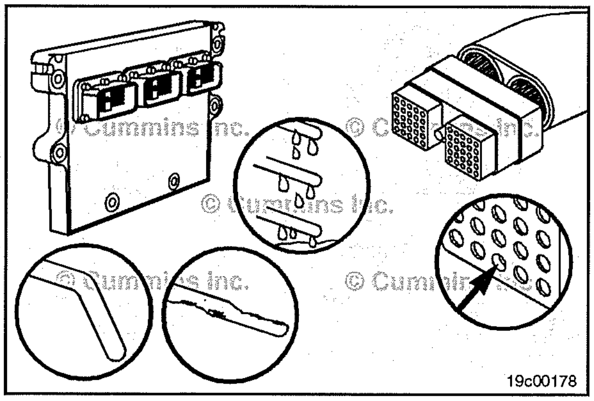


Component Connector and Pin Inspection (019-361)

General Information

The following inspection procedures should be used for any component, connector, or harness connector to ensure there is no pin damage.

To troubleshoot electrical circuit faults that are intermittent and are currently inactive. Refer to Procedure 019-362 in Section 19.



Inspect for Reuse

When disconnecting connectors during troubleshooting, **always** check for loose connectors (gently pull the wires at the back of the connector) and inspect the pins to make sure they are **not** the cause of a bad connection. The things to look for are bent, corroded, and pushed back pins.

Moisture in Connector

Moisture in a connector can also cause system performance issues. Many times it is difficult to see moisture in a connector. If moisture is suspected, the connector **must** be dried by applying contact cleaner, Part Number 3824510, to the connector. A heat gun can also be used on a low heat setting so that it will **not** damage the connector or wires.

NOTE: Do **not** blow compressed air in the electronic control unit ports or connector. Compressed air can contain moisture due to condensation.

Bent or Expanded Pins

Inspect the male terminals of the connector. If any of the terminals are bent, so that they will **not** easily mate with the other side of the connector, or if the male terminals are expanded, that is, bulged out or squashed so as to make them too large to mate with the other side of the connector, then the pin **must** be replaced. See the repair section for the specific connector in question.

Corroded Pins

Inspect both the male and female terminals for corrosion, which can cause a poor electrical connection within the connector. If any corrosion is evident on the pins, then the corroded pins **must** be replaced. See the repair section for the specific connector in question.

Pushed Back Pins

Inspect both the male and female terminals for pins that can **not** be making contact because they are pushed back in the connector. To repair, push the pin into the connector body from the back of the connector. Make sure the terminal locks into place. If the terminal will **not** lock into place, then replace it. See the repair section for the specific connector in question.

Drag Test

Use the correct mating terminal from the test lead kit 4919115, manually insert the new lead into each terminal in the connector. As you slide the terminal in and out, it should fit securely and you should feel a significant amount of drag. If **not**, the terminal **must** be replaced. See the repair section for the specific connector in question.

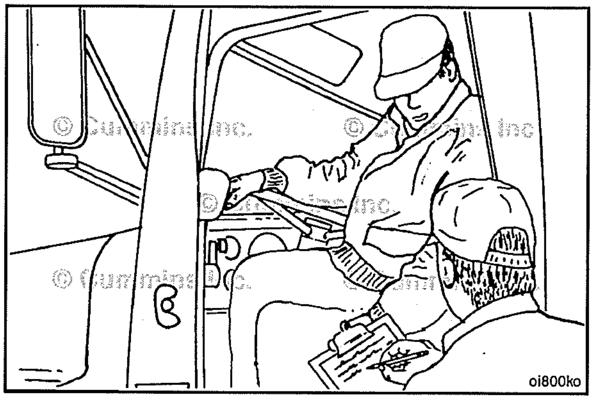
Inactive or Intermittent Fault Code (019-362)

General Information

This procedure is designed to troubleshoot electrical circuit faults that are intermittent and are currently inactive. This procedure can also be used to troubleshoot high inactive counts of circuit related fault codes.

If multiple fault codes are present, use a wiring diagram to check for common sensor supplies and ground circuits that may be shared between sensors, actuators, and switches. Pressure sensors may share a common 5 volt supply and ground circuit. Temperature sensors and actuators may share a common ground circuit. If either a sensor supply or a ground circuit has an intermittent connection, fault codes related to all the sensors may be active or have high counts of inactive fault codes.

If the conditions for a fault code to trigger exist and then the conditions are no longer present, an inactive fault code is created. When conditions are intermittent, there may be multiple inactive counts for a given fault code. If there are more than 10 inactive counts, the fault code should be troubleshot as an active fault code. Troubleshooting priority should be given to fault codes that are associated engine performance components such as the turbocharger, EGR valve, or any system related fault code.



Initial Check

Interview the operator and determine the engine operating conditions when the fault occurs and what symptoms occur when the fault is active.

Determine if there have been any recent service repairs or maintenance performed that may be related to the intermittent condition.

Review the “Shop Talk” section of the fault code troubleshooting tree. Shop Talk will give additional troubleshooting information and will list possible causes for the fault code.

Verify the electronic control module (ECM) calibration is correct. Check the calibration revision history found on QuickServe® Online for applicable fixes to the calibration stored in the ECM. If necessary, recalibrate the ECM. 019-032 (ECM Calibration Code) in Section 19 in the corresponding Troubleshooting and Repair Manual for the engine being serviced.

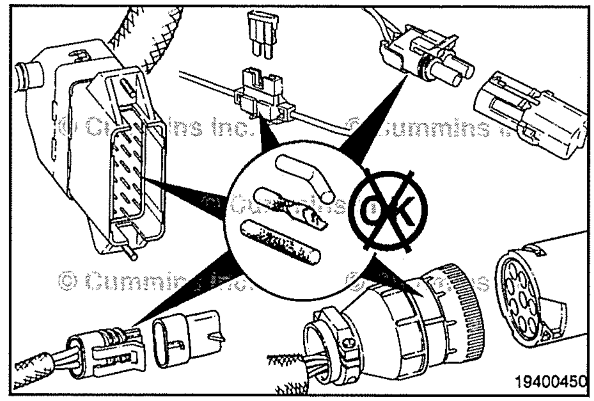
Disconnect the sensor or actuator related to the intermittent condition.

Inspect the wiring harness and connector for the following:

- Loose connector (gently pull the wires at the back of the connectors)
- Corroded pins
- Bent or broken pins
- Pushed back or expanded pins
- Moisture in or on the connectors
- Dirt or debris in, or on, the connector pins
- Missing or damaged connector seals
- Wire insulation damage
- Connector shell broken
- Damaged locking tab connector
- Pin wear (close visual inspection)
- Rusty, painted, corroded, or loose grounds.

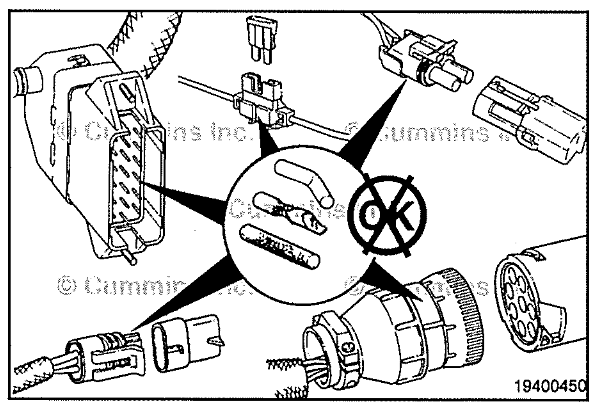
Thoroughly inspect the wiring harness between the suspected component and ECM connection. Check for the proper strain relief on the wiring harness.

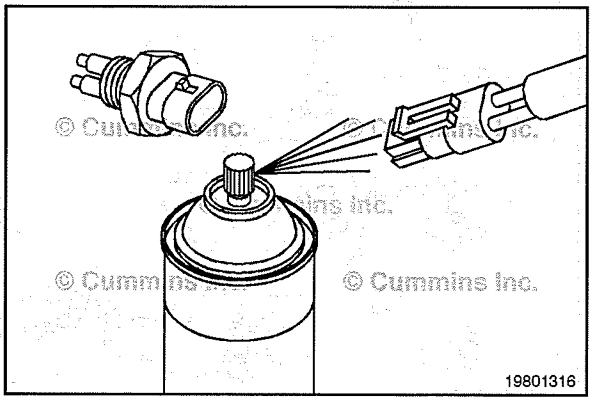
A dark powder found inside the connector may be a sign of pin fretting. Clean the pin contacts and reconnect the connector.



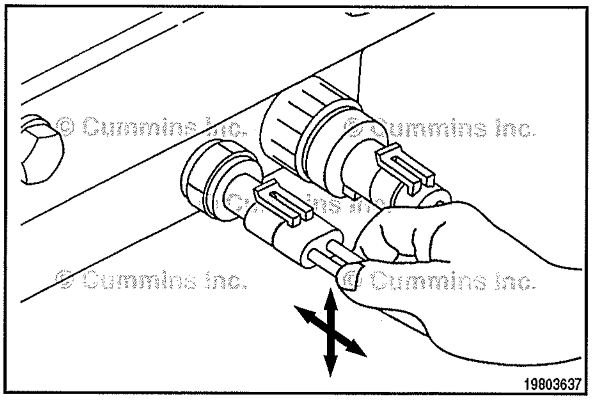
Disconnect the wiring harness connector from the ECM. Inspect the ECM connector for the following:

- Loose connector (gently pull the wires at the back of the connectors)
- Corroded pins
- Bent or broken pins
- Pushed back or expanded pins
- Moisture in or on the connectors
- Dirt or debris in, or on, the connector pins
- Missing or damaged connector seals
- Wire insulation damage
- Connector shell broken
- Damaged locking tab connector
- Pin wear (close visual inspection)
- Rusty, painted, corroded, or loose grounds.





Clean connector(s) of suspect components and clear the fault code.



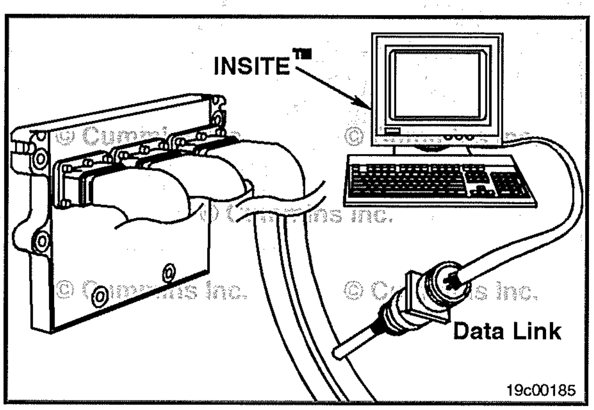
Harness Shake Test

Connect INSITE™ and open the Data Monitor/Logger feature. Monitor the sensor signal voltage for the appropriate sensor. Also monitor the actual value of the sensor or component.

Beginning at the component in question and working back through the harness to the ECM, gently twist, bend and pull at each connection and in between connections in the harness.

While performing the Harness Shake Test, the sensor signal voltage that INSITE™ displays should remain between steady. A typical reading should be between 0.5 and 5.12 volts.

NOTE: This procedure can also be used to check for loose or damaged wires for switches. Switch status can be monitored with INSITE™. Look for switch changes when performing the Harness Shake Test.



If the fault code goes active, if inactive counts increase, the sensor signal voltage fluctuates, or the switch status changes, there is a loose connection or damaged wire at that specific location. Refer to Procedure 019-361, Component Connector and Pin Inspection, and inspect the pins at the connectors in question. Repair or replace as necessary.

NOTE: The ECM will **not** change the status of switches and faults instantaneously. Approximately 10 to 15 seconds should be used to gently twist the harness and see a reading change from the ECM. Trying to monitor too many parameters at one time with INSITE™ will slow down the update rate on the screen. Keep the number of parameters monitored with INSITE™ to minimum to increase the update rate.

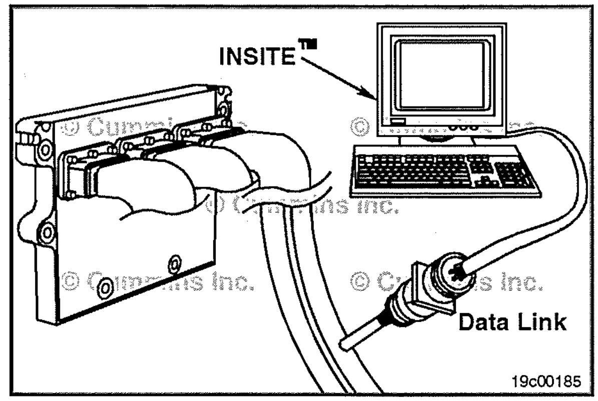
Start the engine.

With the engine running, connect to INSITE™ and open up the Data Monitor/Logger feature. Monitor the sensor signal voltage for the appropriate sensor. Also monitor the actual value of the sensor or component.

While performing the Harness Shake Test, the sensor signal voltage that INSITE™ displays should remain between steady. A typical reading should be between 0.5 and 5.12 volts.

Now gently bend, twist, and pull the connections and in between connections in the harness while monitoring the sensor signal voltage.

If the sensor signal voltage fluctuates during the test, then there is a loose connection or damaged wire at that specific location. Inspect the pins at the connectors in question.

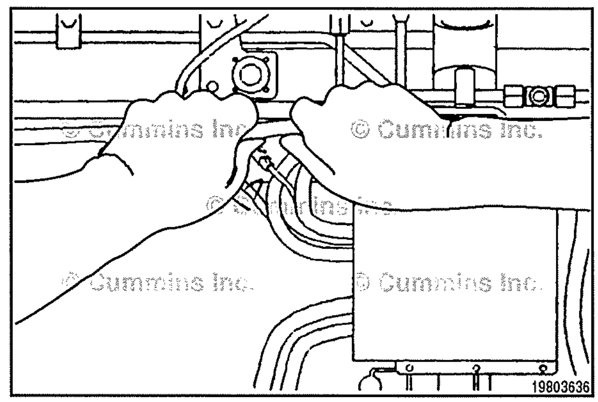


Ground Circuit Check

Check for poor battery and chassis grounds. Firmly pull on ground wires or cables checking for loose connections. Check the following grounds making sure they are secure, clean, and on a non-painted surface:

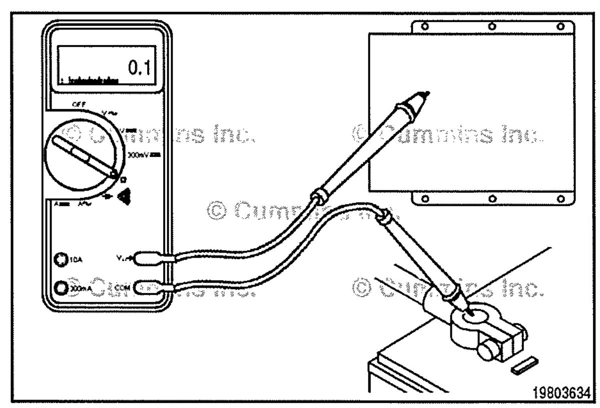
- engine block grounds
- chassis (or frame rail) grounds
- ECM grounds
- alternator and starter negative posts

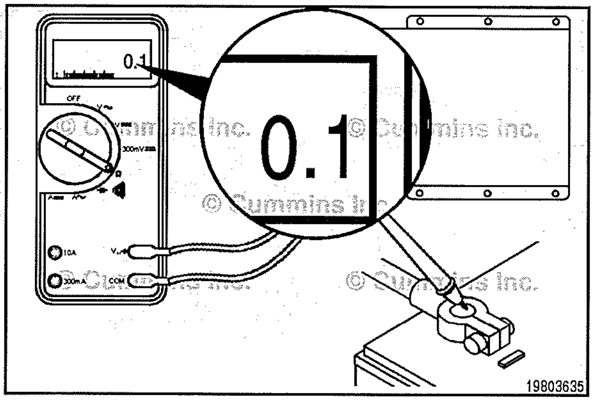
While performing this step, check to see if the fault code goes active, or if inactive counts increase. If this happens, there is a loose connection or damaged wire at that location. Disconnect, clean grounding cables and grounding surfaces, then reconnect. Repair or replace grounding cables or wires if necessary.



Measure resistance from the battery negative (-) post to:

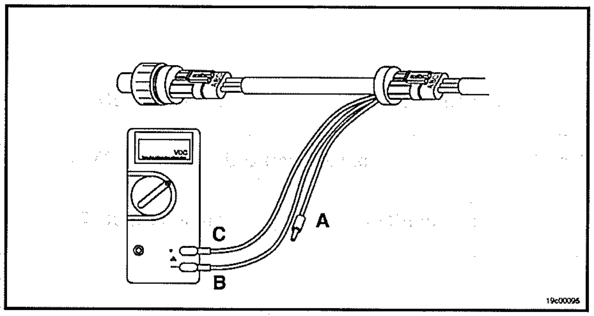
- ECM casing (clean, non-painted surface)
- Engine Block (clean, non-painted surface)
- Starter (-) post
- Alternator (-) post
- Firewall grounding post
- Cab ground (dash switches, common ground)
- Vehicle frame rail.





All resistance values should measure less than 1 ohm. If resistance values exceed 1 ohm, clean grounding cables and grounding surfaces, then reconnect. Repair or replace grounding cables or wires if necessary.

NOTE: Refer to Procedure 019-359, "General Multimeter Usage", for the correct use of a multimeter.



Voltage Check

This test **must** be performed with the actuator connected to the wiring harness.

With the sensor or actuator disconnected from the wiring harness, measure the voltage at the engine harness connector of the component.

Connect the sensor or actuator to the wiring harness and measure the voltage with all the components connected. Use a breakout cable or back-probe the connector with the multimeter leads when performing this check.

The voltage to the component should be within 0.5 volts of the original voltage measured. If the voltage drops more than 0.5 volts, check for intermittent connections, cut wires, or corroded relay connections between the actuator and the ECM.

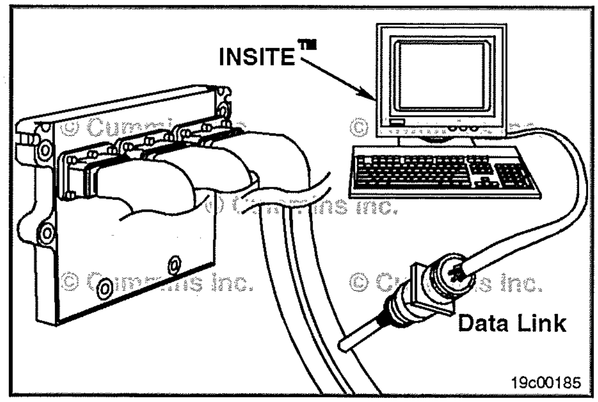
Sensor Accuracy Check

When a sensor circuit is shorted high or shorted low, the sensor value will be locked to a default value when the fault code is active. The default value will usually be set to a value that is within the standard operating range of the sensor. When monitoring the sensor values with a service tool it will appear as if the sensor is reading a correct value even when the fault code is active. Some typical global default sensor values are as follows:

- Engine Coolant Temperature = 104.4°C [219.9°F]
- Intake Manifold Temperature = 21.3°C [70.3°F]
- Intake Manifold Pressure = 2.4 kpa [0.7 inHg]
- EGR Temperature = 37.8°C [100°F]
- Engine Oil Pressure = 73.1 kPa [10.6 psi]

Be aware when troubleshooting intermittent circuit fault codes that the value displayed with a service tool could be a default sensor reading. Always use the sensor signal voltage measurement when troubleshooting intermittent circuit fault codes.

If further investigation is necessary, use the Data Monitor/ Logger feature in INSITE™ to monitor the inputs and outputs of a running engine and to capture data to a log file. The Logger feature in INSITE™ will allow for information to be captured during the intermittent event and can reviewed at a later time.



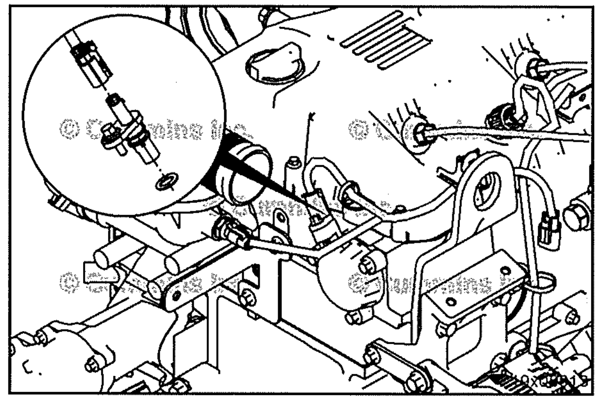
Camshaft Position Sensor (019-363)

Remove

The camshaft position sensor is located on the front of the cylinder head in the timing speed ring cover.

Disconnect the sensor from the engine harness.

Remove the camshaft speed sensor from the timing speed ring cover.

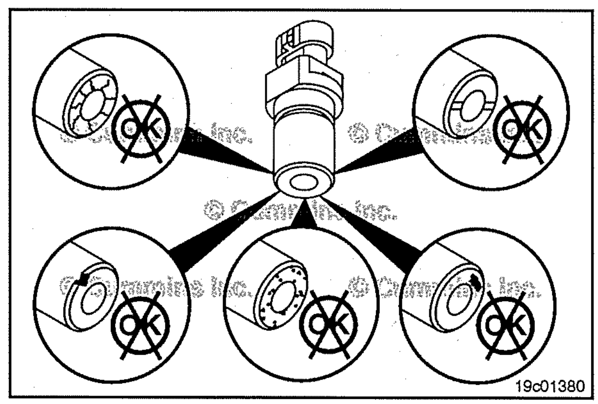


Inspect for Reuse

Inspect the camshaft position sensor for debris, cracks, or other damage from contact with the tone wheel.

If there is debris on the camshaft position sensor, clean the sensor.

If the sensor is chipped, cracked, extruded, or otherwise damaged, the sensor **must** be replaced.



Install

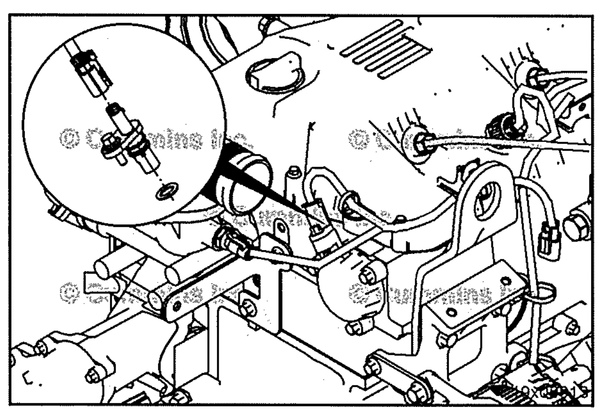
Make sure the o-ring is installed on the camshaft position sensor.

Install the sensor into the timing speed ring cover.

Connect the sensor to the engine harness. Push the connectors together until they lock.

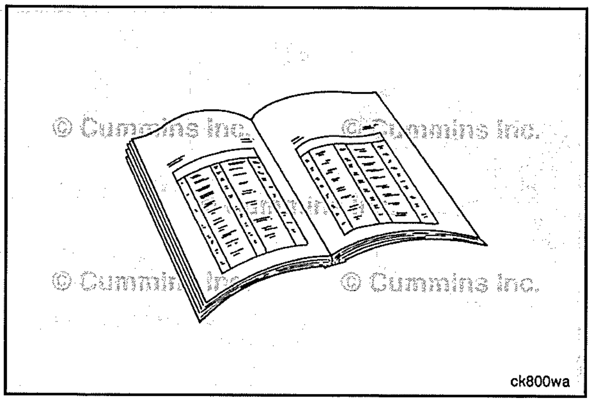
An audible click will be heard as the connectors lock in place.

Torque Value: 7.4 N•m [65 in-lb]



Crankshaft Position Sensor (019-365)

Preparatory Steps

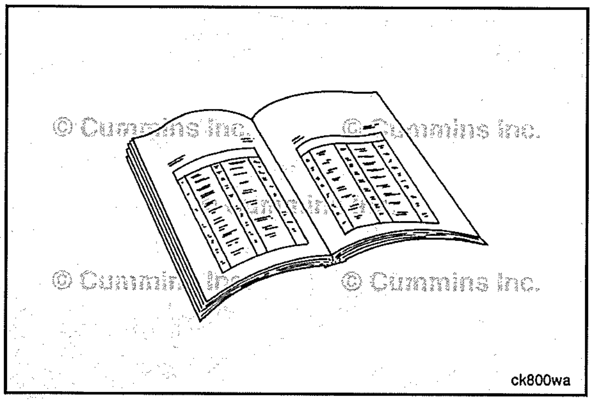


WARNING

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

- Disconnect the batteries. See equipment manufacturer service information.

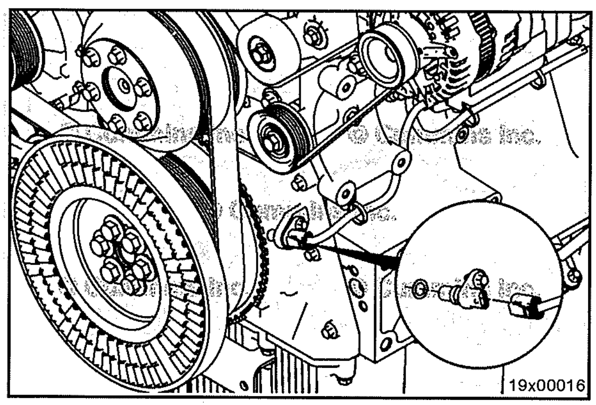
Measure



Measure the crankshaft position sensor air gap. Refer to Procedure 001-071 in Section 1.

If the air gap is **not** within specification, the crankshaft position sensor **must** be replaced.

Remove



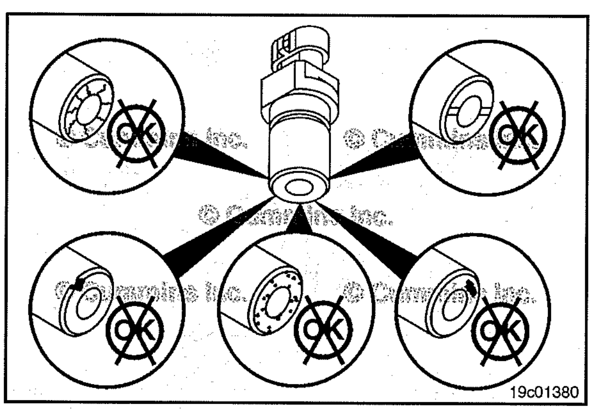
The crankshaft position sensor is located behind the vibration damper on the front of the engine.

Disconnect the sensor from the engine harness. Slide the locking tab to unlock the connector. Push down on the button toward the rear of the connector and disconnect it from the sensor.

Remove the capscrew that secures the sensor to the lubricating oil pump housing.

Remove the sensor from the mounting location.

Inspect for Reuse

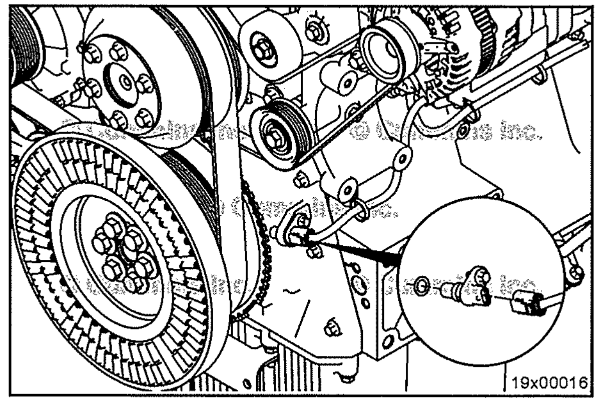


Inspect the engine speed sensor for debris or cracks.

If there is debris on the sensor, clean the sensor.

If the sensor is chipped, cracked, extruded, or otherwise damaged, the sensor **must** be replaced.

Install



Make sure the o-ring is installed on the sensor.

Apply clean engine oil to the o-ring.

Install the sensor into the mounting hole.

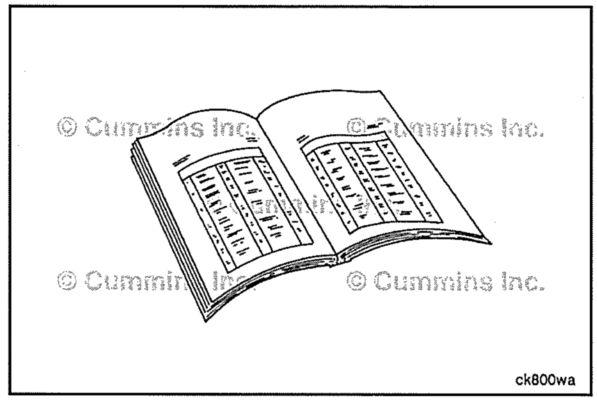
Install and tighten the capscrew.

Torque Value: 7.4 N•m [65 in-lb]

Connect the sensor to the engine harness.

Slide the lock tab to lock the connector to the sensor.

Finishing Steps



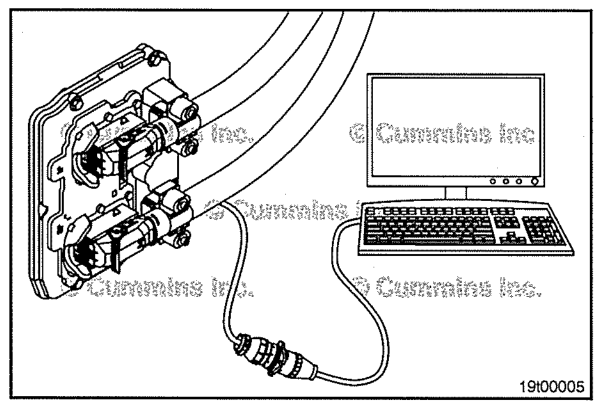
⚠WARNING⚠

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

- Connect the batteries. See equipment manufacturer service information.

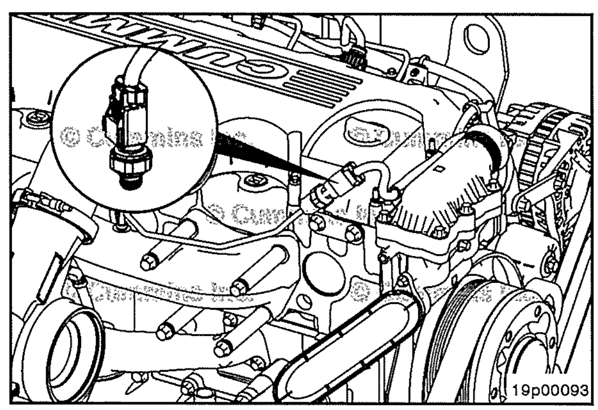
Exhaust Gas Pressure Sensor (019-376)

Initial Check

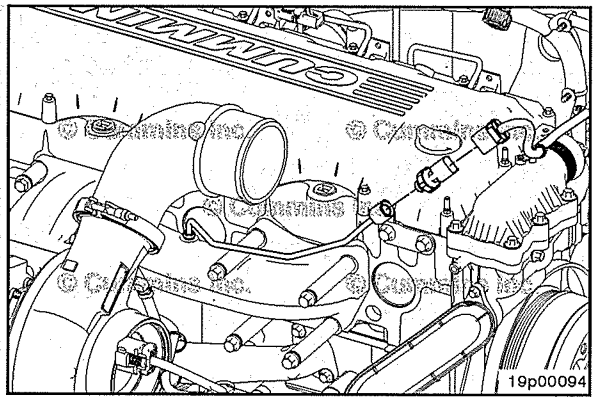


Connect INSITE™ electronic service tool and verify that the exhaust pressure sensor reading with INSITE™ electronic service tool is the same as with the gauge.

Remove

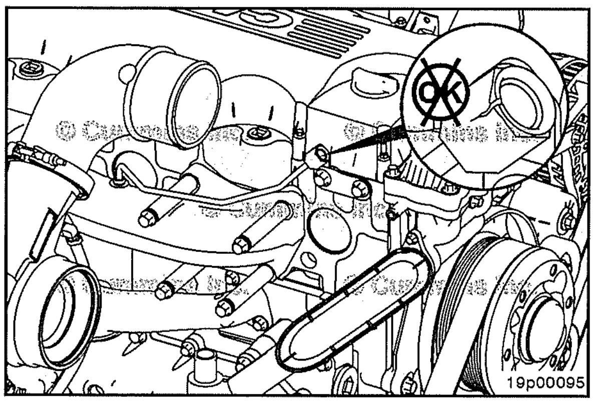


The exhaust gas pressure sensor is located near the thermostat housing.



Disconnect the wiring harness connector.

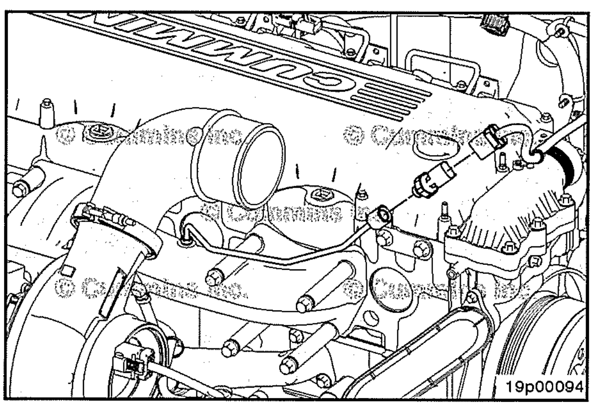
Remove the sensor.



Inspect for Reuse

Inspect the sensor adapter for cracks or fretting.

Replace the adapter if any damage is found.



Install

NOTE: Make sure the sealing washer is captured on the threaded portion of the sensor.

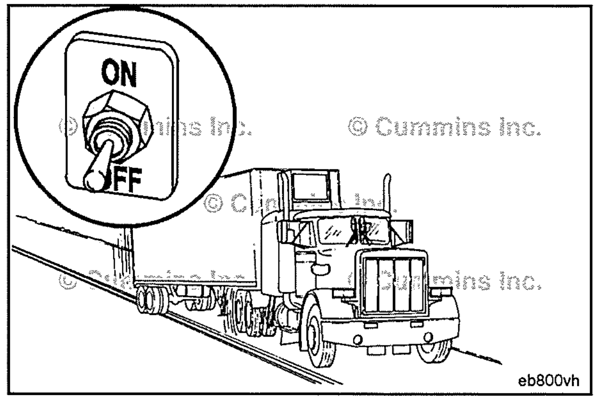
Install the sensor and tighten.

Torque Value: 14 N•m [124 in-lb]

Connect the wiring harness to the sensor. An audible click will be heard as the connector locks in place.

Fan Control Switch (019-380)

General Information

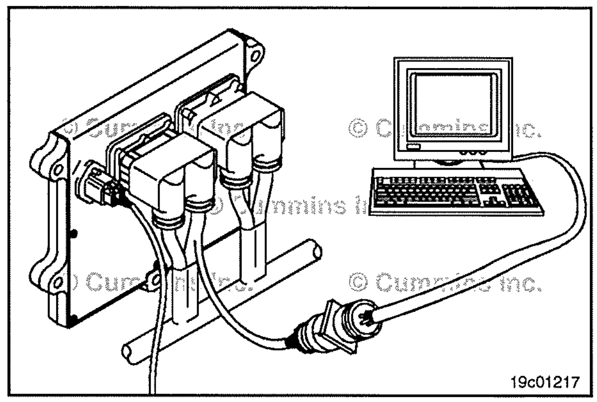


eb800vh

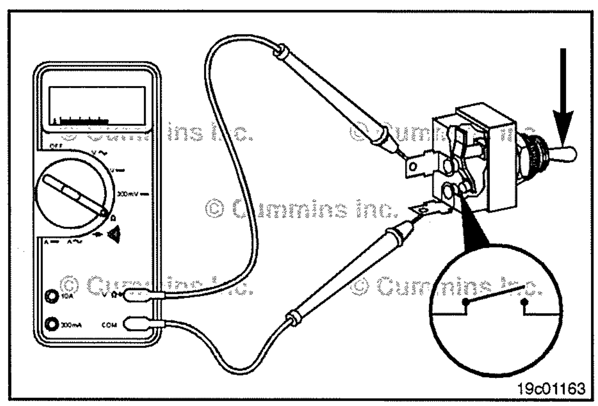
The fan control switch circuit signals the system that the operator is requesting the engine fan to be engaged. The fan on and off circuit consists of the fan control switch signal, the switch return, and the OEM cab-mounted toggle switch. This circuit is considered “fail safe”, meaning when the circuit is open, the engine fan will be engaged by the ECM.

NOTE: This procedure is **only** valid if the fan control switch is wired through the ECM and the feature manual fan switch is enabled in the ECM. If the fan control switch is wired in series with the fan control relay, the ECM could log fan circuit errors during normal operation. Please verify the circuit is wired properly before performing this procedure.

Resistance Check

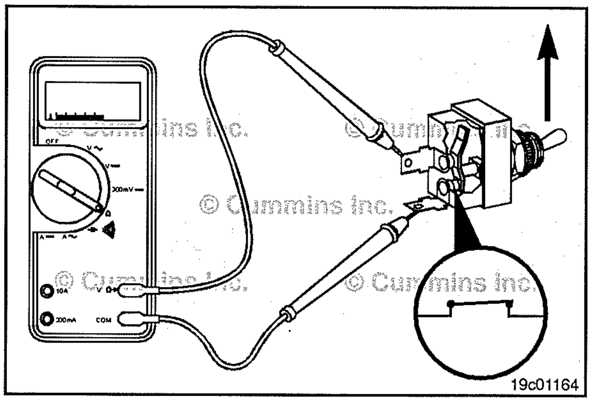

19c01217

If an electronic service tool is available, monitor the fan control switch for proper operation. If **not** operating properly, follow the troubleshooting procedures in this section.

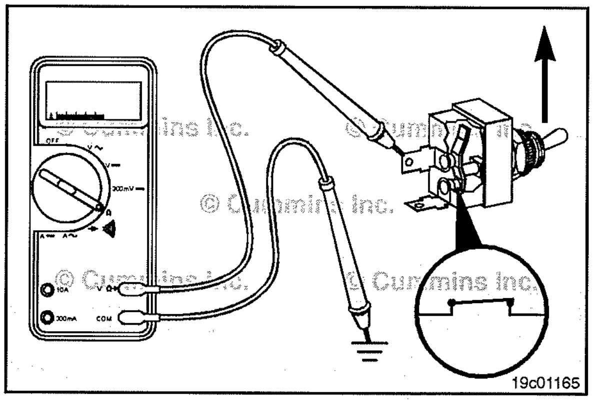

19c01163

Locate the fan control switch. Label the wires with the location of the switch or the wire number. Remove the electrical connectors from the switch. Adjust the multimeter to measure resistance. Touch one multimeter probe to one of the terminals on the switch. Touch the other multimeter probe to the other terminal of the switch.

Move the switch to the ON position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.

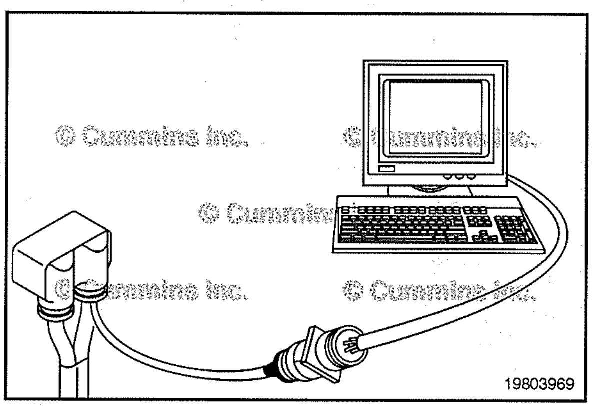


Place the switch in the OFF position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.



Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the OFF position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.



Fan Control Switch Circuit (019-381)

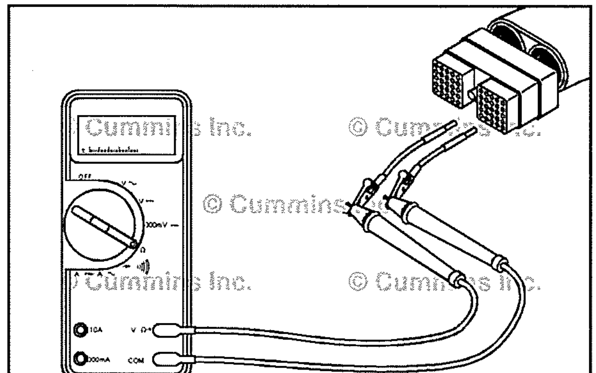
Resistance Check

⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If electronic service tool is available, monitor the fan control switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Insert one of the test leads into the switch return pin of the OEM harness connector and connect the alligator clip to the multimeter probe. Insert the other lead into the fan control switch signal pin of the OEM harness connector and connect the alligator clip to the other multimeter probe.

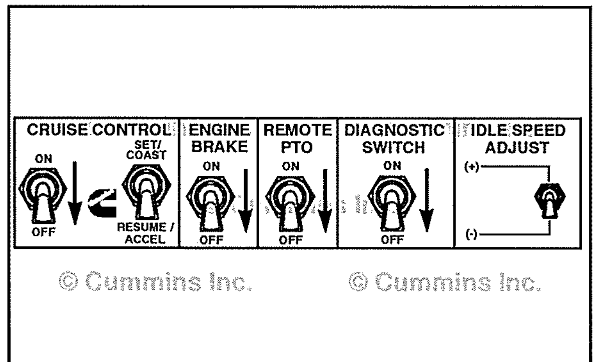


19c01194

Move the fan control switch to the OFF position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the fan control switch, switch return wire, and the fan control switch signal wire for an open circuit, provided that the switch has been previously checked. Refer to the OEM troubleshooting and repair manual for repair procedures. If the resistance is within the specification, the fan control switch, switch return (-) wire, and the fan control signal wire **must** be checked for a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.

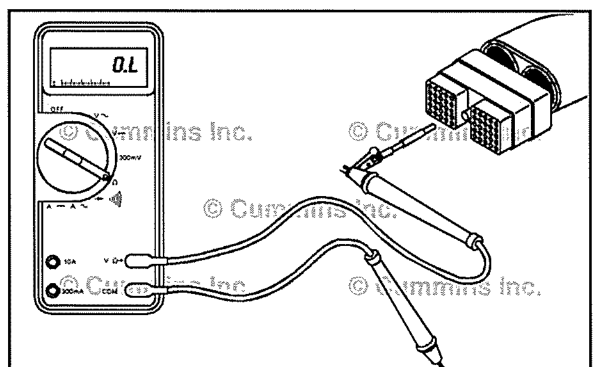
Check for Short Circuit to Ground

To isolate the fan control switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM and fan control switch. Disconnect the clutch position switch/engine protection override switch and the accelerator pedal assembly. Set all cab panel switches to the OFF or neutral position. Set the service brake using the trailer brake hand valve.



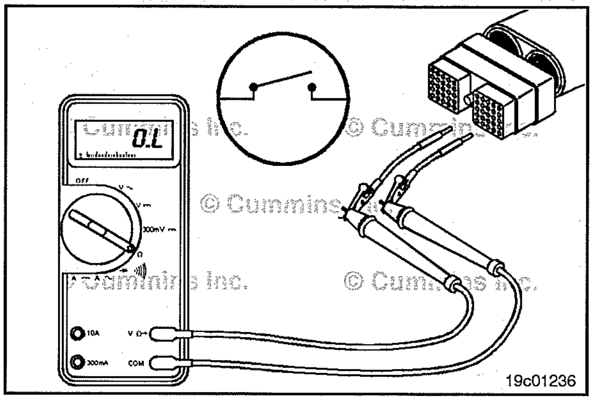
19200292

Adjust the multimeter to measure resistance. Insert a test lead into the fan control switch signal pin of the OEM harness connector and connect it to a multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the resistance.



19c01241

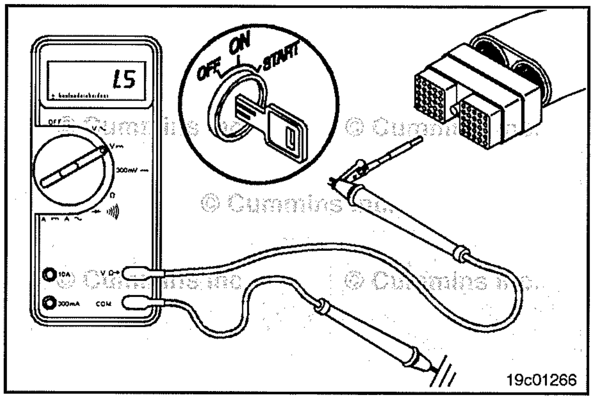
The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the fan switch control circuit, provided that the switch has been previously checked. Repair or replace the wire connected to the fan control switch signal in the OEM harness according to the vehicle manufacturer's procedure.



Check for Short Circuit from Pin to Pin

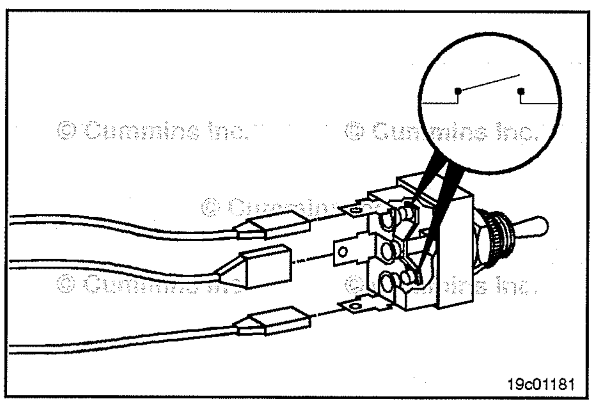
Isolate the fan control switch circuit by setting the switches as in the previous section. Set the fan control switch to the ON position. Insert the lead into the fan control switch signal pin. Connect the alligator clip to the multimeter. With the other lead inserted into the switch return pin, measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the fan control switch signal pin and check all other pins. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit between the fan control switch circuit and any pin that shows a closed circuit, provided the switch has previously been checked. Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to External Voltage Source

Turn the keyswitch to the ON position. Set the fan control switch to OFF. Adjust the multimeter to measure VDC. Insert a test lead into the fan control switch signal pin and attach it to a multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the voltage. The voltage **must** be 1.5 VDC or less.



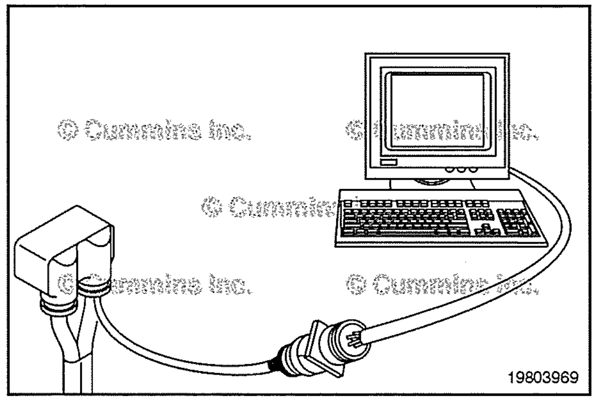
If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the fan control switch circuit and a wire carrying power in the OEM harness. Remove the voltage source or repair the wiring in the OEM harness according to the vehicle manufacturer's procedures.

Connect all components after completing the repair.

NOTE: If the fan control switch circuit was approved in all of the previous tests, it is functioning correctly.

Maximum Engine Speed Switch Circuit (019-383)

Resistance Check

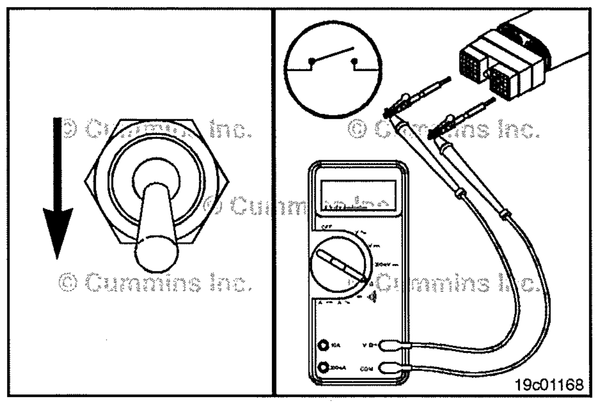


CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If electronic service tool is available, monitor the maximum engine speed switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.

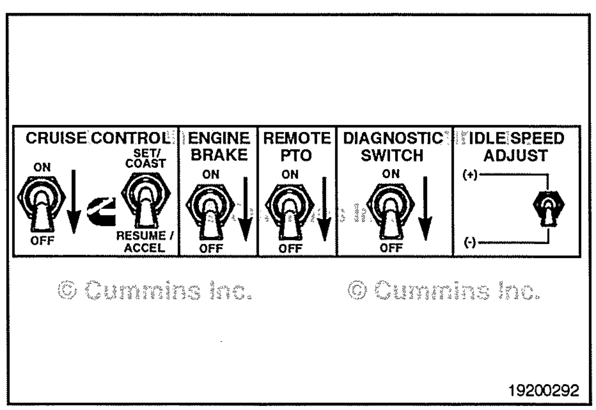
Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Insert one of the test leads into the switch return pin of the OEM harness connector and connect the alligator clip to the multimeter probe. Insert the other lead into the maximum engine speed switch signal pin of the OEM harness connector and connect the alligator clip to the other multimeter probe.



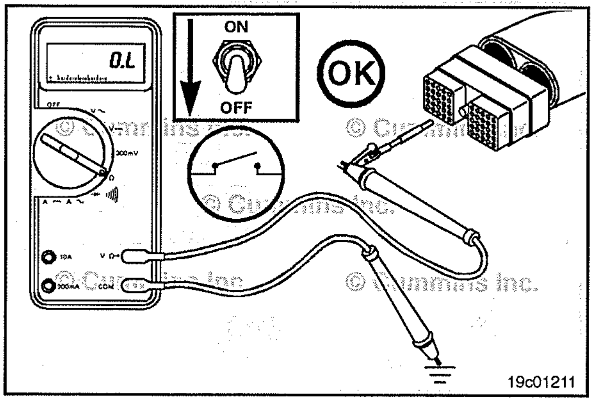
NOTE: The maximum engine speed switch is programmed by the OEM. The open or closed position of the switch can represent "Normal" or "Speed Limit" depending on how the OEM programs the switch. Before continuing to troubleshoot refer to the OEM troubleshooting and repair manual to determine how the switch is programmed and apply the defective switch criteria accordingly when performing the troubleshooting.

Move the maximum engine speed switch to the normal position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the switch return wire and the maximum engine speed switch signal wire for an open circuit, provided that the switch has been previously checked. Refer to the OEM troubleshooting and repair manual for repair procedures. If the resistance is within the specification, the switch return wire and the maximum engine speed switch signal wire **must** be checked for a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.

Check for Short Circuit to Ground



To isolate the maximum engine speed switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM and the OEM harness from the maximum engine speed switch. Disconnect the clutch pedal position switch/engine protection override switch and the accelerator pedal assembly switch. Set all cab panel switches to the OFF or neutral position. Set the service brake using the trailer brake hand valve.

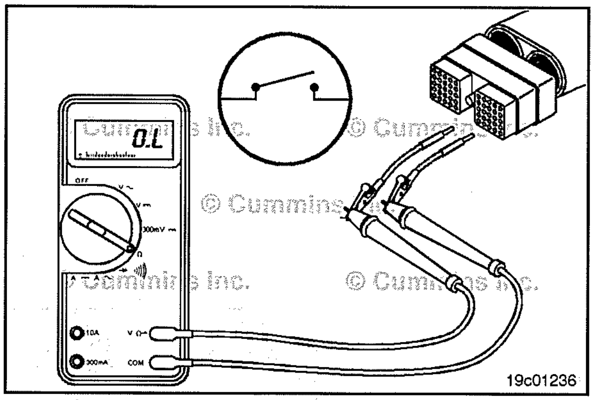


19c01211

Adjust the multimeter to measure resistance. Insert a test lead into the maximum engine speed switch signal pin of the OEM harness connector and connect it to a multimeter probe. Touch the other multimeter probe to the engine block ground.

Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the maximum engine speed switch circuit, provided that the switch has been previously checked.

Repair or replace the wire connected to the maximum engine speed switch signal pin in the OEM harness according to the vehicle manufacturer's procedure.



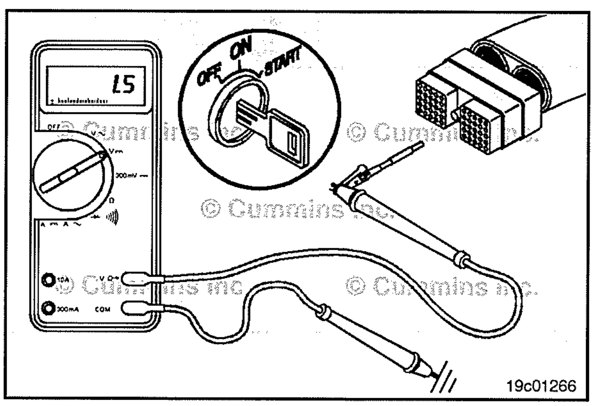
19c01236

Check for Short Circuit from Pin to Pin

Isolate the maximum engine speed switch circuit by setting the switches as in the previous section. Set the maximum engine speed switch to the normal position. Insert the lead into the maximum engine speed switch signal pin. Connect the alligator clip to the multimeter. With the other lead inserted into the switch return pin, measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the maximum engine speed switch signal pin and check all other pins. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit between the manual fan switch circuit and any pin that shows a closed circuit, provided the switch has previously been checked.

Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



19c01266

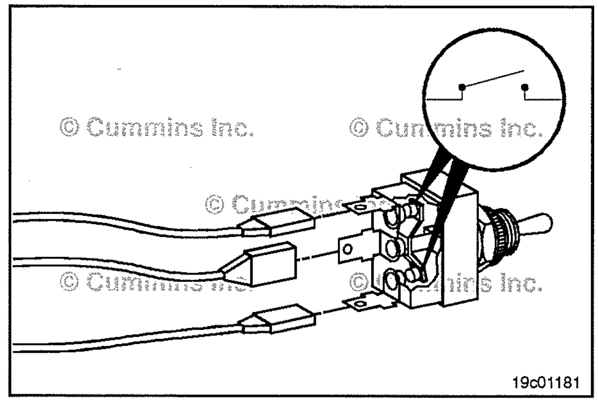
Check for Short Circuit to External Voltage Source

Turn the keyswitch to the ON position. Set the maximum engine speed switch to the normal position. Adjust the multimeter to measure VDC. Insert a test lead into the maximum engine speed switch signal pin and attach it to a multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the voltage. The voltage **must** be 1.5 VDC or less.

If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the maximum engine speed switch circuit and a wire carrying power in the OEM harness.

Remove the voltage source or repair the wiring in the OEM harness according to the OEM troubleshooting and repair manual. Connect all components after completing the repair.

NOTE: If the maximum engine speed switch circuit was approved in all of the previous tests, it is functioning correctly.



19c01181

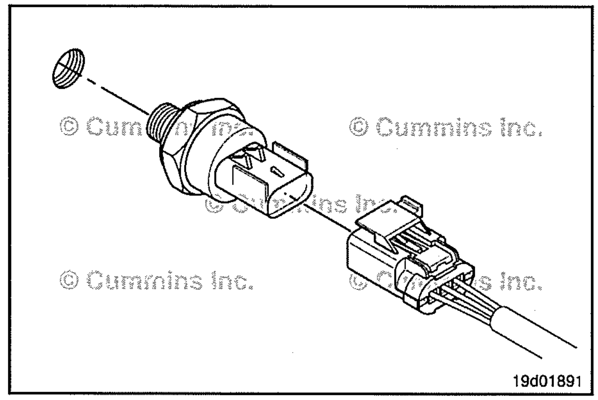
OEM Pressure Sensor (019-400)

General Information

Some original equipment manufacturers (OEMs) can choose to install an additional pressure sensor.

The OEM pressure sensor monitors an OEM-defined pressure and passes that information on to the electronic control module (ECM) through the OEM harness. The ECM uses this information to determine the state of an OEM switched output device.

Refer to the OEM troubleshooting and repair manual for the location of the OEM pressure sensor.

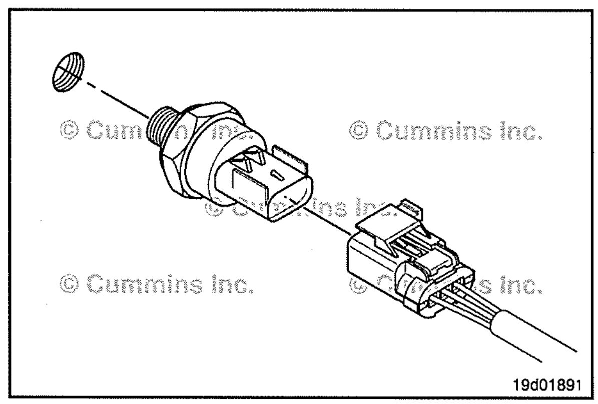


19d01891

Inspect for Reuse

Inspect the OEM pressure sensor for damaged or broken connector pins.

Refer to the OEM troubleshooting and repair manual for removal and installation instructions.



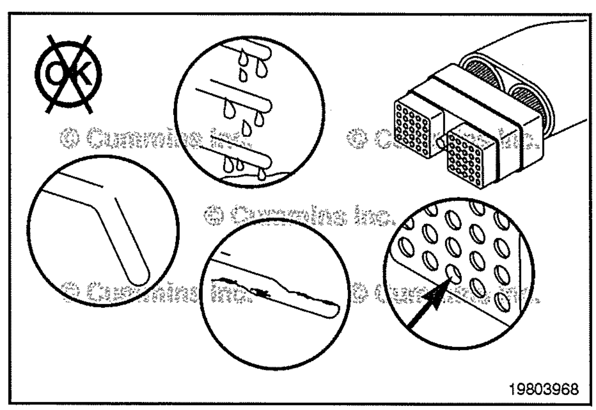
19d01891

OEM Pressure Sensor Circuit (019-401)

Initial Check

Disconnect the original equipment manufacturer (OEM) pressure sensor connector from the OEM harness. Disconnect the OEM harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Check the OEM pressure sensor connector and OEM harness connectors for broken, bare, or melted wires; loose, dirty, damaged, or missing pins; and other visible signs of damage.



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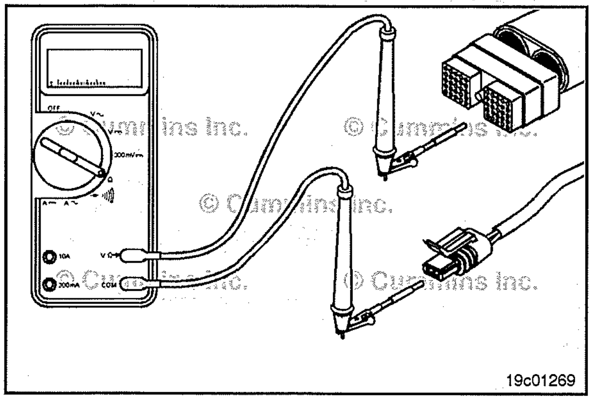


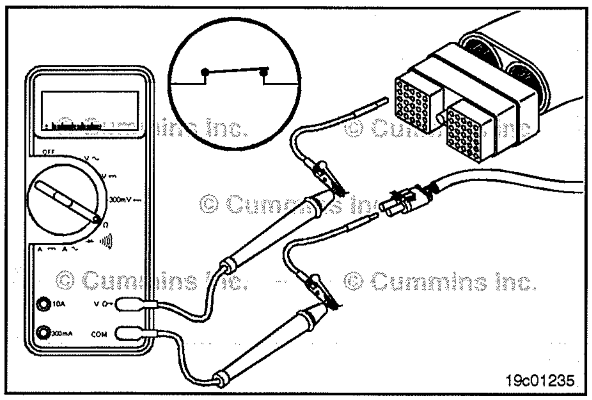
Resistance Check

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the OEM harness engine interface connector. Disconnect the OEM pressure sensor from the OEM harness. Set the multimeter to measure resistance.

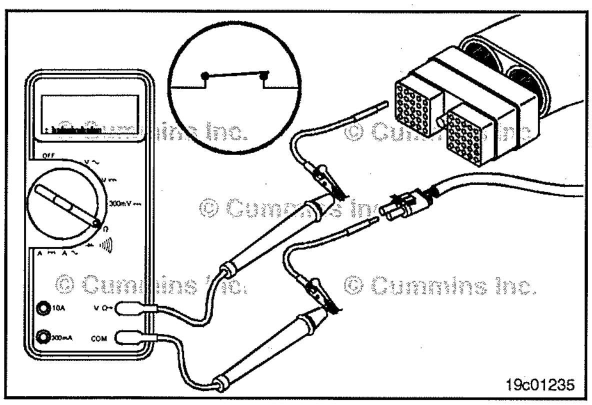
Insert a test lead into the OEM pressure sensor signal pin of the OEM harness connector. Connect the alligator clip to a multimeter probe. Insert the second test lead to the signal pin of the OEM pressure sensor harness connector and connect the clip to the other multimeter probe. Measure the resistance.



The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the signal wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.



Repeat the resistance check for the return wire. Measure the resistance from the OEM pressure sensor return pin of the OEM harness connector to the OEM pressure sensor return pin of the harness connector.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the return wire.

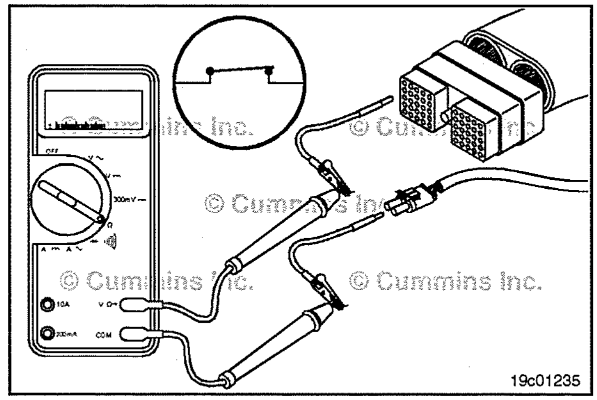
Repair or replace the OEM harness. Refer to Procedure 019-071.

Repeat the resistance check for the 5 volt supply wire. Measure the resistance from the OEM pressure sensor 5 volt supply pin of the OEM harness connector to the OEM pressure sensor 5 volt supply pin of the harness connector.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the 5 volt supply wire.

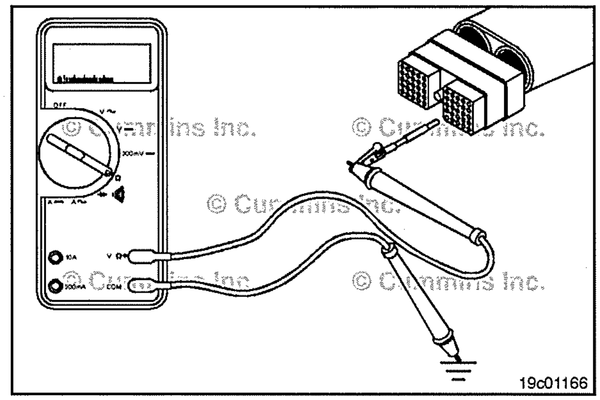
Repair or replace the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to Ground

Disconnect the OEM harness engine interface connector. Disconnect the OEM pressure sensor from the OEM harness. Set the multimeter to measure resistance.

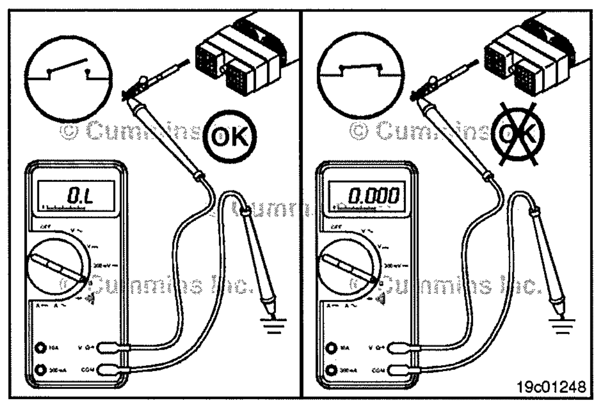
Insert the test lead into the OEM pressure sensor signal pin of the OEM harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.



The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the signal wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.

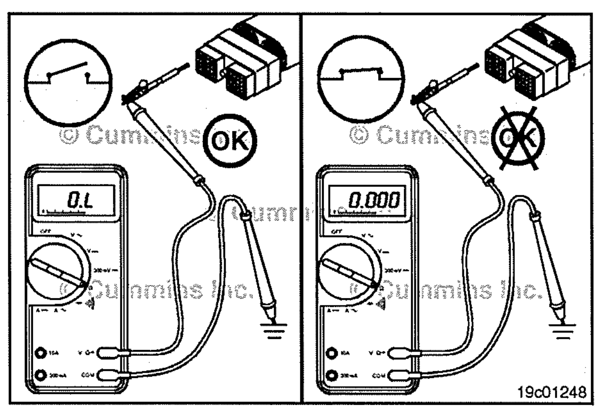


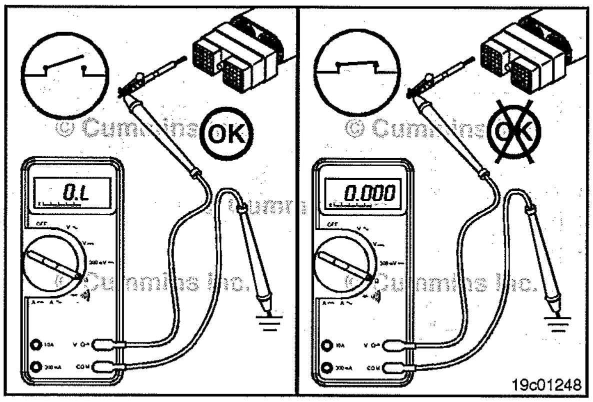
Repeat the short-to-ground check for the return wire. Measure the resistance from the OEM pressure sensor return pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the return wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.



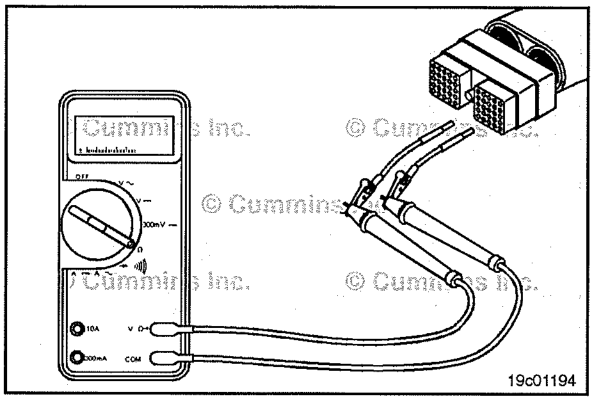


Repeat the short-to-ground check for the 5 volt supply wire. Measure the resistance from the OEM pressure sensor 5 volt supply pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the 5 volt supply wire.

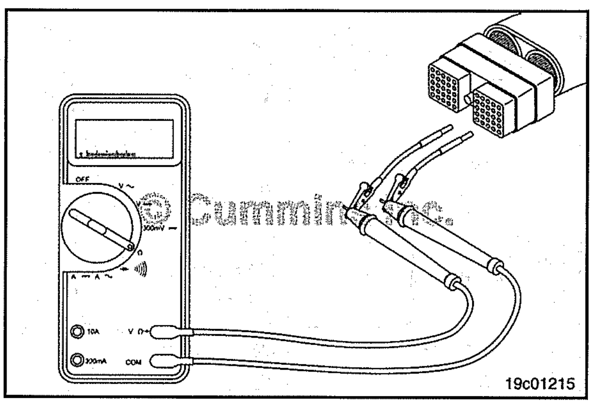
Repair or replace the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit from Pin to Pin

Disconnect the OEM harness engine interface connector. Disconnect the OEM pressure sensor from the OEM harness. Set the multimeter to measure resistance.

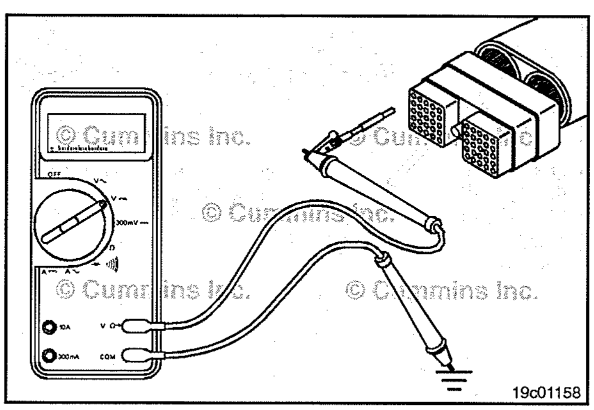
Measure the resistance from the OEM pressure sensor signal pin in the OEM harness connector to all other pins in the connector.



The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit between the signal wire and any other pin that measured a closed circuit.

Repair or replace the OEM harness. Refer to Procedure 019-071.



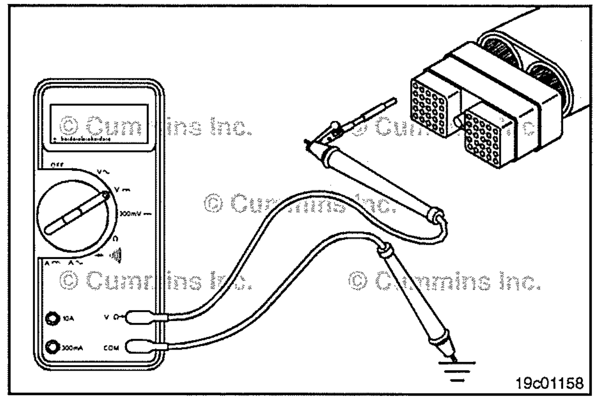
Check for Short Circuit to External Voltage Source

Disconnect the OEM harness engine interface connector. Disconnect the OEM pressure sensor from the OEM harness. Set the multimeter to measure VDC. Turn the vehicle keyswitch to the ON position.

Insert the test lead connected to the positive (+) multimeter probe into the OEM pressure sensor signal pin of the OEM harness connector. Touch the negative (-) multimeter probe to engine block ground and measure the voltage.

If there is voltage present, there is a short circuit from the signal wire to an external voltage source.

Repair or replace the OEM harness. Refer to Procedure 019-071.



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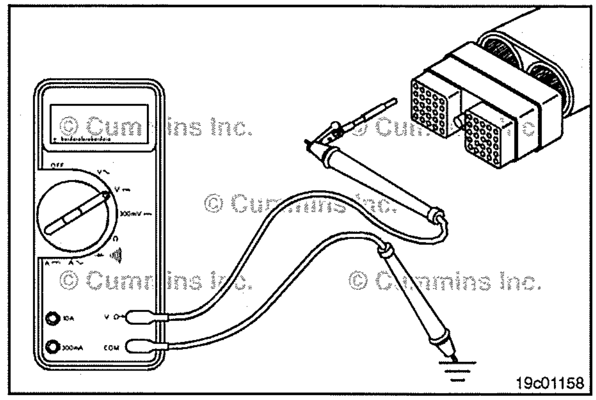
Repeat the short to external voltage source check for the return wire. Measure the voltage from the OEM pressure sensor return pin of the OEM harness connector to engine block ground.

If there is voltage present, there is a short circuit from the return wire to an external voltage source.

Repair or replace the OEM harness. Refer to Procedure 019-071.



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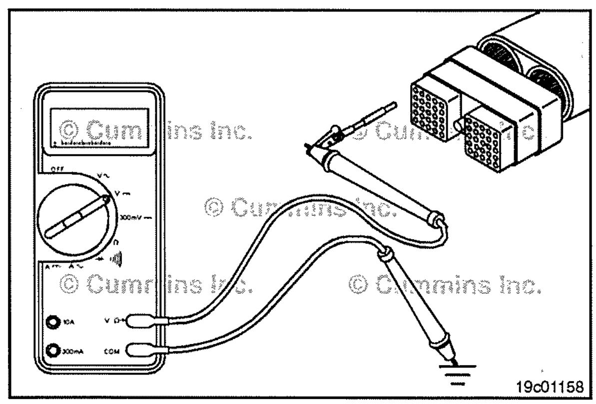
Repeat the short to external voltage source check for the 5 volt supply wire. Measure the voltage from the OEM pressure sensor 5 volt supply pin of the OEM harness connector to engine block ground.

The multimeter **must** show a voltage of less than 5.5 VDC. If the voltage is greater than 5.5 VDC, there is a short circuit from the 5 volt supply wire to an external voltage source.

Repair or replace the OEM harness. Refer to Procedure 019-071.



19c01158

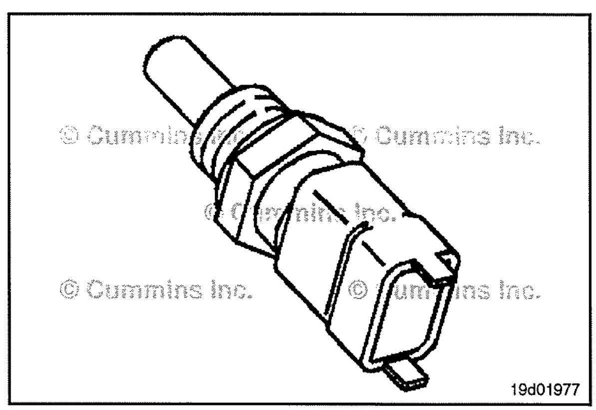
OEM Temperature Sensor (019-402)

General Information

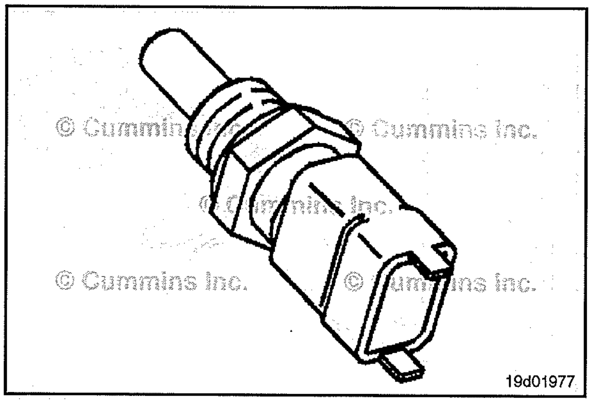
Some original equipment manufacturers (OEMs) can choose to install an additional temperature sensor.

The OEM temperature sensor monitors an OEM-defined temperature and passes that information on to the electronic control module (ECM) through the OEM harness. The ECM uses this information to determine the state of an OEM switched output device.

Refer to the OEM troubleshooting and repair manual for the location of the OEM temperature sensor.



19d01977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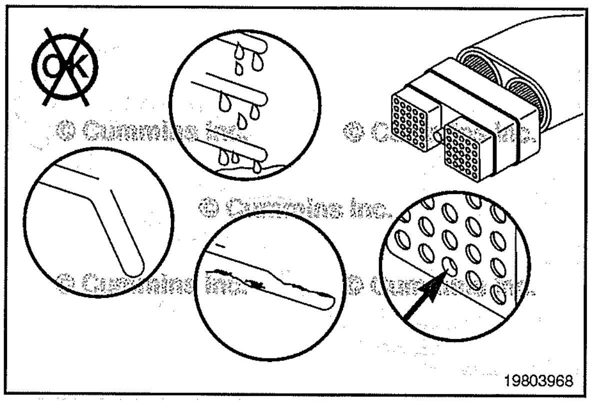
Inspect for Reuse

Inspect the OEM temperature sensor for damaged or broken connector pins.

Refer to the OEM troubleshooting and repair manual for removal and installation instructions.

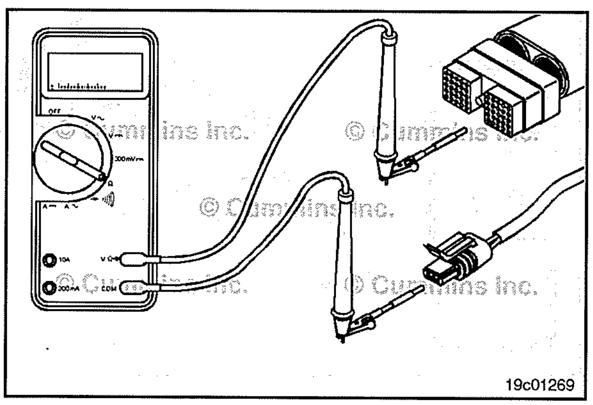

19803968

OEM Temperature Sensor Circuit (019-403)

Initial Check

Disconnect the original equipment manufacturer (OEM) temperature sensor connector from the OEM harness. Disconnect the OEM harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Check the OEM temperature sensor connector and OEM harness connectors for broken, bare, or melted wires; loose, dirty, damaged, or missing pins; and other visible signs of damage.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Resistance Check

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

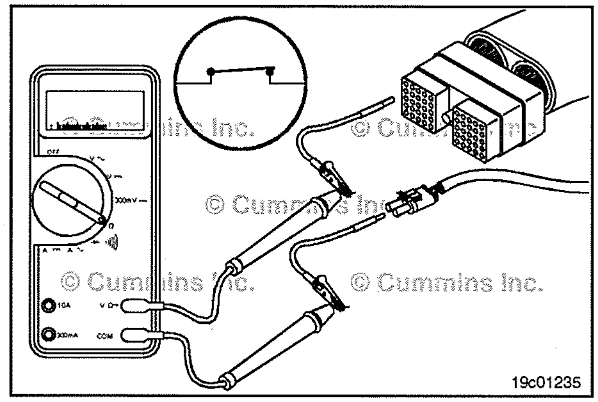
Disconnect the OEM harness engine interface connector. Disconnect the OEM temperature sensor from the OEM harness. Set the multimeter to measure resistance.

Insert a test lead into the OEM temperature sensor signal pin of the OEM harness connector. Connect the alligator clip to a multimeter probe. Insert the second test lead to the signal pin of the OEM temperature sensor harness connector and connect the clip to the other multimeter probe. Measure the resistance.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the signal wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.

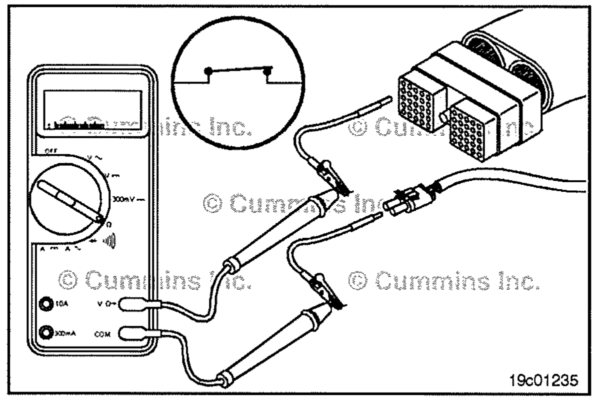


Repeat the resistance check for the return wire. Measure the resistance from the OEM temperature sensor return pin of the OEM harness connector to the OEM temperature sensor return pin of the harness connector.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the return wire.

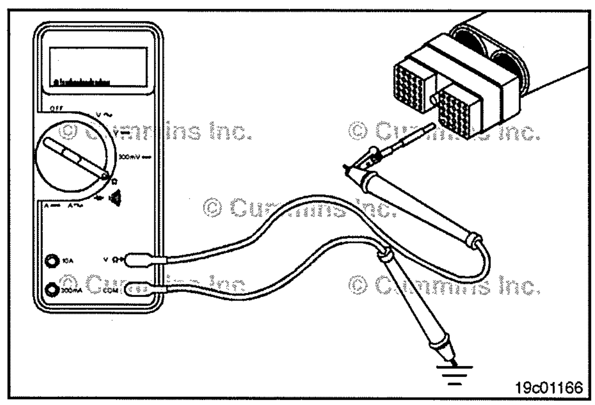
Repair or replace the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to Ground

Disconnect the OEM harness engine interface connector. Disconnect the OEM temperature sensor from the OEM harness. Set the multimeter to measure resistance.

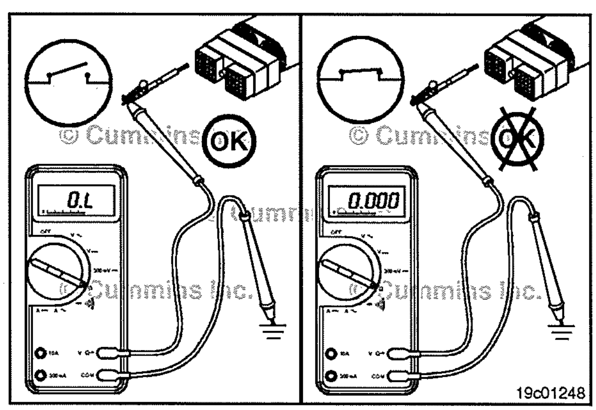
Insert the test lead into the OEM temperature sensor signal pin of the OEM harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.

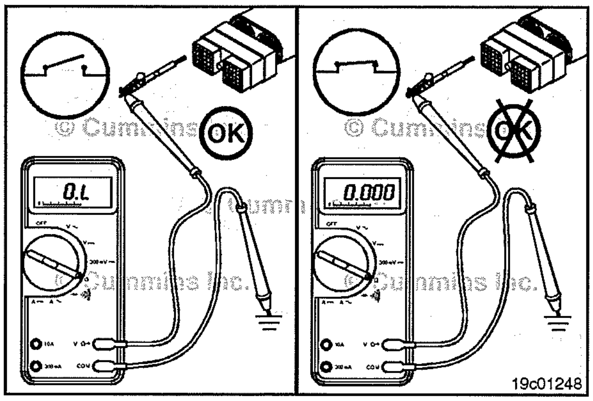


The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the signal wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.



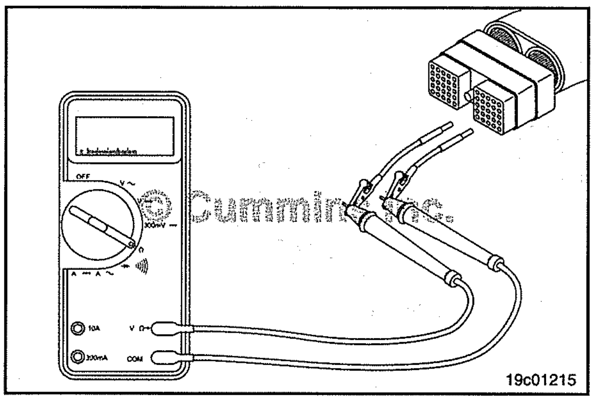


Repeat the short-to-ground check for the return wire. Measure the resistance from the OEM temperature sensor return pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the return wire.

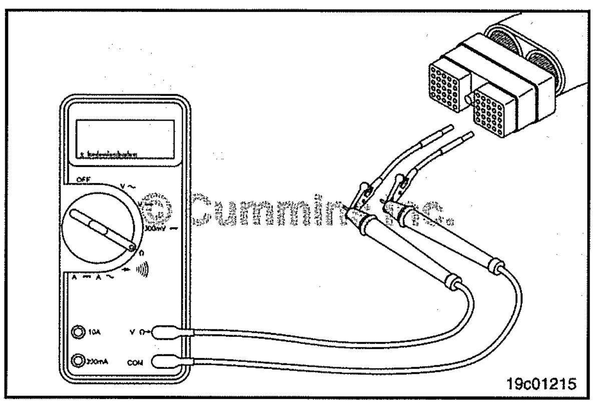
Repair or replace the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit from Pin to Pin

Disconnect the OEM harness engine interface connector. Disconnect the OEM temperature sensor from the OEM harness. Set the multimeter to measure resistance.

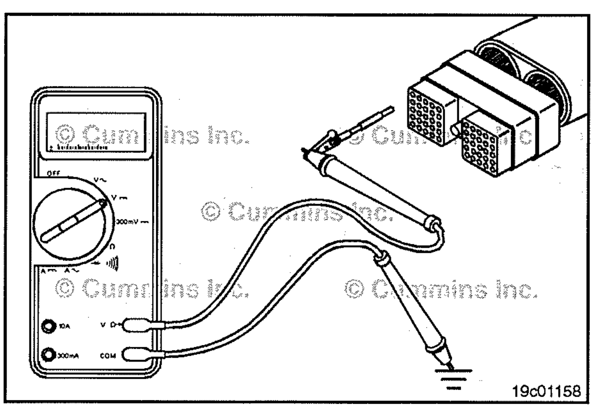
Measure the resistance from the OEM temperature sensor signal pin in the OEM harness connector to all other pins in the connector.



The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit between the signal wire and any other pin that measured a closed circuit.

Repair or replace the OEM harness. Refer to Procedure 019-071.



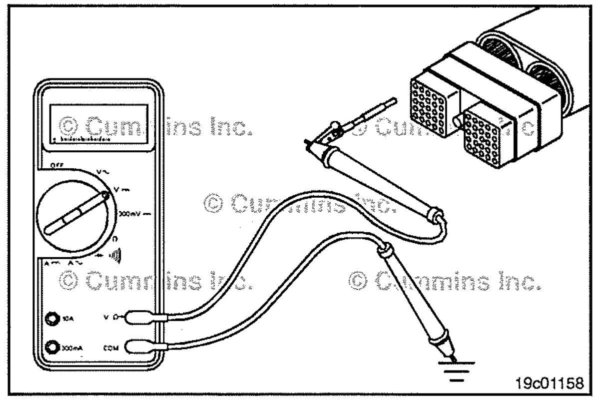
Check for Short Circuit to External Voltage Source

Disconnect the OEM harness engine interface connector. Disconnect the OEM temperature sensor from the OEM harness. Set the multimeter to measure VDC. Turn the vehicle keyswitch to the ON position.

Insert the test lead connected to the positive (+) multimeter probe into the OEM temperature sensor signal pin of the OEM harness connector. Touch the negative (-) multimeter probe to engine block ground and measure the voltage.

The multimeter **must** show voltage of 5.5 VDC or less. If the voltage is incorrect, there is a short circuit from the signal wire to an external voltage source.

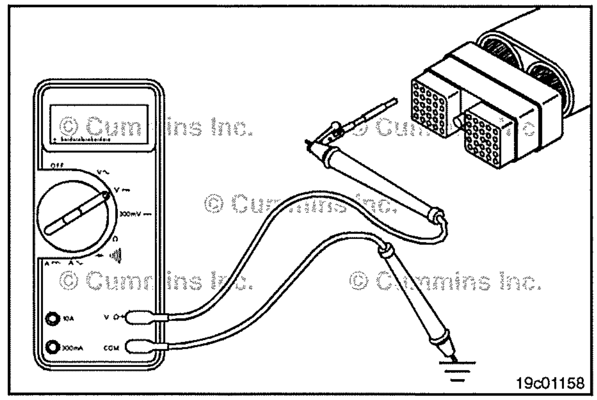
Repair or replace the OEM harness. Refer to Procedure 019-071.



Repeat the short to external voltage source check for the return wire. Measure the voltage from the OEM temperature sensor return pin of the OEM harness connector to engine block ground.

The multimeter **must** show voltage of 5.5 VDC or less. If the voltage is incorrect, there is a short circuit from the return wire to an external voltage source.

Repair or replace the OEM harness. Refer to Procedure 019-071.



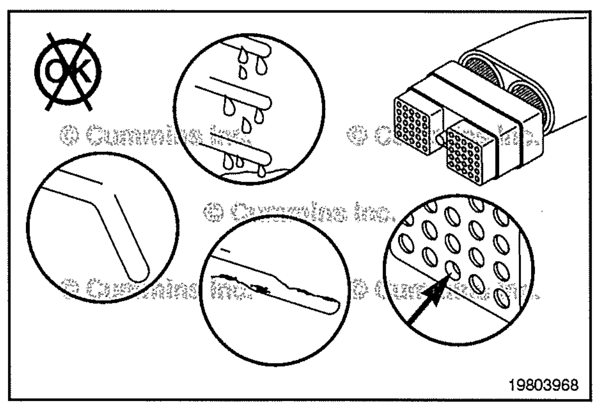
Intake Air Heater Control Relay Circuit (019-408)

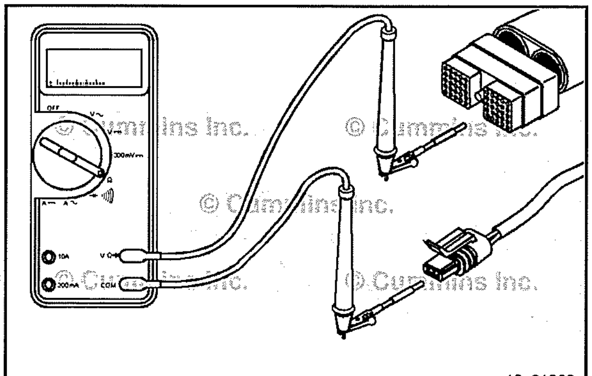
Initial Check

Disconnect the intake air heater control relay from the original equipment manufacturer (OEM) harness.

Disconnect the OEM harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram.

Check the intake air heater control relay and harness connector for broken, bare, or melted wires; loose, dirty, damaged, or missing pins; and other visible signs of damage.





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Resistance Check

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the OEM harness engine interface connector. Disconnect the intake air heater control relay from the OEM harness. Set the multimeter to measure resistance.

Insert a test lead into the intake air heater control relay signal pin of the OEM harness connector. Connect the alligator clip to a multimeter probe. Insert the second test lead to the signal pin of the intake air heater control relay harness connector and connect the clip to the other multimeter probe. Measure the resistance.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

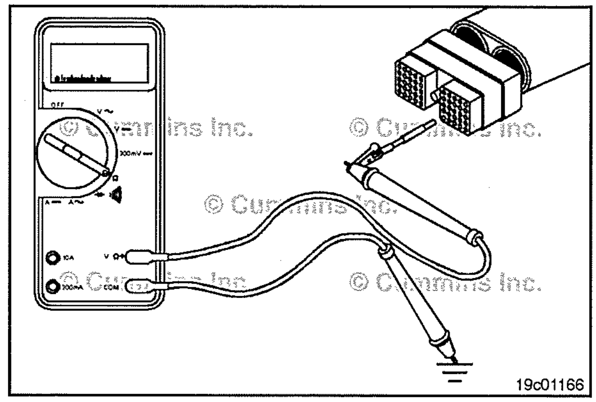
If the measured value is more than 10 ohms, there is an open circuit in the signal wire. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Repeat the resistance check for the return wire. Measure the resistance from the intake air heater control relay return pin of the OEM harness connector to the intake air heater control relay return pin of the harness connector.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the return wire. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Check for Short Circuit to Ground



Disconnect the OEM harness engine interface connector. Disconnect the intake air heater control relay from the OEM harness. Set the multimeter to measure resistance.

Insert the test lead into the intake air heater control relay signal pin of the OEM harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

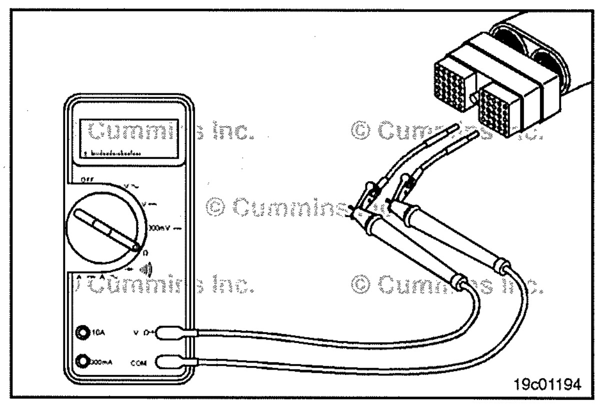
If the measured value is less than 100k ohms, there is a short circuit to ground in the signal wire. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Repeat the short to ground check for the return wire. Measure the resistance from the intake air heater control relay return pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the return wire. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Check for Short Circuit from Pin to Pin

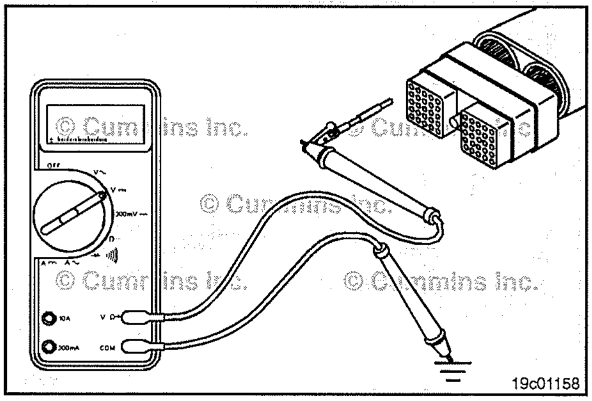


Disconnect the OEM harness engine interface connector. Disconnect the intake air heater control relay from the OEM harness. Set the multimeter to measure resistance.

Measure the resistance from the intake air heater control relay signal pin in the OEM harness connector to all other pins in the connector.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit between the signal wire and any other pin that measured a closed circuit. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



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Check for Short Circuit to External Voltage Source

Disconnect the OEM harness engine interface connector. Disconnect the intake air heater control relay from the OEM harness.

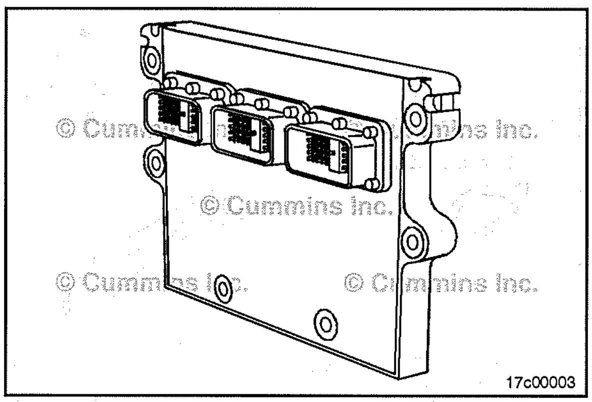
Set the multimeter to measure VDC. Turn the keyswitch to the ON position.

Insert the test lead connected to the positive (+) multimeter probe into the intake air heater control relay signal pin of the OEM harness connector. Touch the negative (-) multimeter probe to engine block ground and measure the voltage.

If voltage is present, there is a short circuit from the signal wire to an external voltage source. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Repeat the short to external voltage source check for the return wire. Measure the voltage from the intake air heater control relay return pin of the OEM harness connector to engine block ground.

If voltage is present, there is a short circuit from the return wire to an external voltage source. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



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Data Link Circuit, Proprietary (019-417)

General Information

The proprietary data link circuit is located in the wiring harness and originates from the engine connector of the engine control module (ECM). This is different from the public data link which originates in the OEM connector of the ECM.

The purpose of this data link is to allow the engine control module (ECM) to communicate to other data link devices such as the Variable Geometry Turbocharger (VGT) actuator, NOx sensors, aftertreatment temperature sensor modules, etc.

INSITE electronic service tool can communicate with the ECM on the proprietary data link via the 3-pin service data link connector.

Proprietary Data link Backbone Harness Overview:

The proprietary data link has strict guidelines that **must** be followed for successful communication. Understanding some fundamentals about proprietary data link will help make sure these guidelines are followed.

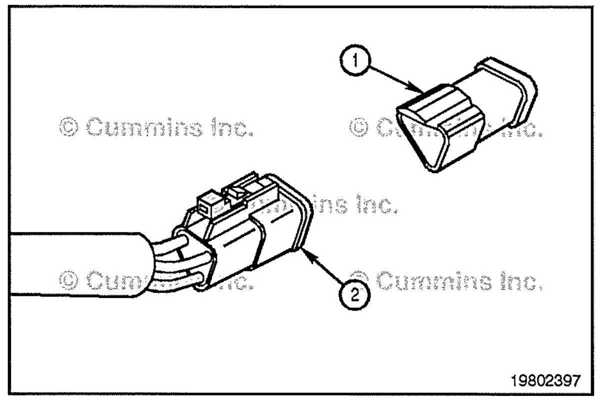
The main component of the proprietary data link system is a backbone harness. The harness can be up to 40 meters [131 feet] in length. The backbone harness is terminated at each end with a 120 ohm terminating resistor.

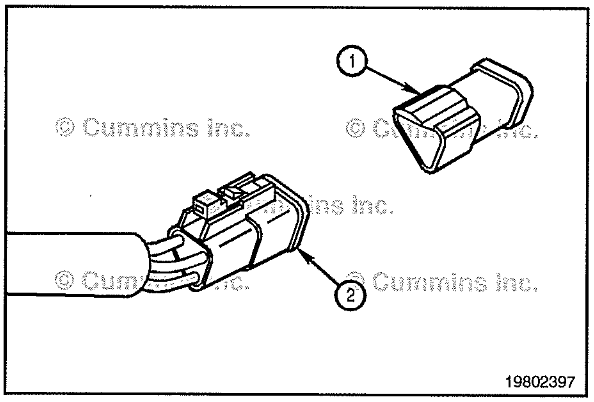
A maximum of thirty devices can be attached to the proprietary data link backbone at once. Each device is connected to the backbone through a stub, which can be up to 1 meter in length.

The proprietary data link incorporates two terminating resistors. One of the terminating resistors is built into the Private Data Link Connectors. The other terminating resistor is provided by the original equipment manufacturer (OEM) and should be located at the end of the backbone.

The purpose of the terminating resistors is to minimize reflection of data on the data link. Reflection of data on the data link can cause messages to become partially or completely lost resulting in intermittent fault codes.

Although the data link may function with a missing or failed terminating resistor, the terminating resistors **must** be in place to maintain proper communication.





There are several different malfunctions that can influence communication on the proprietary data link. Below is a table of malfunctions and the corresponding effects on communication.

Malfunction	Effects
Open in the SAE J1939 (+) or SAE J1939 (-) circuit	Data communication is **NOT** possible with devices located after the open circuit. Communication with the remaining devices is possible, but may be intermittent.
SAE J1939 (+) shorted to voltage	Data communication is **NOT** possible
SAE J1939 (+) shorted to ground	Data communication is **NOT** possible
SAE J1939 (-) shorted to voltage	Data communication is **NOT** possible
SAE J1939 (-) shorted to ground	Data communication is possible, but may be intermittent.
SAE J1939 (+) shorted to SAE J1939 (-)	Data communication is **NOT** possible
Loss of terminating resistor or incorrect terminating resistance	Data communication is possible, but may be intermittent.

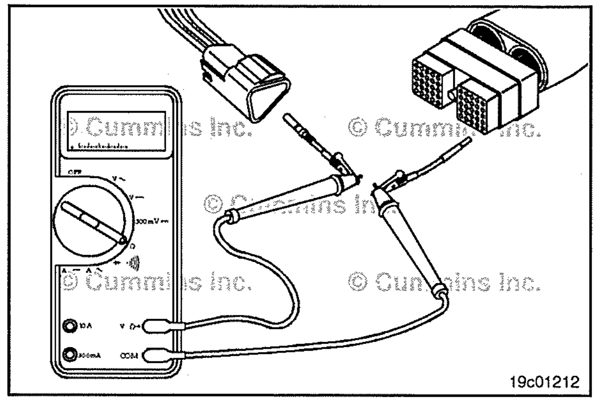
Resistance Check

⚠WARNING⚠

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

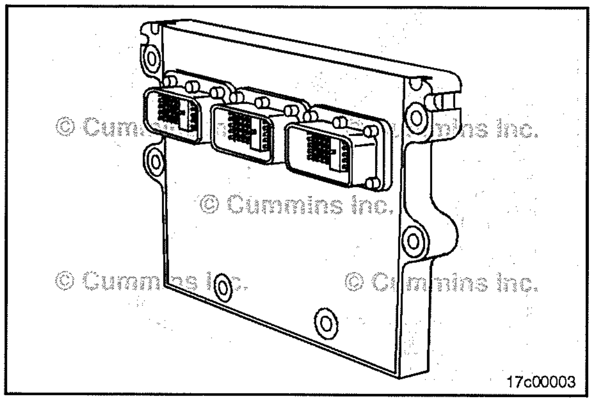
Disconnect the batteries.

Measure the resistance between the SAE J1939 Data Link (+) pin and the SAE J1939 Data Link (-) pin at the 3-pin service data link connector.



Resistance	Possible Cause
54 to 66 ohms	Terminating resistance is correct
108 to 132 ohms	One of the terminating resistors is missing, One of the terminating resistors is open, or There may be an open between the terminating resistors in the proprietary data link circuit.
36 to 44 ohms	Three terminating resistors have been installed in the harness. One **must** be removed. There **must** be one terminating resistor at each end of the backbone.
0 to 5 ohms	There is a short between the SAE J1939 (+) and SAE J1939 (-) in the proprietary data link circuit.
Greater than 1000 ohms	There may be an open between the 3-pin service data link connector and the backbone or Both terminating resistors are missing or open.
Any other readings	Incorrect terminating resistor resistance, Poor or corroded connections, or Short circuit to ground or an open in the proprietary data link.

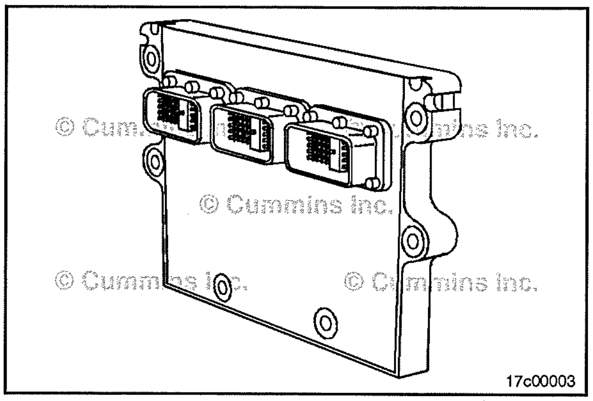
To pinpoint the cause of the incorrect terminating resistance, isolate it by systematically disconnecting connections on the data link until the resistance reads within the acceptable limits.



Engine Harness Terminating Resistance Isolation

To isolate the engine side of the proprietary SAE J1939 data link, disconnect the 24-pin OEM crossover connector and measure the resistance between the SAE J1939 Data link (+) pin and the SAE J1939 Data link (-) pin at the 3-pin service data link connector.

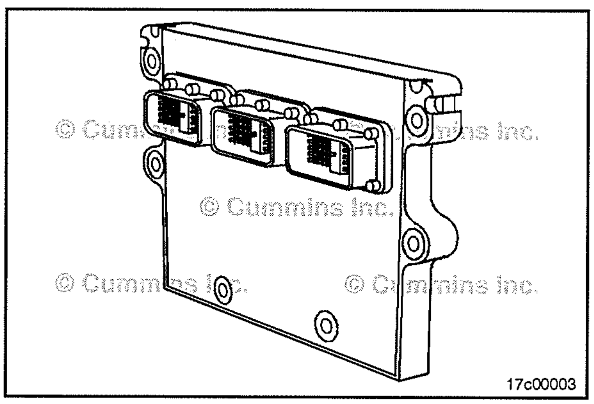
If the resistance is **NOT** between 108 to 132 ohms a malfunction has been detected in the engine side of the proprietary SAE J1939 data link.



Disconnect the Aftertreatment Intake NOx sensor and measure the resistance between the SAE J1939 Data link (+) pin and the SAE J1939 Data link (-) pin at the 3-pin service data link connector to determine if the aftertreatment intake NOx sensor is the cause of the malfunction.

If the resistance is between 108 to 132 ohms with the aftertreatment intake NOx sensor disconnected, a malfunctioning aftertreatment intake NOx sensor has been connected.

Replace the aftertreatment intake NOx sensor. Refer to Procedure 019-463 in Section 19.



If the resistance is **NOT** between 108 to 132 ohms after disconnecting the aftertreatment intake NOx sensor, then disconnect the Private Data Link Connectors from the engine harness and measure the resistance between the SAE J1939 Data link (+) pin and the SAE J1939 Data link (-) pin of the VGT actuator.

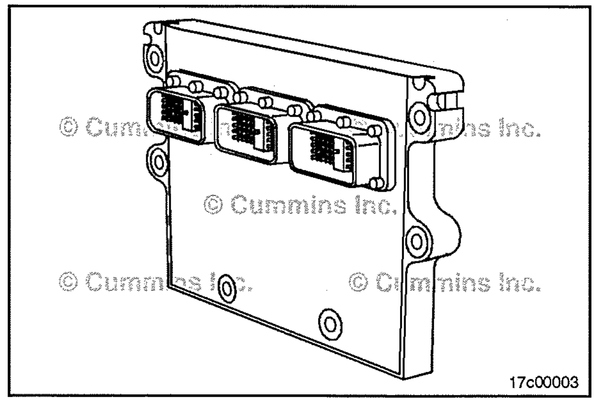
If the resistance of the Private Data Link Connectors is **NOT** between 108 to 132 ohms, then a malfunctioning Private Data Link Connectors has been detected. Replace the Private Data Link Connectorsr. Refer to Procedure 019-165 in Section 19.

If the resistance of the Private Data Link Connectors is between 108 to 132 ohms, then a malfunction has been detected in the engine harness. Repair or replace the engine harness. Refer to Procedure 019-043 in Section 19.

Aftertreatment Harness Terminating Resistance Isolation

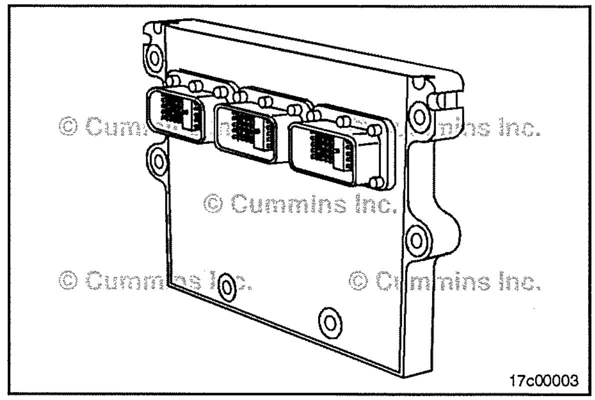
To isolate the aftertreatment side of the proprietary SAE J1939 data link, measure the resistance between the SAE J1939 Data link (+) pin and the SAE J1939 Data link (-) pin on the OEM side of the 24-pin crossover connector.

If the resistance is **NOT** between 108 to 132 ohms a malfunction has been detected in the aftertreatment side of the proprietary SAE J1939 data link.



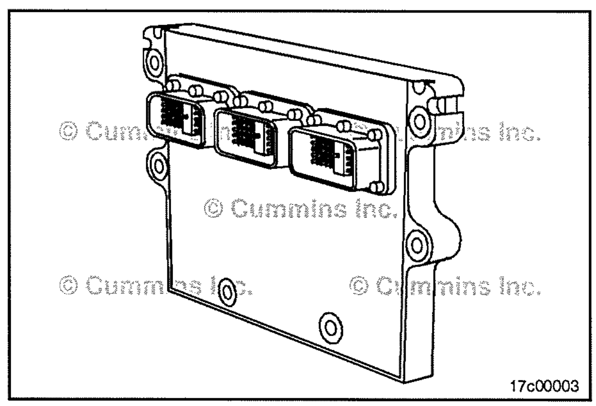
To isolate the aftertreatment side of the proprietary SAE J1939 data link, disconnect the following devices from the data link one at a time while measuring the resistance between the SAE J1939 Data link (+) pin and the SAE J1939 Data link (-) pin on the OEM side of the 24-pin crossover connector:

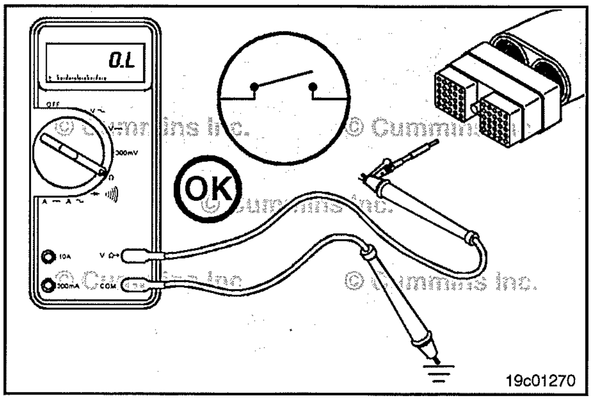
- Aftertreatment Outlet NOx Sensor
- Aftertreatment DPF Temperature Sensor Module
- Aftertreatment SCR Temperature Sensor Module
- Aftertreatment Diesel Exhaust Fluid Tank Quality Sensor
- Aftertreatment Diesel Exhaust Fluid Tank Level / Temperature Sensor



If the resistance reads between 108 to 132 ohms after disconnecting a data link device, then a malfunction has been detected in that data link device. Replace the malfunctioning device.

If the resistance is **NOT** between 108 to 132 ohms after disconnecting all of the data link devices, then the malfunction is located in the OEM wiring or OEM installed terminating resistor. Repair or replace the OEM wiring harness. Refer to the OEM troubleshooting and repair manual.





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Short Circuit Check

Connect the batteries.

Turn the keyswitch ON.

Measure the voltage between the SAE J1939 Data Link (+) pin at the 3-pin service data link connector and battery ground.

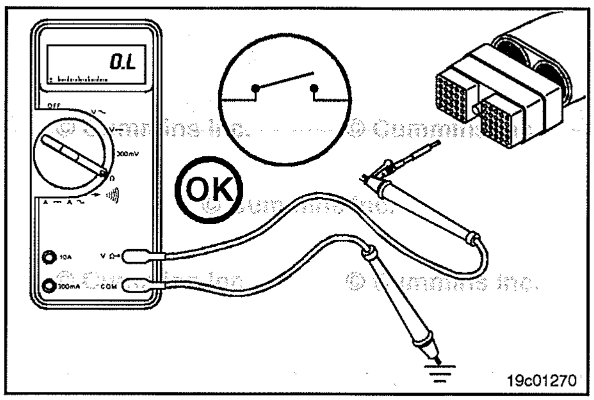
Measure the voltage between the SAE J1939 Data Link (-) pin at the 3-pin service data link connector and battery ground.

Min	Normal	Max
0.1 V	2.5 V	4.5 V

If the voltage reading is less than 0.1 volts, then the SAE J1939 Data Link is shorted to ground.

If the voltage reading is greater than 4.5 volts, then the SAE J1939 Data Link is shorted to a voltage source.

To pinpoint the short, isolate it by systematically disconnecting connections on the data link until voltage reads within the acceptable limits.



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Data link Short Circuit Isolation

If the short circuit was detected on the SAE J1939 Data Link (+) circuit, perform the isolation checks while measuring the voltage between the SAE J1939 Data Link (+) pin and battery ground.

If the short circuit was detected on the SAE J1939 Data Link (-) circuit, perform the isolation checks while measuring the voltage between the SAE J1939 Data Link (-) pin and battery ground.

Disconnect the following devices one at a time while measuring the voltage at the 3-pin service data link connector:

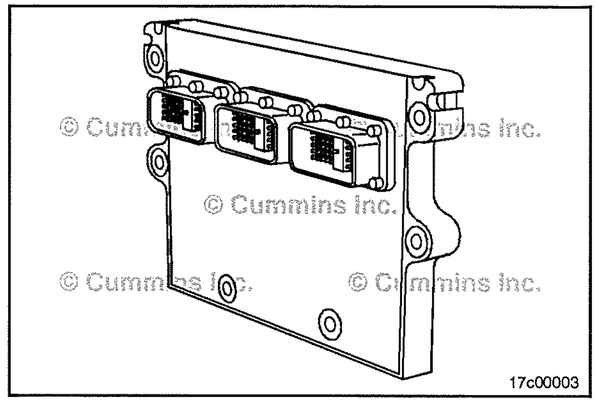
- Aftertreatment Intake NOx Sensor
- Aftertreatment Outlet NOx Sensor
- Aftertreatment DPF Temperature Sensor Module
- Aftertreatment SCR Temperature Sensor Module
- Aftertreatment Diesel Exhaust Fluid Tank Level / Temperature Sensor
- Aftertreatment Diesel Exhaust Fluid Tank Level / Temperature Sensor

If the voltage reads between 0.1 to 4.5 volts after disconnecting a data link device, then a malfunction has been detected in that data link device. Replace the malfunctioning device.

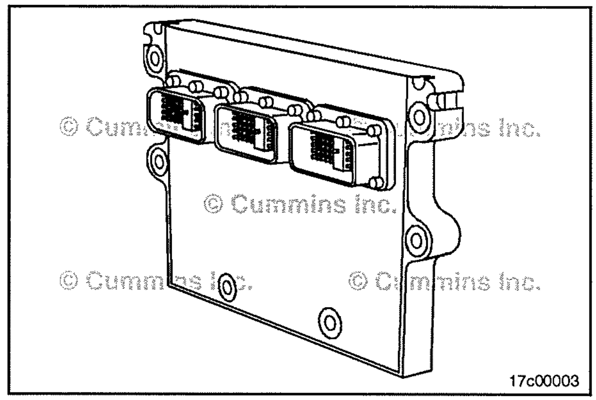
If the voltage is **NOT** between 0.1 to 4.5 volts after disconnecting all of the data link devices, then the malfunction is located in the wiring.

Disconnect the 24-pin OEM crossover connector while measuring the voltage at the 3-pin service connector.

If the voltage is **NOT** between 0.1 to 4.5 volts after disconnecting the 24-pin OEM crossover connector, then a short circuit has been detected in the engine harness. Repair or replace the engine harness. Refer to Procedure 019-043 in Section 19.



If the voltage is between 0.1 to 4.5 volts after disconnecting the 24-pin OEM crossover connector, then a short circuit has been detected in the OEM wiring. Repair or replace the OEM wiring harness. Refer to the OEM troubleshooting and repair manual.

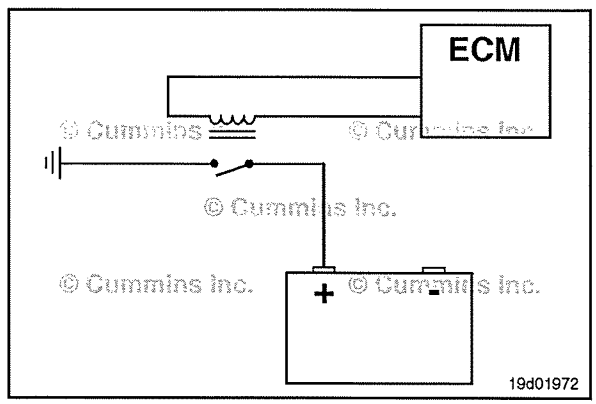


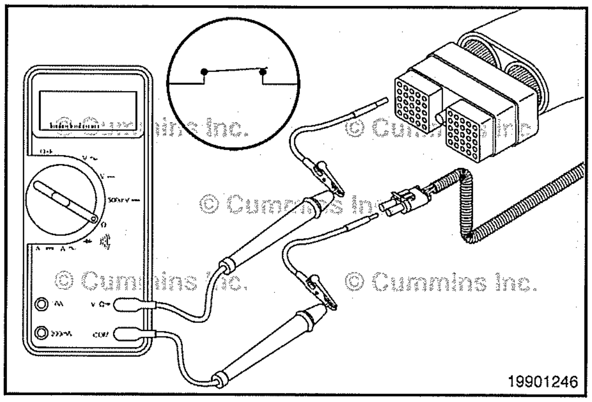
Starter Lockout/Switched Outputs Relay Circuit (019-419)

General Information

The ECM can control a starter lockout relay or an OEM relay.

Refer to the vehicle manufacturer's publications for more information on troubleshooting and repair of the starter lockout relay or OEM relay.





Resistance Check

⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the original equipment manufacturer (OEM) harness engine interface connector. To determine the location of the connector, see the corresponding engine wiring diagram. Disconnect the OEM wiring at the starter lockout or OEM relay. Set the multimeter to measure resistance.

Insert a test lead into the starter lockout relay signal/ switched output relay number 1 signal pin of the OEM harness connector and connect the alligator clip to a multimeter probe. Touch the other test lead to the starter lockout relay signal/switched output relay number 1 signal terminal at the component. Measure the resistance.

The multimeter **must** show 10 ohms or less (closed circuit).

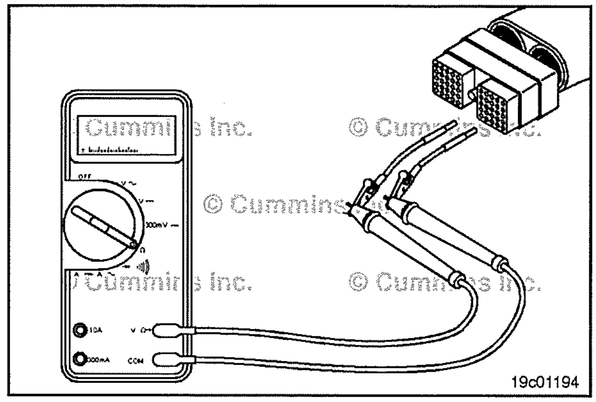
Check the return pin. Insert a test lead into the starter lockout relay signal/switched output relay number 1 return pin of the OEM harness connector and connect the alligator clip to a multimeter probe. Touch the other test lead to the starter lockout relay signal/switched output relay number 1 return terminal at the component. Measure the resistance.

The multimeter **must** show 10 ohms or less (closed circuit).

If the circuit is closed, it **must** still be checked for a short circuit from pin to pin.

If the circuit is **not** closed, there is a connection problem or an open circuit in the harness.

Check for Short Circuit from Pin to Pin


19c01194

Check for a short circuit between the starter lockout relay signal/switched output relay number 1 signal pin and all other pins in the OEM harness connector.

Disconnect the OEM harness engine interface connector.

Set the multimeter to measure resistance.

Disconnect the starter lockout or OEM relay from the OEM harness.

Insert a test lead into the signal pin of the OEM harness connector, and connect the alligator clip to a multimeter probe. Insert the second test lead to the first pin in the OEM harness connector, and connect the alligator clip to the other multimeter probe.

Measure the resistance from the signal pin to all other pins in the connector, one at a time.

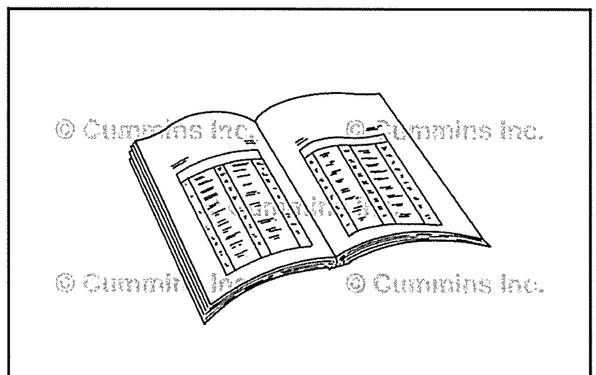
The multimeter **must** show 100k ohms or more (open circuit) at all pins.

If any pin-to-pin check shows a closed circuit, there is a short circuit between the applicable pins that measured a closed circuit.

Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Engine Control Module Mounting Bracket (019-421)

Preparatory Steps

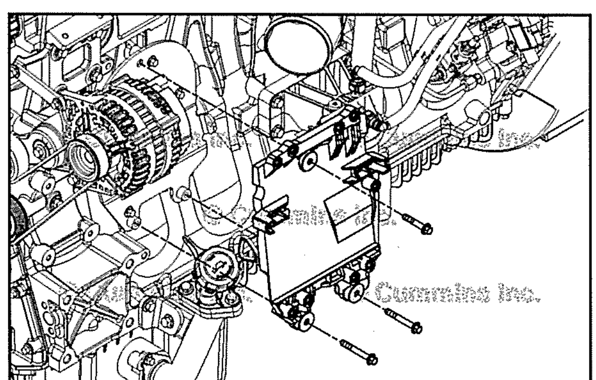

ck800wa

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.

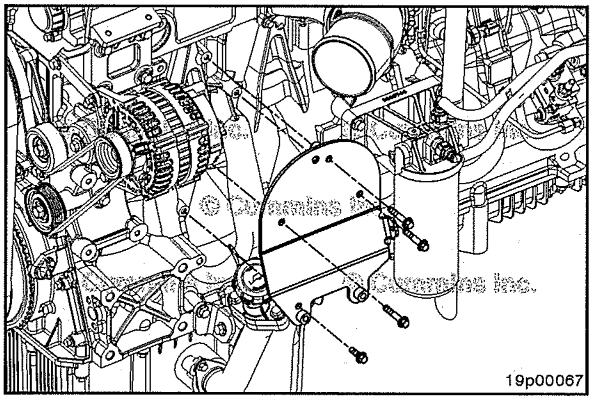
- Disconnect batteries. See equipment manufacturer service information.
- Remove the Engine Control Module (ECM). Refer to Procedure 019-031 in Section 19.

Remove


19p00066

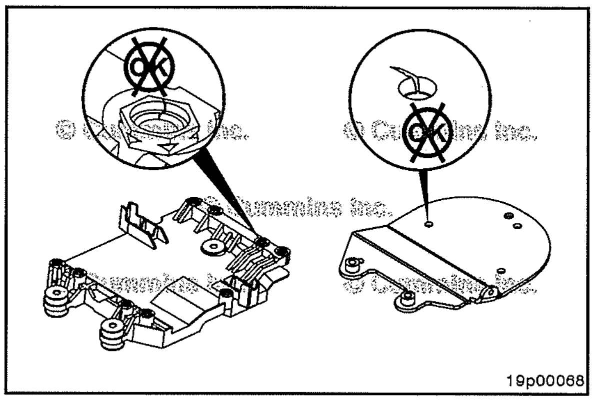
Remove capscrews.

Remove plastic ECM mounting bracket.



Remove capscrews.

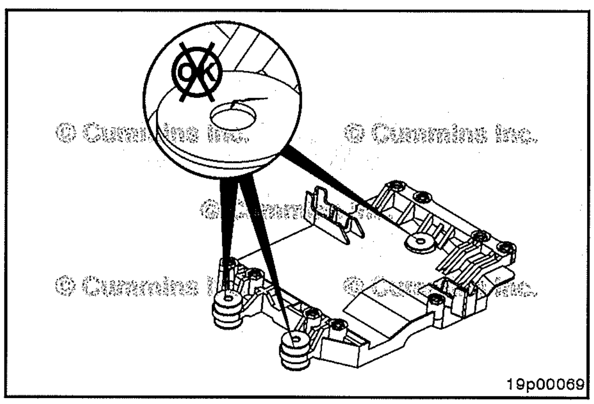
Remove metal ECM mounting bracket.



Inspect for Reuse

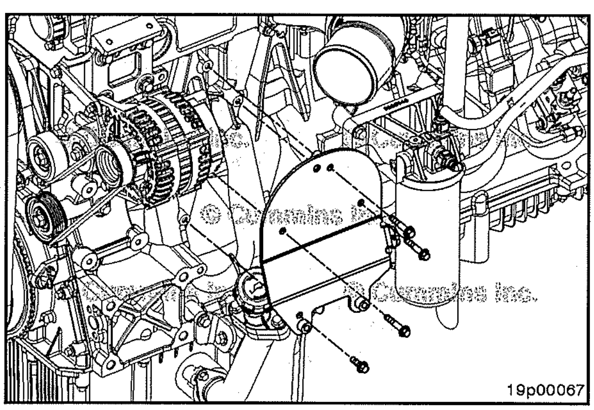
Inspect the ECM mounting brackets for cracks or other damage.

Replace the bracket if it is damaged.



Inspect the vibration isolators for cracks or other damage.

Replace the vibration isolators if they are damaged.



Install

Install metal ECM mounting bracket.

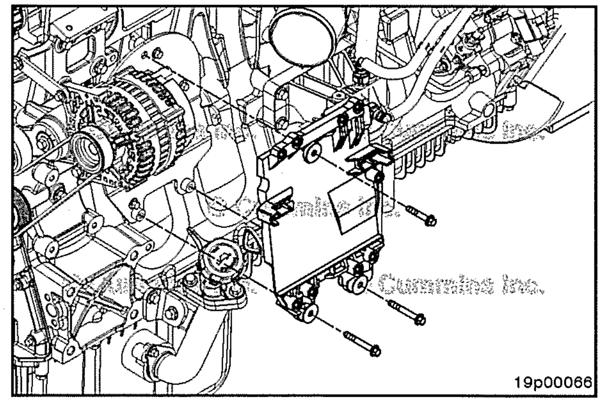
Install and tighten capscrews.

Torque Value: 23 N•m [204 in-lb]

Install plastic ECM mounting bracket.

Install and tighten capscrews.

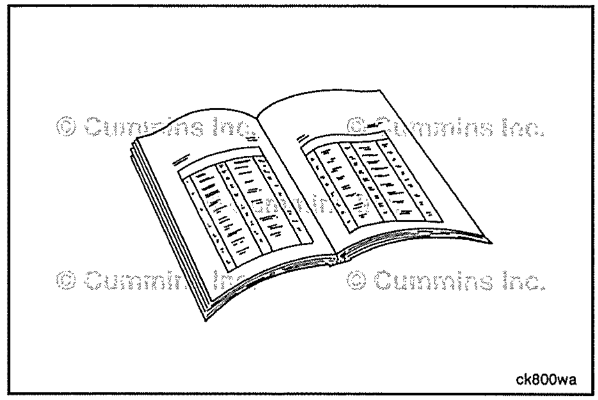
Torque Value: 23 N•m [204 in-lb]



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 Engine Control Module. Refer to Procedure 019-031 in Section 19.
- Connect batteries. See equipment manufacturer service information.



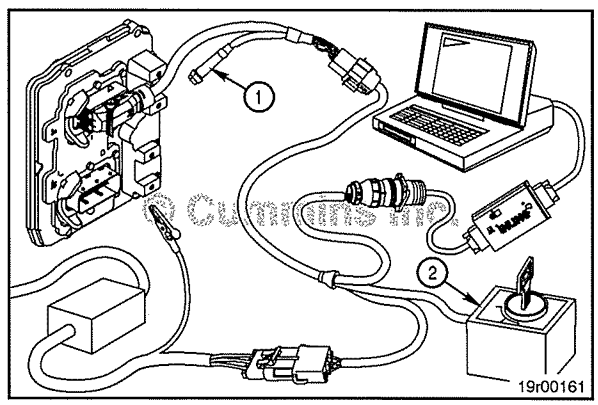
Engine Control Module ROM Boot (019-427)

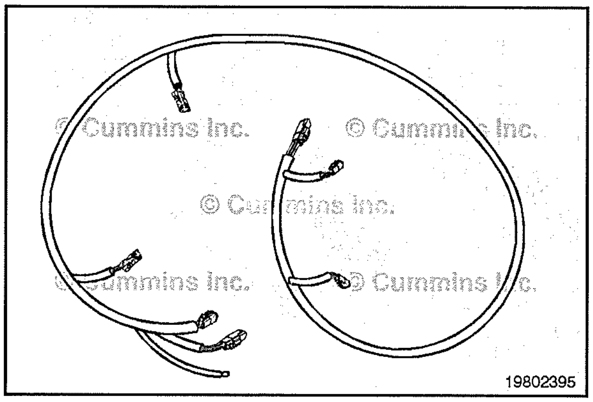
General Information

Engine Control Module (ECM) ROM Boot Procedure:

- Install the calibration cable with ROM boot switch.
- With the keyswitch (2) in the OFF position, press the ROM boot switch (1), located on the ECM-specific calibration adapter harness, and hold.
- Switch the keyswitch to the ON position while holding the ROM boot switch down, wait for five seconds.
- Release the ROM boot switch.
- Recalibrate the ECM. Refer to Procedure 019-032 in Section 19.
- Remove the ROM boot cable from the ECM.

For general tool information, including the correct installation configuration, see the ECM-specific calibration adapter cable with ROM boot switch in the ECM Bench Calibration Base Harness, Bulletin 3377791.





Engine Datalinks (019-428)

General Information

⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

The engine data link consists of circuitry located in the engine wiring harness. On older engines, the engine data link circuitry supports J1587/J1708 protocol. On newer engines, the engine data link circuitry supports J1939 protocol.

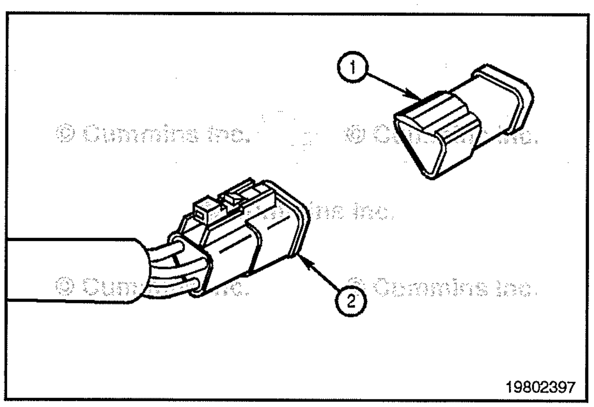
The purpose of the engine data link is to provide an access point for a service tool, such as INSITE™ electronic service tool, to communicate with the engine control module (ECM). A service tool can communicate with the ECM on the engine data link free from data link traffic from other electronic devices that can be present on the OEM data link.

SAE J1939 Backbone Harness Overview:

SAE J1939 has strict guidelines that **must** be followed for successful communication. Understanding some fundamentals about SAE J1939 will help make sure these guidelines are followed.

The main component of an SAE J1939 system is a backbone harness. The harness can be up to 40 m [131 ft] long. The backbone harness is terminated at each end with 120 ohm resistors.

A maximum of 30 different devices can be attached to the SAE J1939 backbone at once. Each device, such as the data link adapter, is connected to the backbone through a stub which can be up to 1 m [3.2 ft] in length. The stub connector is a 3-pin plug.

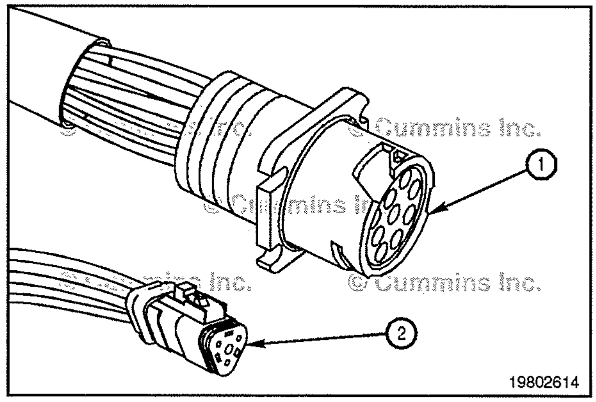


The terminating resistor caps (1) **must** be in place on the OEM backbone harness plugs (2) to maintain proper communication. Each resistor is 120 ohms and is located in a removable cap. This resistance is required when communicating with INSITE™ electronic service tool over the J1939 data link.

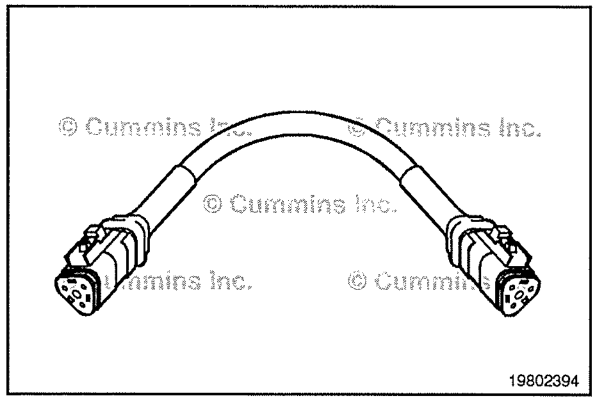
Some engine harnesses include a complete SAE J1939 backbone harness. If this is supplied, connection to INSITE™ electronic service tool is accomplished either by a 9-pin data link connector (1), Part Number 4918416, or a 3-pin receptacle (2), Part Number 3165141.

To check for the J1939 backbone, turn the keyswitch to the OFF position. Measure the resistance from the SAE J1939 data link positive (+) pin to the SAE J1939 data link negative (-) pin of the 3-pin Deutsch™ connector.

The multimeter will show 60 ohms when the engine harness has provided a backbone on the data link bus.



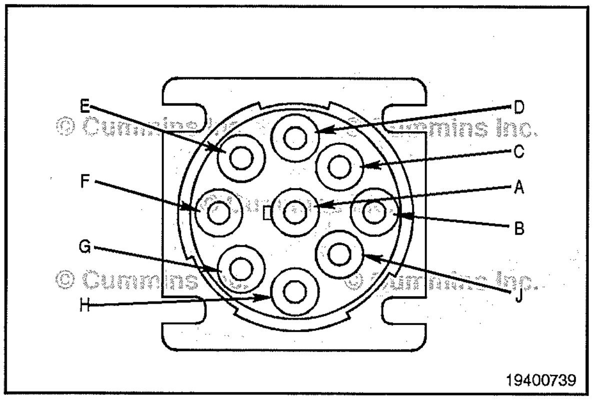
If the engine harness does **not** supply the J1939 backbone harness and the data link connector is a 3-pin receptacle, a mini-backbone harness will have to be added.



Engine Data Link Connectors

The engine data link connector available on the engine harness will depend upon the data link circuitry in the engine harness and the vintage of the engine. Engine data link connectors available on Cummins® engines are summarized in the table below.

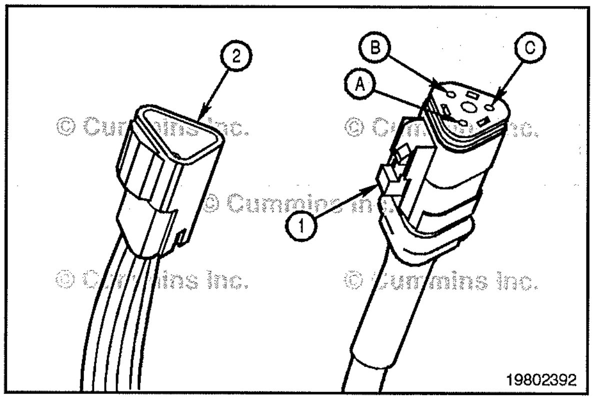
Connector Type	Data Link Protocols Supported
2-pin Weather Pack™	J1587/J1708
3-pin Deutsch™	J1939
6-pin Deutsch™	J1587/J1708
9-pin Deutsch™	J1587/J1708, J1939



Each connector type is described in more detail in the following information.

The 9-pin Deutsch™ connector, Part Number 3824018, connector can supply SAE J1587/SAE 1708 and SAE J1939 communications, and battery voltage. The following are pin-outs for the 9-pin connector:

Pin	Signal
A	Ground
B	Unswitched Battery
C	J1939 data link (+)
D	J1939 data link (-)
E	J1939 data link (shield) (**not** applicable for Marine)
F	J1708 data link (+)
G	J1708 data link (-)
H	Open
J	Open



The 3-pin SAE J1939 Deutsch™ connectors are also found on some Cummins® engine harnesses. Two possible types of 3-pin connectors can be present: A 3-pin plug (1), Part Number 3824288; and a 3-pin receptacle (2), Part Number 3824290. The following are the pin-outs for the 3-pin connector:

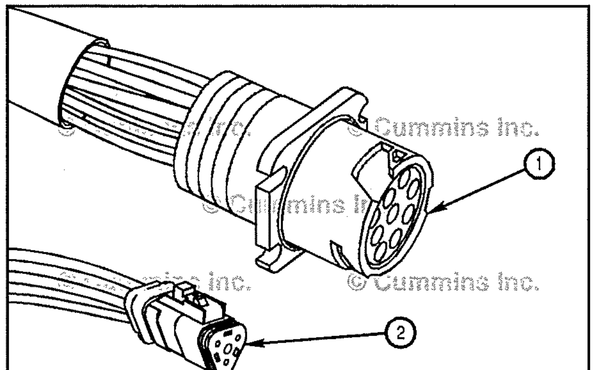
Pin	Signal
A	J1939 data link (+)
B	J1939 data link (-)
C	J1939 data link (shield)

The 3-pin connector **only** supports the SAE J1939 data link.

To meet the SAE J1939 standard, the 3-pin receptacle connector **must** be within 0.66 m [2.16 ft] of the ECM. Use of the J1939 mini-backbone harness, Part Number 3163096, may be required for proper termination resistance. The mini-backbone harness is required when no backbone is provided on the data link. Gender changer cable, Part Number 3163597, may be required to connect the mini-backbone harness to the engine harness or service tool cable.

NOTE: If there is 60 ohm resistance measured between pins A and B of the 3-pin connector, a backbone is on the data link.

Resistance Check



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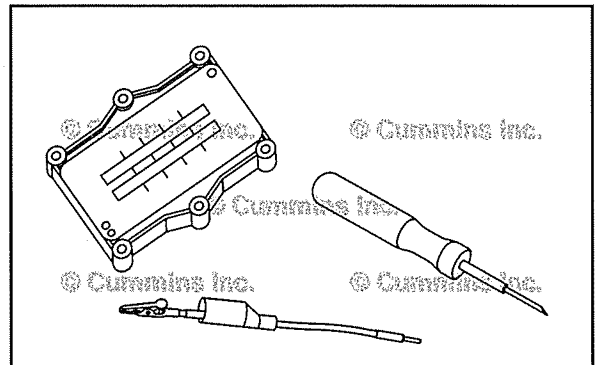
⚠WARNING⚠

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⚠

For the J1939 engine data link, use ECM connector electrical circuit tester Part Number 2892510, on the ECM connector to avoid damage to the connector pins. Use test lead, Part Number 3824811, for the 9-pin Deutsch™ connector. Use test lead, Part Number 3823993 for the 3-pin Deutsch™ connector pin receptacle or test lead, Part Number 3823994 for the 3-pin Deutsch™ connector.

Determine the type of engine data link available on the engine, either J1939 or J1587/J1708. Follow the instructions provided to measure the resistance for the type of engine data link identified.



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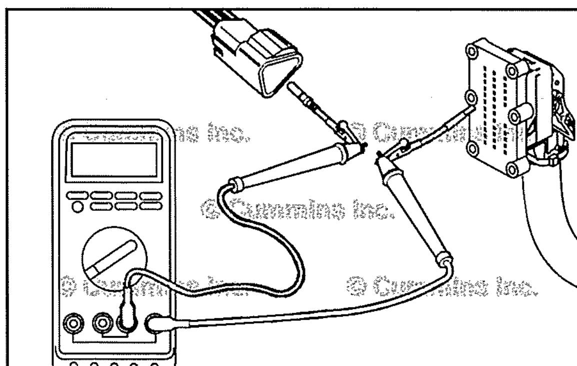
⚠CAUTION⚠

Do not insert test leads into the ECM connector terminals. Doing so may cause terminals to spread and cause intermittent electrical connections.

To perform pin-out diagnostic checks, use ECM connector electrical circuit tester, Part Number 2892510, and test lead, Part Number 3164113.

All diagnostic test leads, connector repair tools, and repair terminals can be found in CM2350 ECM Connector Repair Kit, Part Number 2892512.



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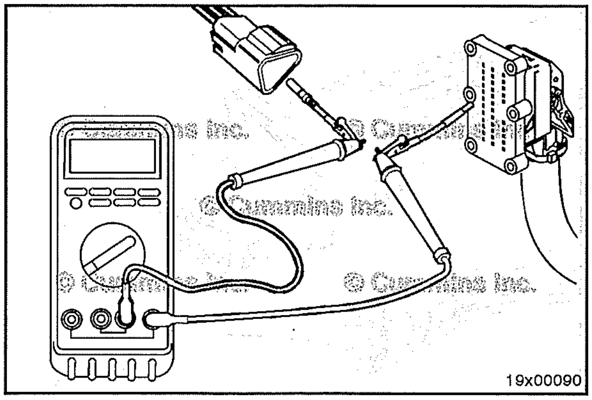
J1939 Engine Data Link

- Disconnect the batteries.
- Disconnect the engine harness connector from the ECM. Turn the keyswitch to the OFF position.



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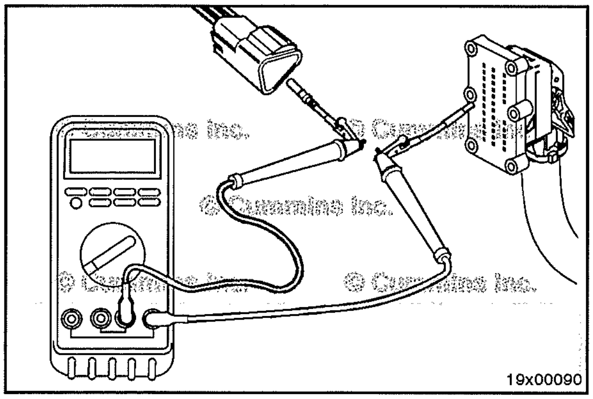
Use ECM circuit tester Part Number 2892510 to connect the SAE J1939 data link positive (+) pin on the ECM connector to the multimeter. Insert the other test lead into the SAE J1939 data link positive (+) pin of the 3-pin or 9-pin Deutsch™ connector, and connect it to the multimeter.

Measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.

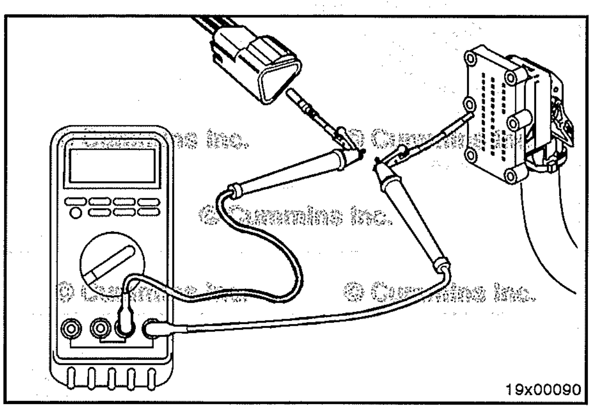


19x00090

Use ECM circuit tester Part Number 2892510 to connect the SAE J1939 data link positive (+) pin on the ECM connector to the multimeter. Touch the other lead to the SAE J1939 data link negative (-) pin of the 3-pin or 9-pin Deutsch™ connector. Measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.



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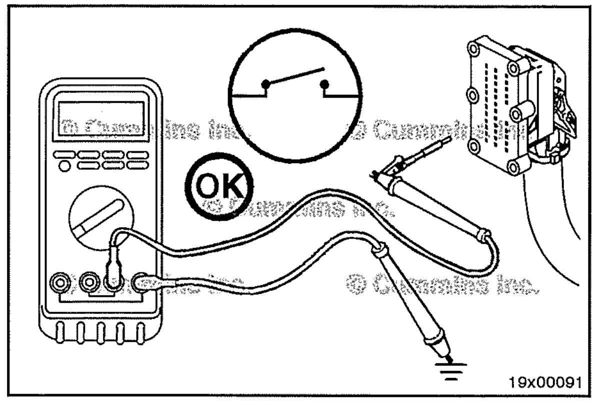
If the values are correct, the circuit **must** still be checked for a short circuit to ground and a short circuit from pin-to-pin.

The multimeter **must** show a closed circuit (10 ohms or less). If more than 10 ohms are measured in any of these steps, there could be an open circuit in the SAE J1939 data link (shield) pin, the SAE J1939 data link negative (-) pin, or the SAE J1939 data link positive (+) pin, or the polarity is **not** correct.

Check for Short Circuit to Ground



CAUTION

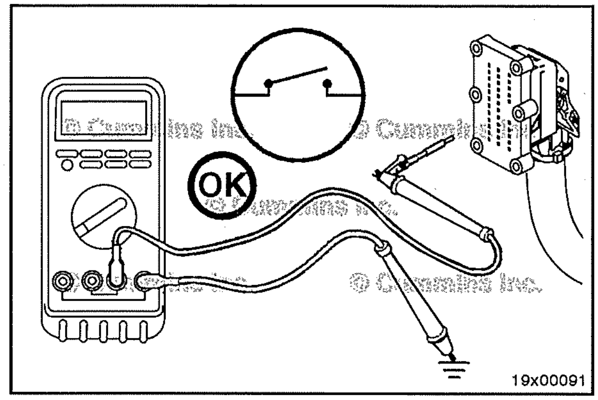
For the J1939 engine data link, use ECM circuit tester, Part Number 2892510, on the ECM connector to avoid damage to the connector pins.

Disconnect the engine harness connector from the ECM. Use ECM ciruit tester, Part Number 2892510, to connect SAE J1939 data link positive (+) pin of the engine harness ECM connector to a multimeter probe. Touch the other multimeter probe to engine block ground.

Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.



Use ECM circuit tester Part Number 2892510 and measure the resistance from the SAE J1939 data link negative (-) pin of the engine harness ECM connector to the engine block ground. The multimeter **must** show an open circuit (100k ohms or more).

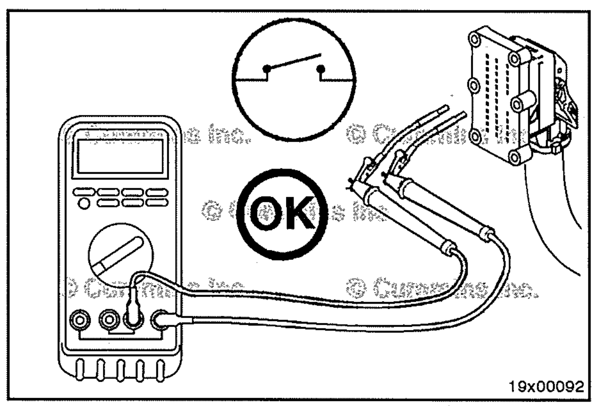
If the circuit is **not** open, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.

If less than 100k ohms is measured in any of the previous steps, there is a short to circuit to ground. Repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.

Check for Short Circuit from Pin to Pin



CAUTION

For the J1939 engine data link, use test lead, Part Number 3822758, on the ECM connector to avoid damage to the connector pins.

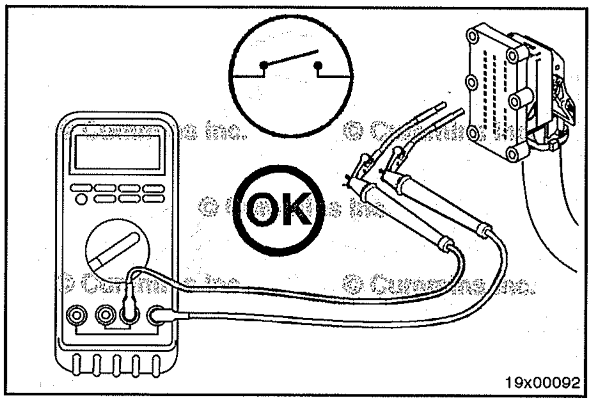
Disconnect the engine harness connector from the ECM.

Use ECM circuit tester Part Number 2892510 to connect the SAE J1939 data link positive (+) pin on the ECM connector to the multimeter probe. Connect the other multimeter probe to another pin on the ECM circuit test, Part Number 2892510.

Measure the resistance from the SAE J1939 data link positive (+) pin to the first pin in the connector. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the engine harness.

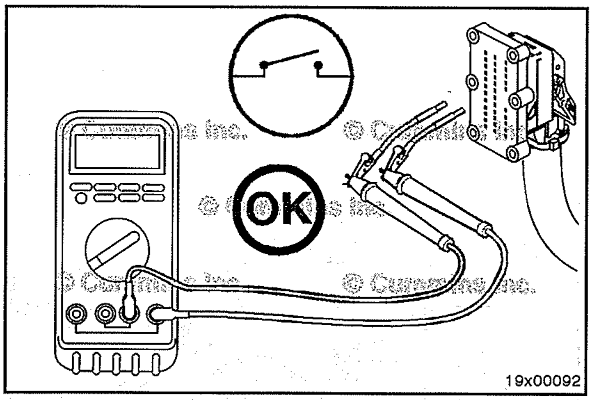
See the Troubleshooting and Repair manual for additional information.



Measure the resistance from the SAE J1939 data link positive (+) pin of the engine harness ECM connector to all other pins in the connector, one at a time using the ECM circuit tester. The multimeter **must** show an open circuit (100k ohms or more) at all pins.

If the circuit is **not** open, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.



Use ECM circuit tester Part Number 2892510 to connect the SAE J1939 data link positive (-) pin on the ECM connector to the multimeter probe. Connect the other multimeter probe to another pin on the ECM circuit test, Part Number 2892510. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

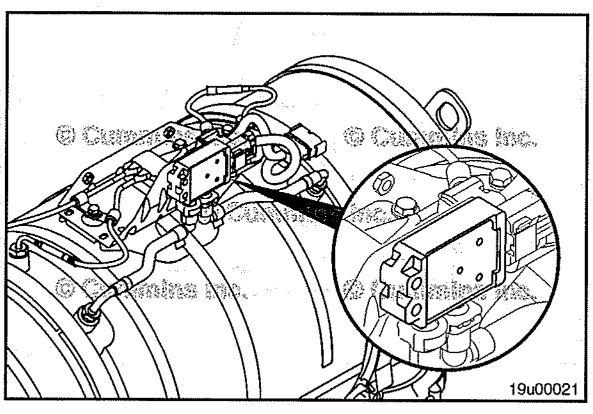
If the circuit is **not** open, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.

Measure the resistance from the SAE J1939 data link negative (-) pin of the engine harness connector to all other pins in the connector, one at a time using the ECM circuit tester. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.



Aftertreatment Diesel Particulate Filter Differential Pressure Sensor (019-443)

General Information

The aftertreatment diesel particulate filter (DPF) differential pressure sensor measures pressure across the aftertreatment DPF and outlet pressure.

The aftertreatment DPF differential/outlet pressure sensor is mounted on the aftertreatment DPF differential pressure sensor mounting bracket.

Initial Check

In INSITE™ electronic service tool, add the following parameter to the Data Monitor/Logger screen:

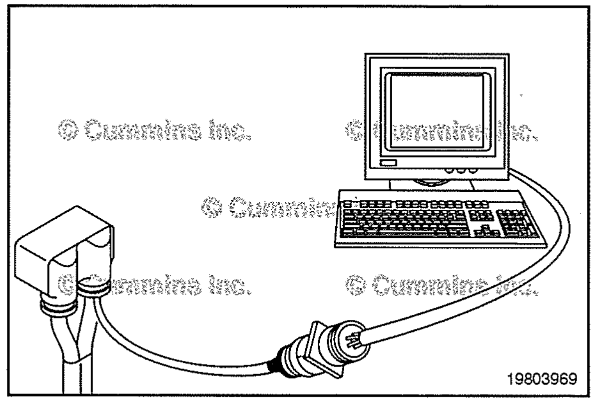
1 Aftertreatment DPF differential pressure sensor signal voltage.

Verify that the parameter aftertreatment DPF differential pressure sensor signal voltage at keyswitch ON, engine OFF.

At 25°C [77°F] and below the reading should be 0.69 +/- 0.1-VDC.

At 26°C [78°F] and above the reading should be 0.69+/- 0.06-VDC.

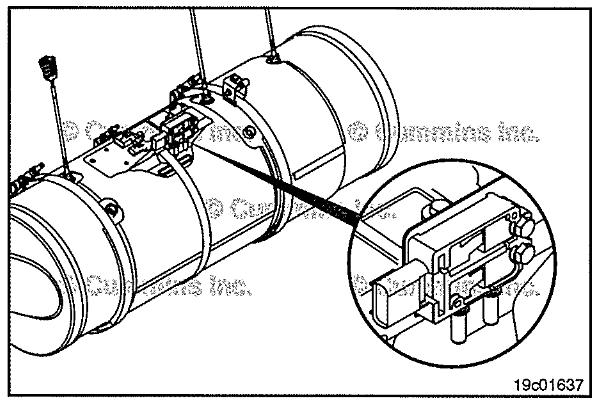
NOTE: If the aftertreatment DPF differential pressure sensor signal voltage does **not** read within specification, inspect the aftertreatment DPF differential pressure sensor wiring for correct resistance and pin-to-pin routing. Inspect DPF differential pressure tubes for blockage. Refer to Procedure 011-047 in Section 11.



Disconnect the aftertreatment DPF differential pressure sensor wiring harness connector.

Use INSITE™ electronic service tool to verify that Fault Codes 1881 and 3134 are active.

NOTE: If Fault Codes 1881 and 3134 did **not** become active, inspect the aftertreatment DPF differential pressure sensor wiring for correct resistance and pin-to-pin routing.

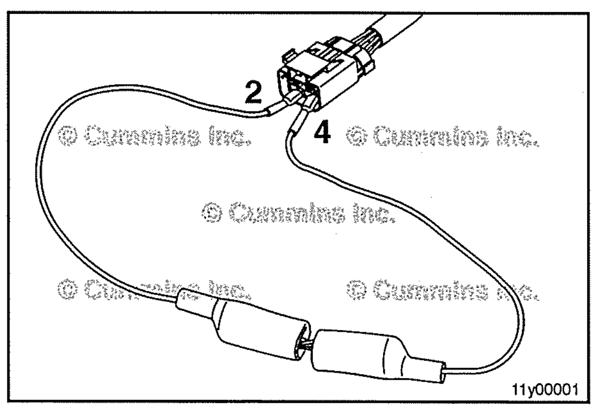


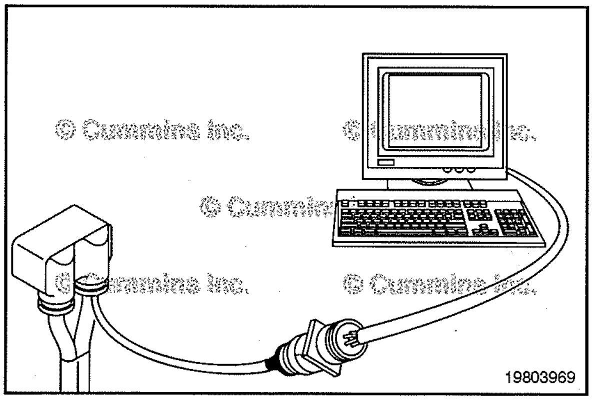
Use the Framatome™ male test lead, Part Number 3164596, or equivalent, to short the aftertreatment DPF differential pressure sensor SUPPLY pin to the aftertreatment DPF differential pressure sensor SIGNAL pin.

Use INSITE™ electronic service tool to verify that Fault Codes 1879 and 3134 are active.

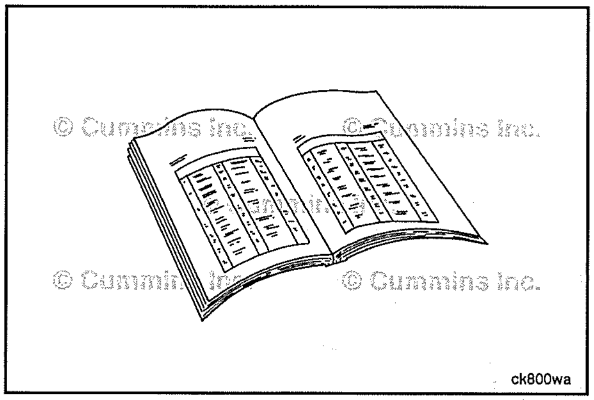
NOTE: If Fault Codes 1879 and 3134 did **not** become active, the aftertreatment DPF differential pressure sensor signal and aftertreatment DPF outlet pressure sensor signal could be incorrectly routed from pin-to-pin. See equipment manufacturer service information.

NOTE: If Fault Codes 1881 and 3134 did **not** become active, inspect the aftertreatment DPF differential pressure sensor wiring for correct resistance and pin-to-pin routing.





If the aftertreatment DPF differential pressure sensor signal voltage does **not** meet specification and circuit response tests meet expectations, replace the aftertreatment DPF differential pressure sensor.

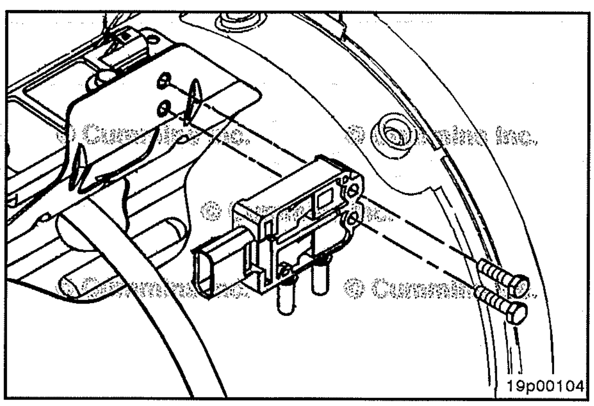


Preparatory Steps

⚠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.

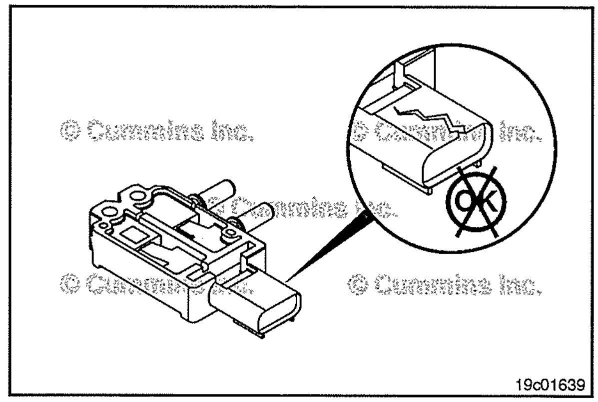
- Disconnect the vehicle batteries. See equipment manufacturer service information.
- Disconnect the differential pressure sensor tubes from the sensor by releasing the quick connect locking tab and pulling the tubes off the sensor.
- Squeeze the locking tab and pull the connector apart to disconnect the differential pressure sensor wiring harness connector.



Remove

Remove the aftertreatment DPF differential pressure sensor from the aftertreatment DPF differential pressure sensor mounting bracket.

Clean and Inspect for Reuse



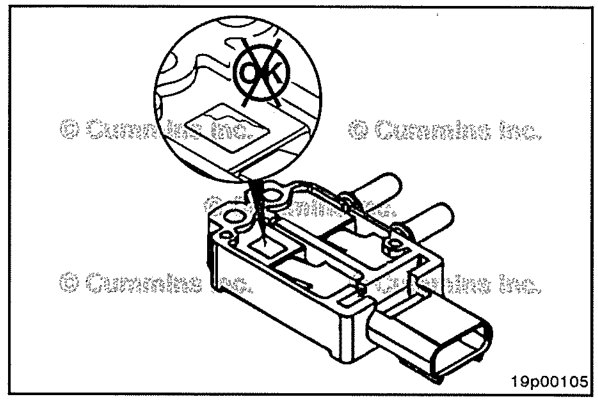
Inspect the tubes for cuts or holes. Replace the tubes if damage is found.

Inspect the inside of the tubes for plugging or soot accumulation. If plugging or soot accumulation is present, the tubes **must** be cleaned. Refer to Procedure 011-047 in Section 11.

Inspect the differential/outlet pressure sensor electrical connector for damage.

Inspect the differential/outlet pressure sensor for cracks or body damage.

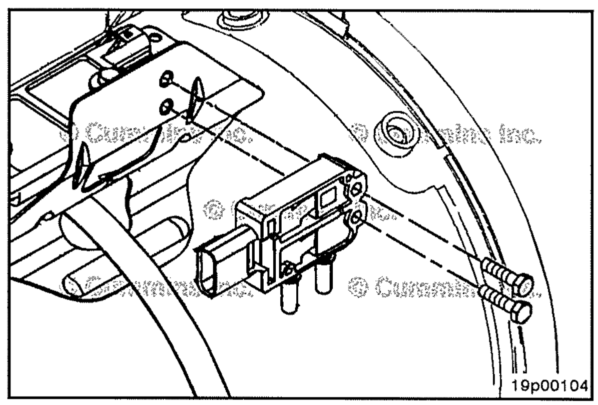
Replace the differential/outlet pressure sensor if damage is found.



Inspect the differential/outlet pressure sensor vent for blockage or damage.

Replace the differential/outlet pressure sensor if blockage or damage is found.

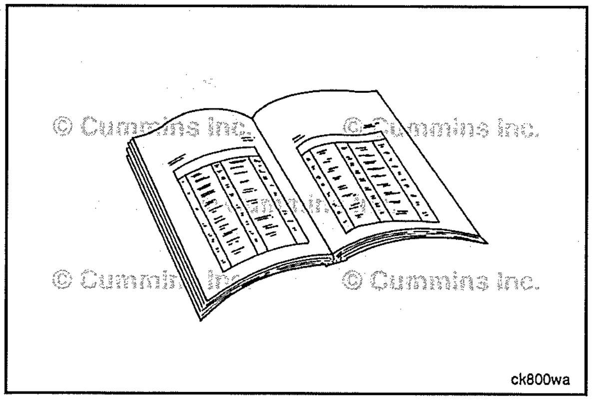
Install



Install the aftertreatment DPF differential pressure sensor and the two mounting capscrews.

Tighten the two mounting capscrews.

Torque Value: 14 N•m [124 in-lb]

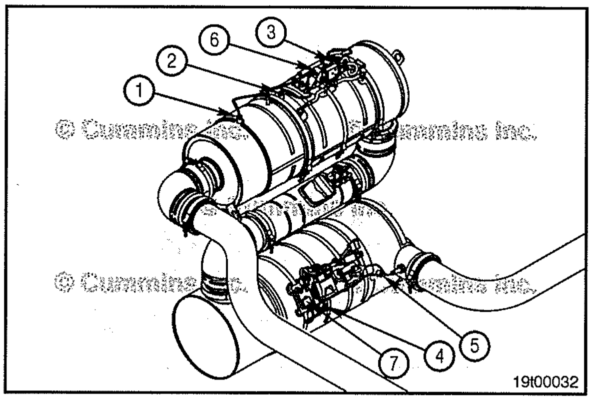


Finishing Steps

⚠ 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 aftertreatment DPF differential pressure sensor to the DPF aftertreatment interface harness.
- Install the differential pressure sensor tubes. Refer to Procedure 011-047 in Section 11.
- Connect the vehicle batteries. See equipment manufacturer service information.



Aftertreatment Exhaust Gas Temperature Sensor (019-449)

General Information

Exhaust gas temperature sensors are used to measure the temperature of exhaust gases, for use with the aftertreatment system.

The exhaust gas temperature sensor is a one-piece unit made up of several small temperature sensors with wire connections to the temperature sensor module. The parts **must not** be separated.

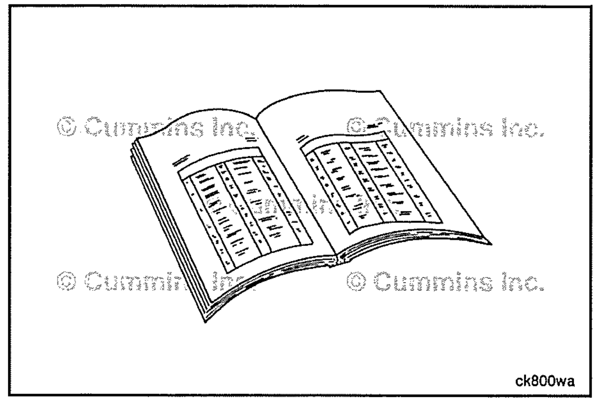
The aftertreatment temperature sensors are located in the aftertreatment system. The aftertreatment diesel particulate filter (DPF) has one temperature sensor module with three temperature sensors. The aftertreatment selective catalytic reduction (SCR) catalyst has one temperature sensor module with two temperature sensors.

The aftertreatment diesel oxidation catalyst (DOC) intake temperature sensor (1) is located closest to the turbocharger outlet. The aftertreatment DPF intake temperature sensor (2) is located between the aftertreatment DOC and the aftertreatment DPF. The aftertreatment DPF filter outlet temperature sensor (3) is located in the outlet of the aftertreatment DPF. The aftertreatment SCR catalyst intake temperature sensor (4) is located in the intake of the aftertreatment SCR catalyst. The aftertreatment SCR catalyst outlet temperature sensor (5) is located in the oultet of the aftertreatment SCR catalyst.

NOTE: Some of the sensor wires will have the same lead lengths and can be installed incorrectly. Record the location of each sensor before removing it from the aftertreatment system. Install each sensor in the same location as removed.

Due to the number of various aftertreatment configurations, this procedure has been written to be generic. **Not** all illustrations within this procedure will represent the application that is being worked on.

Preparatory Steps

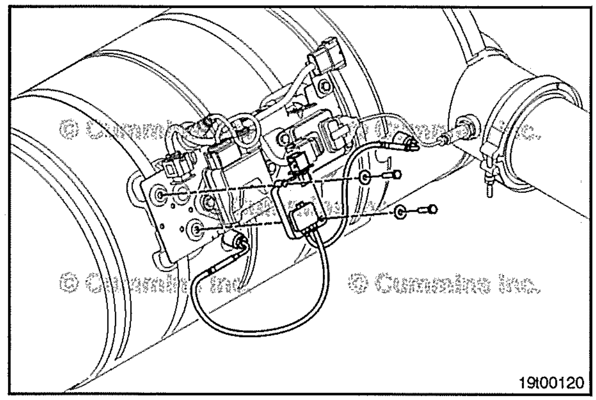


ck800wa

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

- Disconnect the batteries. See equipment manufacturer service information.
- Remove necessary shielding to access aftertreatment temperature sensor. See equipment manufacturer service information.

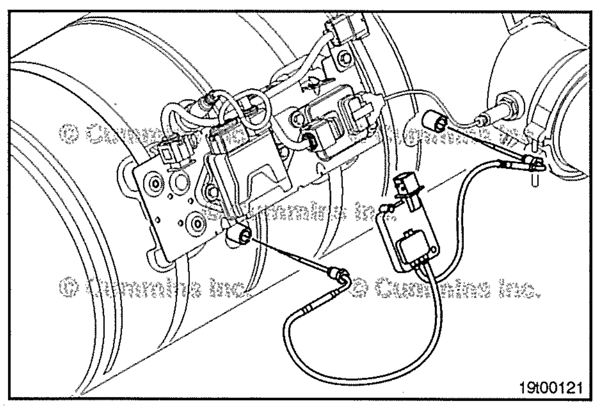
Remove



19t00120

NOTE: Label each of the temperature sensors prior to removal. Some of the temperature probe lead lengths are the same. The temperature probes **must** be installed in the same location that they were removed.

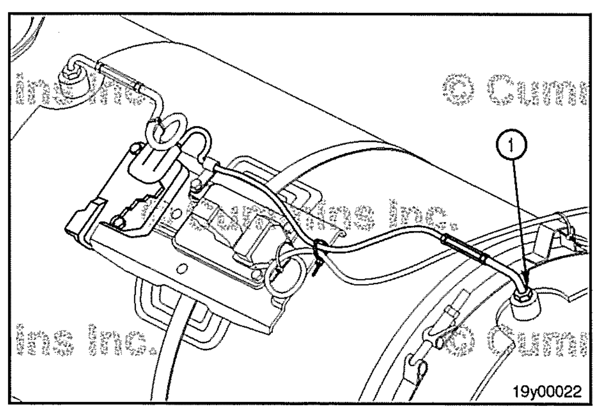
Pull the yellow connector locking tab to disconnect the aftertreatment wiring harness from the temperature sensor module (1).



19t00121

⚠WARNING⚠
The aftertreatment system will stay hot to touch for long periods of time after the engine has been shut down. To reduce the possibility of personal injury, avoid direct contact of hot components with your skin.

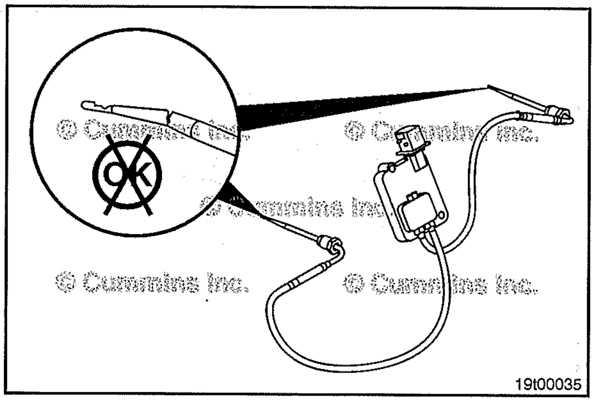
Loosen the retaining nuts and remove the aftertreatment temperature sensors (1) from the aftertreatment system.



19y00022

Side out horizontal selective catalytic reduction assemblies temperature sensor (1) requires an extra step.

To remove the temperature sensor (1) in addition to the generic steps mentioned above, it is required to separate the lead connection between the mono-nitrogen oxides (NOx) sensor and the temperature sensor (zip ties connection).

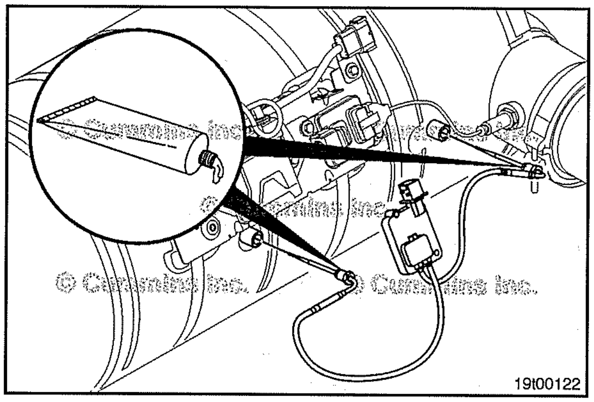


Inspect for Reuse

Inspect the aftertreatment gas temperature sensors and module for damaged or exposed wires, bent or broken pins, damaged connectors, or damaged threads.

Inspect the tip of the aftertreatment gas temperature sensors for cracks, dents, kinks, and carbon buildup.

Replace the entire assembly if damage is found.



Install

⚠CAUTION⚠

If the temperature sensor wire connectors are not installed in the proper locations, aftertreatment system damage can result.

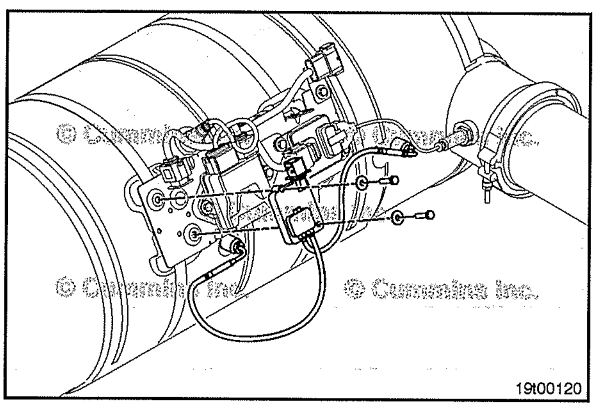
Apply a coating of Loctite™ 80209, 51002, 76732 copper or silver grade anti-seize, or equivalent, to the exhaust gas temperature sensor threads prior to assembly.

NOTE: Make sure to install the aftertreatment gas temperature sensors in the same location from which they were removed.

Install the aftertreatment gas temperature sensors.

Tighten the nut that secures the sensors to the aftertreatment system.

Torque Value: 30 N•m [22 ft-lb]



Attach the temperature sensor module (1) to the aftertreatment system. Tighten the mounting capscrews.

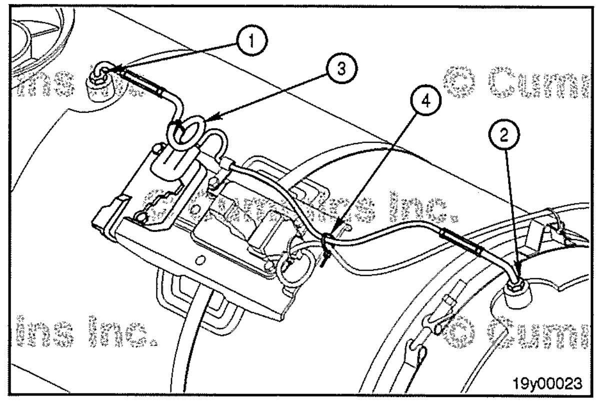
Torque Value: 13.6 N•m [120 in-lb]

Connect the temperature sensor module to the aftertreatment wiring harness.

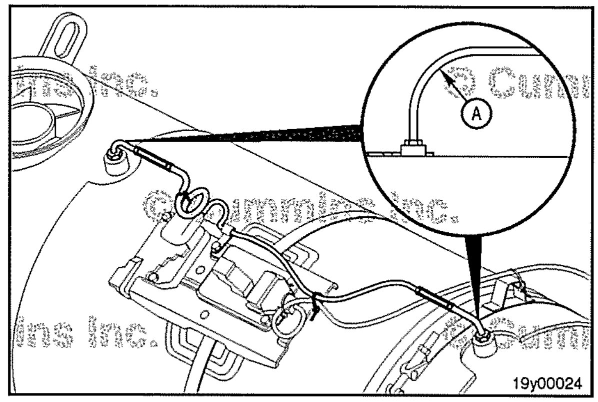
Side out horizontal selective catalytic reduction assemblies temperature sensors (1) and (2) require an extra step in comparison to the generic installation.

A loop in the lead (3) is required for sensor (1). The sensor **must** be mounted so that the sensor lead components do **not** come in contact with any component other than the clips used to make sure the sensor lead is secured.

Sensor (2) lead should be attached with a zip tie (4), Part Number A046C278, to the NOx sensor lead. Use the following procedure for NOx sensor lead management. Refer to Procedure 019-451 in Section 19.



Sensors probe lead (A) near the exit from the sensor connection **must** be installed to have a bend radius of 20 mm [0.787 in] or more.

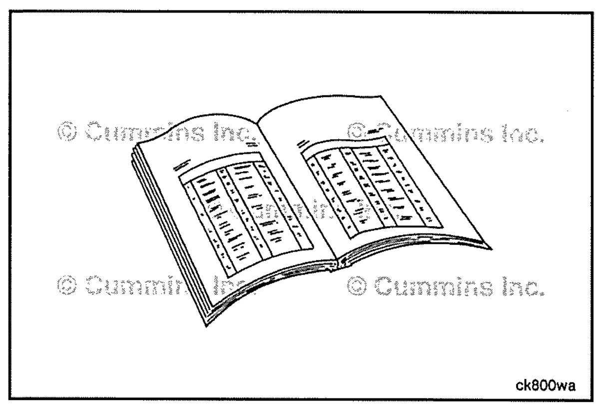


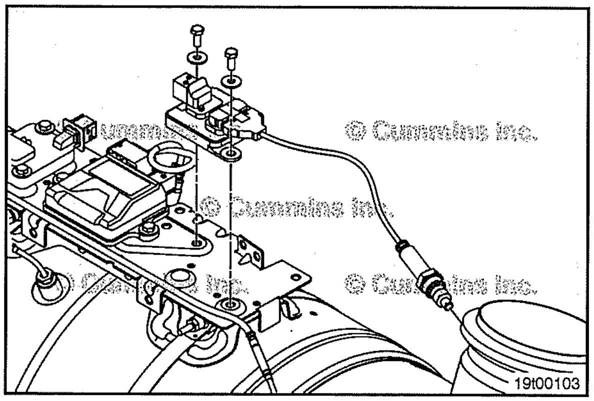
Finishing Steps

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 shielding that was removed for access. See equipment manufacturer service information.
- Connect the batteries. See equipment manufacturer service information.
- Start and operate the engine and check for proper operation.





Aftertreatment Outlet NOx Sensor (019-451)

General Information

⚠CAUTION⚠

The exhaust catalyst will stay hot to the touch for long periods of time after the engine has been switched off.

⚠CAUTION⚠

The mono-nitrogen oxides (NOx) sensor will stay hot to the touch for long periods of time after the engine has been switched off. The NOx sensor will also be hot if the engine keyswitch is on.

⚠CAUTION⚠

Do not underseal or coat/paint any part of the NOx sensor.

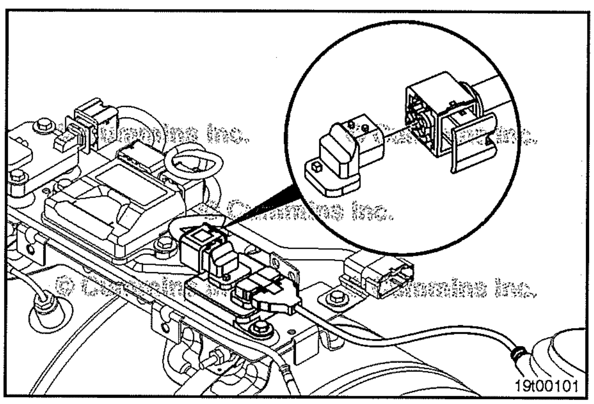
⚠CAUTION⚠

Wear goggles and protective clothing to reduce the possibility of personal injury.

The NOx sensor is located either in the exhaust muffler or in the exhaust tailpipe.

The NOx sensor is a one-piece unit made up of two parts, a small module with a wire connection to a metal sensor body that sits in the exhaust system. The parts **must not** be separated.

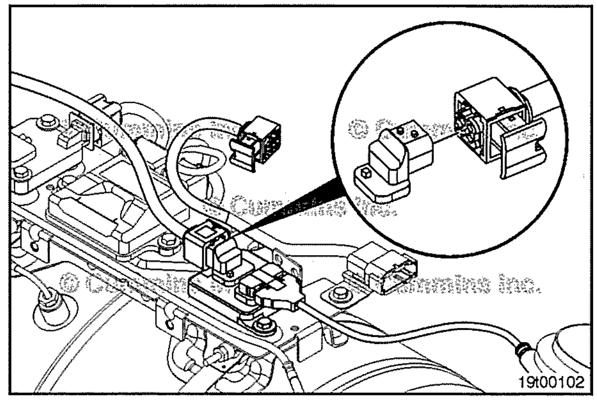
The NOx sensor is **not** serviceable. If malfunctioning, the sensor **must** be replaced.



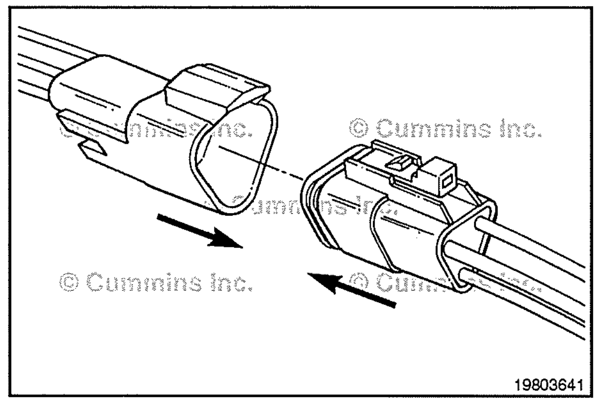
Test

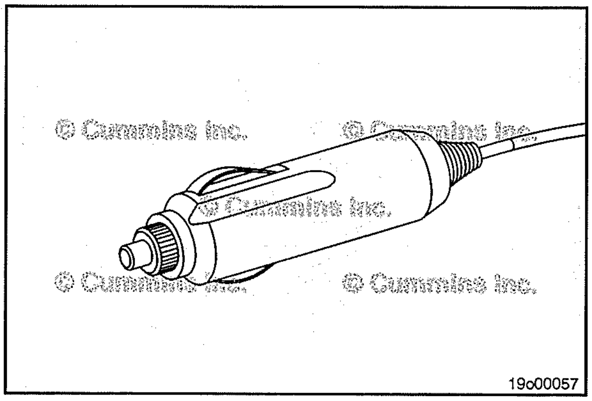
Unplug the NOx sensor from the vehicle harness.

Connect the Cummins® service tool, Part Number 5298821, to the NOx sensor module.



Connect the service tool data link, 3-pin Deutsch™, to the engine Society of Automotive Engineers (SAE) J1939 data link connection, located on the driver's side of the engine.





19o00057

Use the vehicle 12 VDC to supply power to the service tool.

NOTE: Cummins® battery adapter cable, Part Number 3823955, can be used to provide power from the vehicle battery supply.

For Fault Codes 3681 and 3682 - the following conditions **must** be met before checking the status of the active fault code.

Start the engine and allow the NOx sensor to reach operating temperature.

This diagnostic runs when the exhaust gas temperature of the aftertreatment intake or outlet NOx sensor is above 200°C [392°F] and the engine is running. Use INSITE™ electronic service tool to monitor exhaust gas temperature.

NOTE: For the aftertreatment outlet NOx sensor, there is also a 60 second delay after the exhaust gas temperature reaches 200°C [392°F].

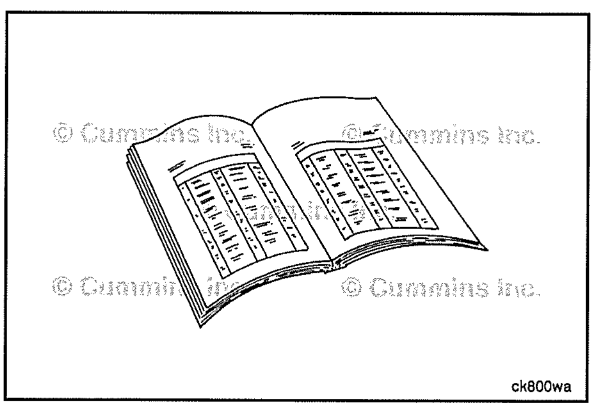
For Fault Codes 2771 and 3232 - the following conditions **must** be met before checking the status of the active fault code.

This diagnostic runs continuously when the keyswitch is in the ON position.

NOTE: If service tool is being used on 24 volt sensor, battery adapter cable, Part Number 3823955, will need to be used to provide power from the vehicle. battery supply.

Check for inactive fault codes. After the above conditions have been met for the active fault code:

- Check to see if any of the active fault codes listed (2771, 3232, 3681, and 3682) now display as inactive.
- If the active fault codes now display as inactive, the sensor is operating normally and should **not** be replaced. The source of the fault code is located within the wiring that was isolated by the service tool.



ck800wa

Preparatory Steps

WARNING

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

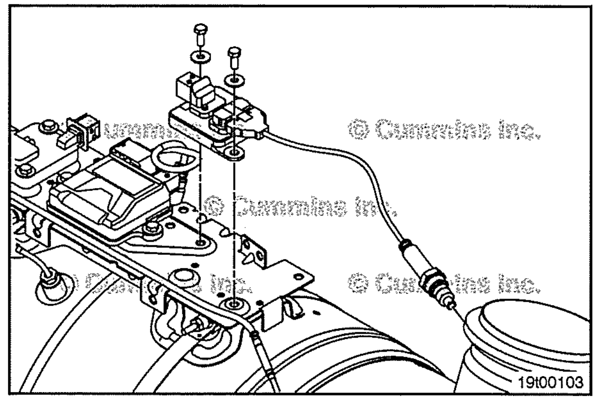
- Disconnect the batteries. See equipment manufacturer service information.

Remove

Disconnect the slide-lock connector from the NOx sensor module.

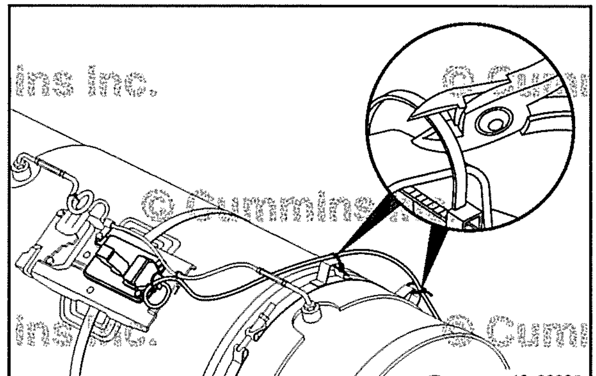
Remove the two retaining capscrews.

Remove the retaining nut and pull out the NOx sensor from the exhaust catalyst/exhaust pipework.


19t00103

Side out horizontal selective catalytic reduction assemblies NOx sensor requires an extra step.

In order to remove the NOx sensor, in addition to the generic steps mentioned above, it is required to separate the wire connection between the NOx sensor and the temperature sensor (zip tie connections).


19y00025

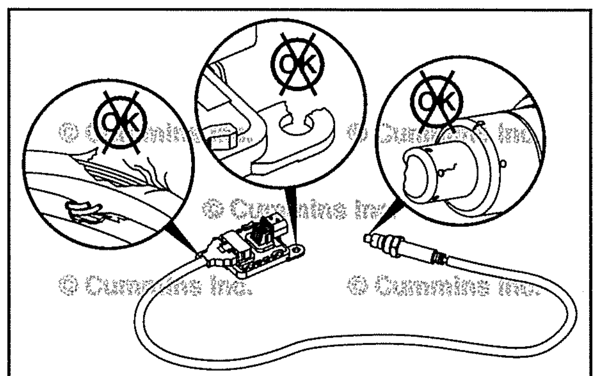
Clean and Inspect for Reuse

⚠CAUTION⚠
Do not clean the NOx sensor with any kind of fluid.

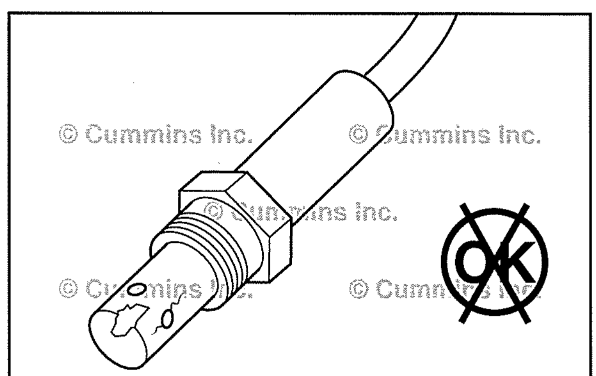
⚠CAUTION⚠
Do not immerse the NOx sensor in water or any kind of chemical wash.

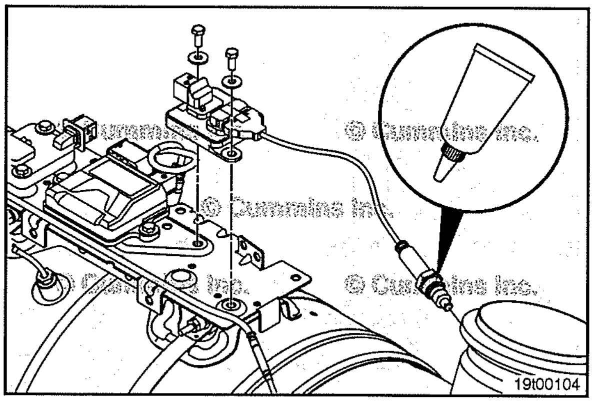
⚠CAUTION⚠
Do not jet-wash or steam clean the NOx sensor.

Visually inspect the NOx sensor for damage to the wiring or the body of the sensor.


19u00018

Visually inspect the tip of the NOx sensor for other damage.


19d02417

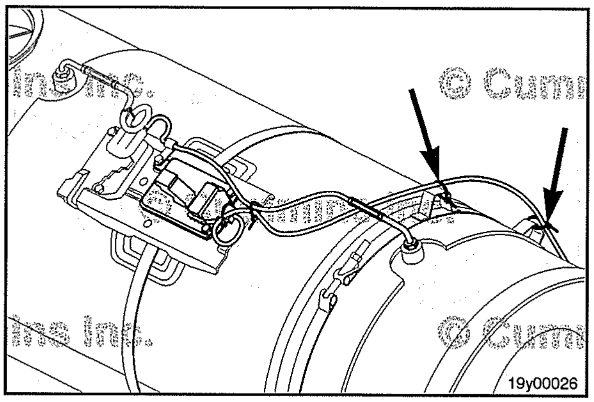


Install

Apply a light coating of anti-seize compound, Part Number 3824879, to the threads of the NOx sensor.

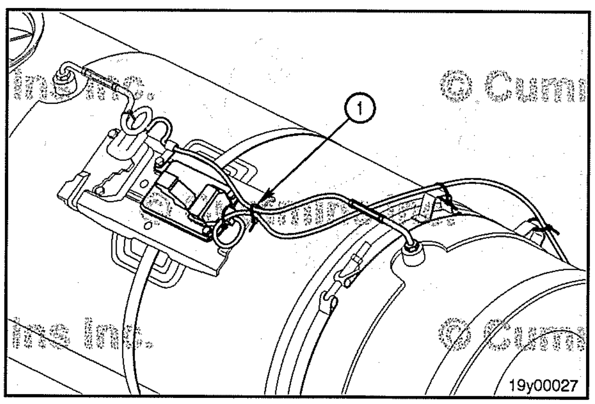
Install the NOx sensor to the exhaust system and tighten the retaining nut.

Torque Value: 50 N•m [37 ft-lb]

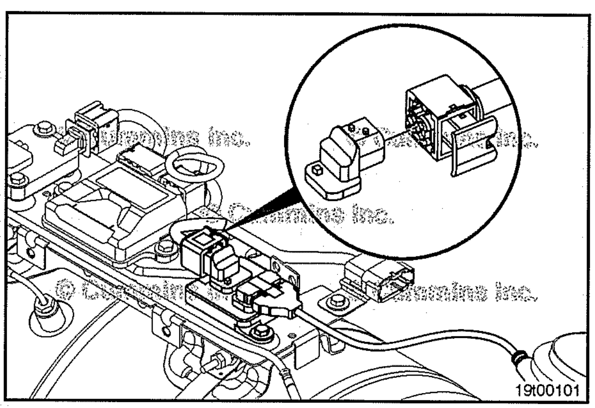


Side out horizontal selective catalytic reduction assemblies NOx sensors installation requires extra steps.

The sensor **must** be mounted so that the sensor lead components do **not** come in contact with any component other than the clips used to make sure the sensor lead is secured.



Make sure to provide the adequate loops to the lead in order to manage the excess. Secure the loop by adding a final zip tie connection (1) between the temperature sensor and the NOx sensor lead.

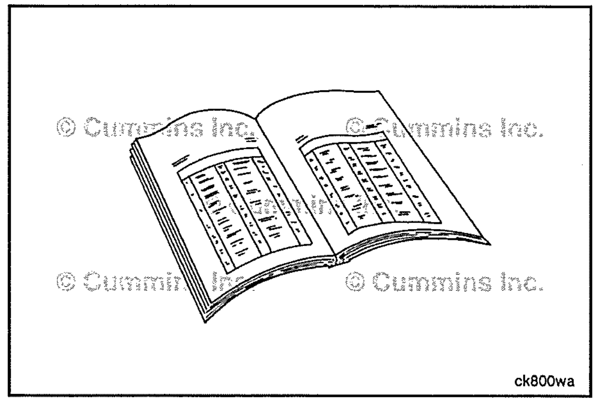


Make sure that the NOx sensor is connected to the SCR aftertreatment interface harness.

Make sure that the small module is secured to the application by the two mounting capscrews.

Torque Value: 10 N•m [89 in-lb]

Finishing Steps

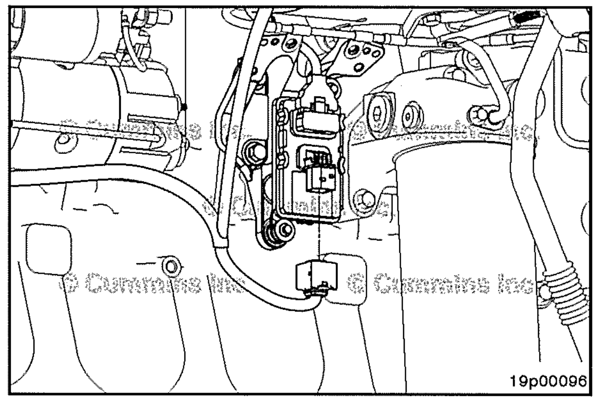


⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for proper operation.
- Use INSITE™ electronic service tool to check for active fault codes.

Aftertreatment Intake NOx Sensor (019-463)

General Information



⚠CAUTION⚠
The NOx sensor will stay hot to the touch for long periods of time after the engine has been switched OFF. The NOx sensor will also be hot if the engine keyswitch is in the ON position.

⚠CAUTION⚠
Do not underseal, coat, or paint any part of the NOx sensor.

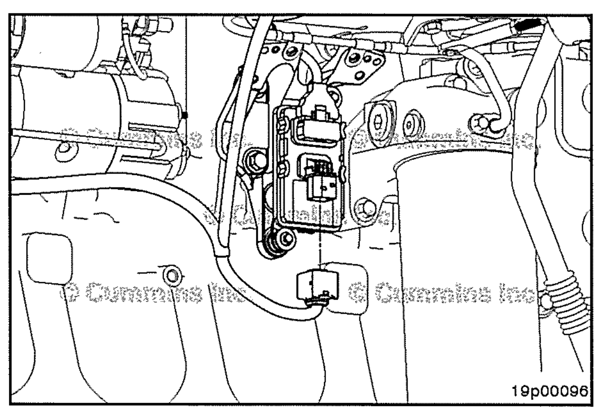
⚠CAUTION⚠
Wear goggles and protective clothing to reduce the possibility of personal injury.

The aftertreatment intake NOx sensor is located under the turbocharger.

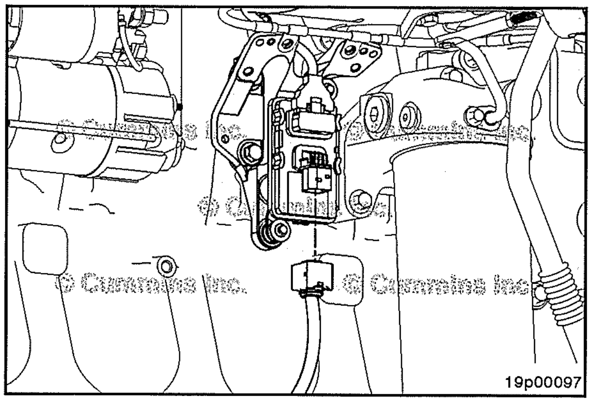
The NOx sensor is a one-piece unit made up of two parts, a small module with a wire connection to the metal sensor body that sits in the exhaust system. The parts **must not** be separated.

The NOx sensor is **not** serviceable. If the sensor is malfunctioning, the part **must** be replaced.

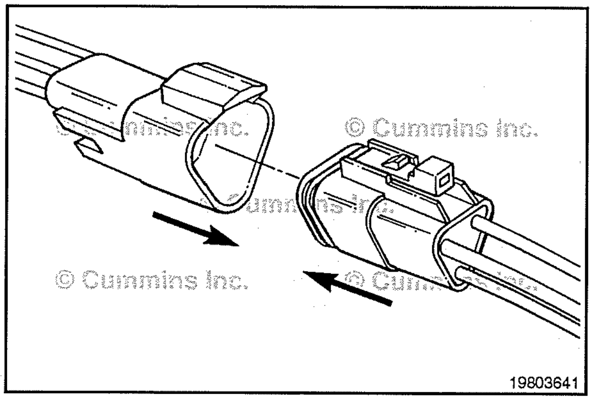
Test



Unplug the NOx sensor from the engine harness.



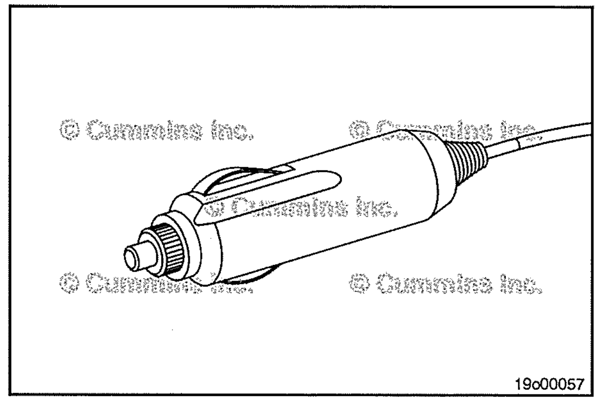
Connect the service tool, Part Number 5298821, to the NOx sensor module.



Connect the service tool data link (3-pin Deutsch™) to the engine Society of Automotive Engineering (SAE) J1939 data link connection, located on the driver's side of the engine.

Use the vehicle 12-VDC to supply power to the service tool.

NOTE: Battery adapter cable, Part Number 3823955, can be used to provide power from the vehicle battery supply.



For Fault Codes 3681 and 3682, the following conditions **must** be met before checking the status of the active fault.

Start the engine and allow the NOx sensor to reach operating temperature.

This diagrnostic runs when the exhaust gas temperature of the aftertreatment intake outlet NOx sensor is above 200°C [392°F] and the engine is running. Use INSITE™ electronic service tool to monitor exhaust gas temperature.

NOTE: For the aftertreatment outlet NOx sensor, there is also a 60 second delay after the exhaust gas temperature reaches 200°C [392°F].

For Fault Codes 2771 and 3232, the following conditions **must** be met before checking the status of the active fault.

This diagnostic runs continuously when the keyswitch is in the ON position.

NOTE: If the service tool is being used on a 24-VDC sensor, battery adapter cable, Part Number 3823955, will need to be used to provide power from the vehicle battery supply.

Check for inactive fault codes after the above conditions have been met for the active fault code.

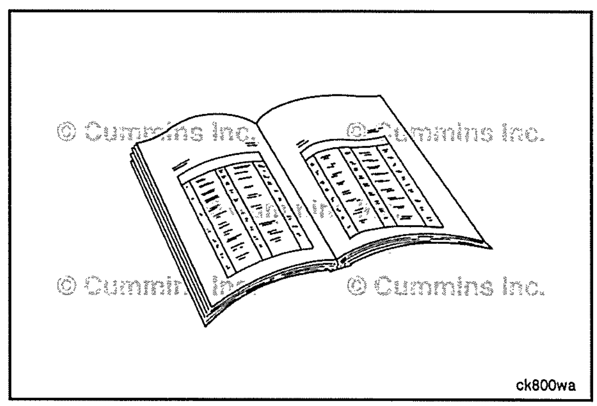
- Check to see if any of the "active" fault codes listed (2771, 3232, 3681, and 3682) now display as "inactive".
- If the active fault codes now display as "inactive", the sensor is operating normally and should **not** be replaced. The source of the fault code is located within the wiring that was isolated by the service tool.

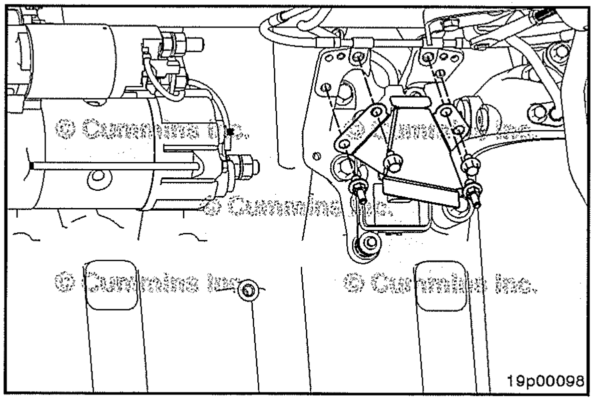
Preparatory Steps

⚠WARNING⚠

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

- Disconnect the batteries. See equipment manufacturer service information.





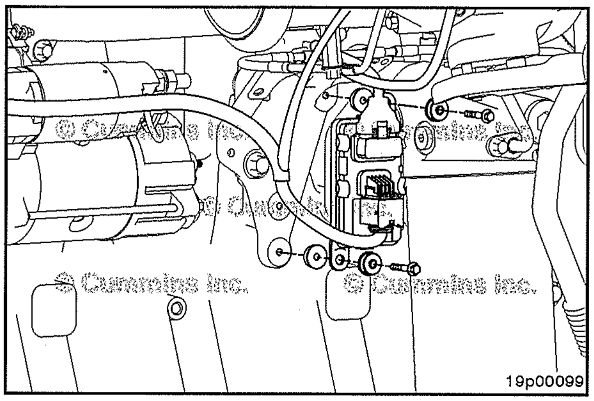
Remove

Note the wire routing of the sensor, so that it can be installed correctly to avoid hot objects and wear areas.

Remove heat shield capscrews.

Remove p-clips.

Remove NOx sensor heat shield.

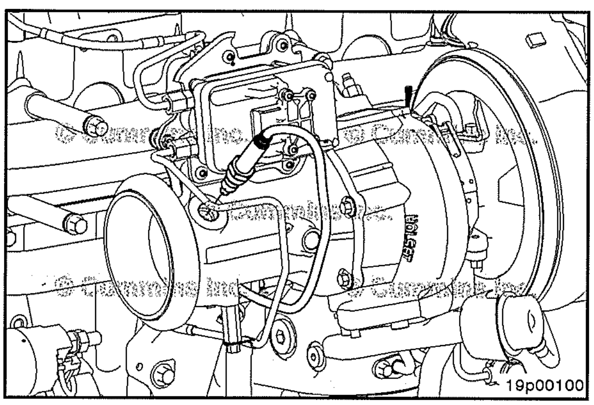


Disconnect the slide-lock connector from the NOx sensor module.

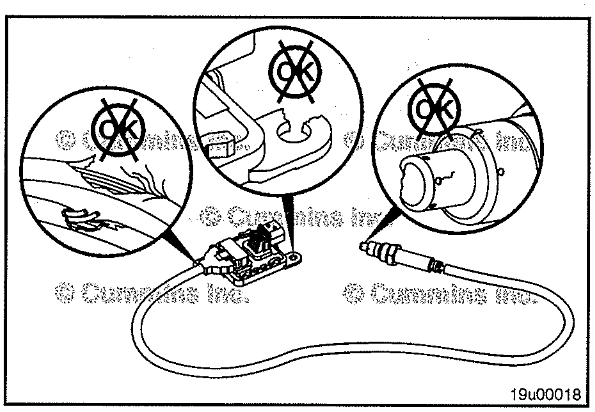
Remove the two retaining capscrews.

Remove vibration isolators.

Remove NOx sensor module.



Remove the retaining nut and pull out the NOx sensor from the exhaust pressure regulator.



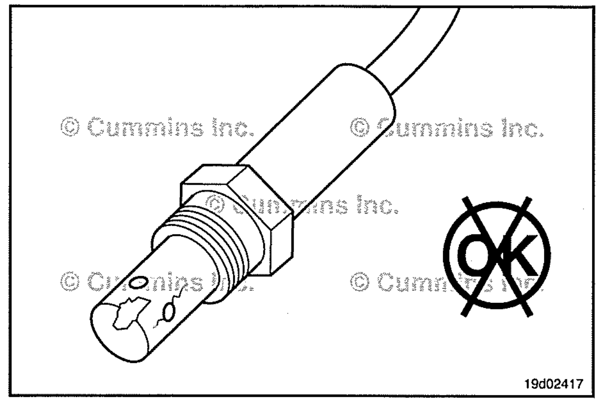
Inspect for Reuse

⚠CAUTION⚠

Do not clean the NOx sensor with any kind of fluid. Do not immerse the NOx sensor in water or any kind of chemical wash. Do not jet-wash or steam clean the NOx sensor.

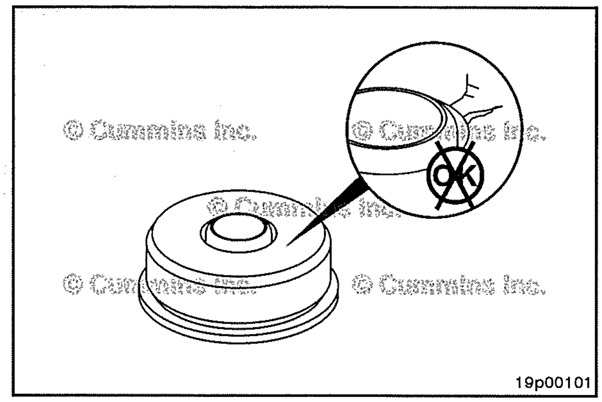
Inspect the NOx sensor for damage to the wiring or the body of the sensor.

Inspect the tip of the NOx sensor for damage.



Inspect vibration isolators for cracks or tears.

Replace the isolators if cracks or tears are found.

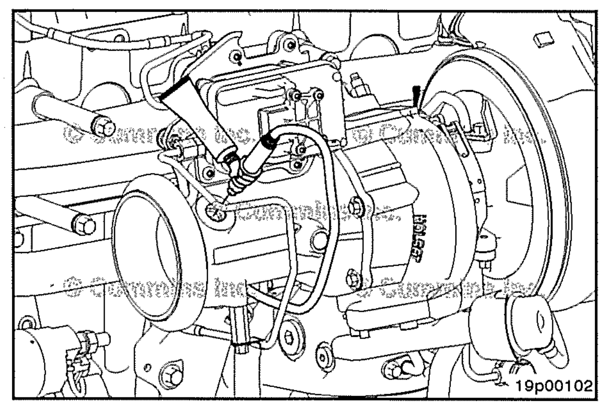


Install

Apply a light coating of anti-seize compound, Part Number 3824879, to the threads of the NOx sensor.

Install NOx sensor into exhaust pressure regulator and tighten retaining nut.

Torque Value: 50 N•m [37 ft-lb]



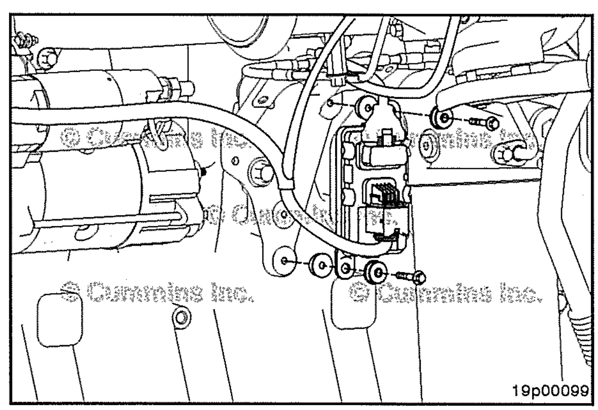
Install vibration isolators.

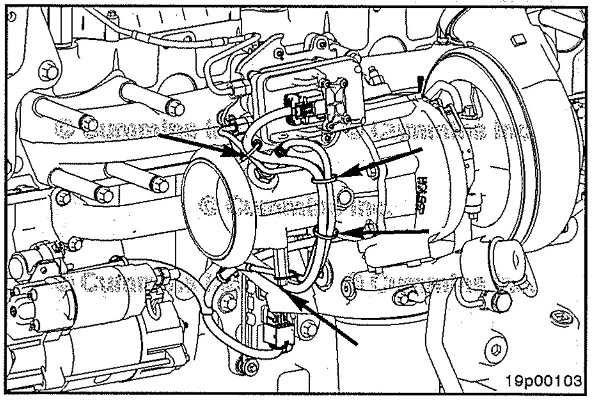
Install NOx sensor module.

Install and tighten capscrews.

Torque Value: 4.4 N•m [39 in-lb]

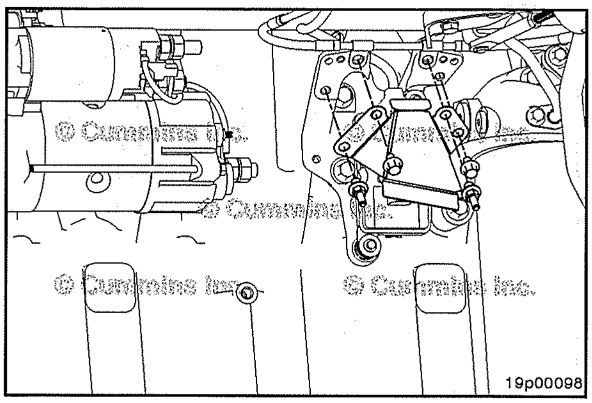
NOTE: The NOx sensor wire connection **must not** be pulled tight. Damage to the sensor can occur.





Route NOx sensor wires in same location as removed.

Wire tie the NOx sensor wire and exhaust pressure regulator wire to the exhaust pressure regulator coolant lines. Use high temperature wire ties.

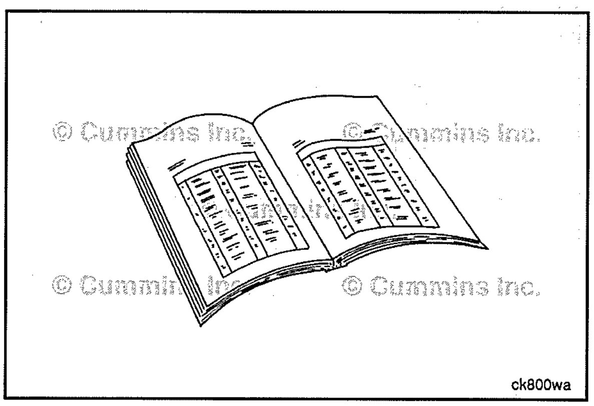


Install heat shield.

Install p-clips.

Install and tighten capscrews.

Torque Value: 18 N•m [159 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 batteries. See equipment manufacturer service information.
- Operate the engine.
- Use INSITE™ electronic service tool to check for active fault codes.

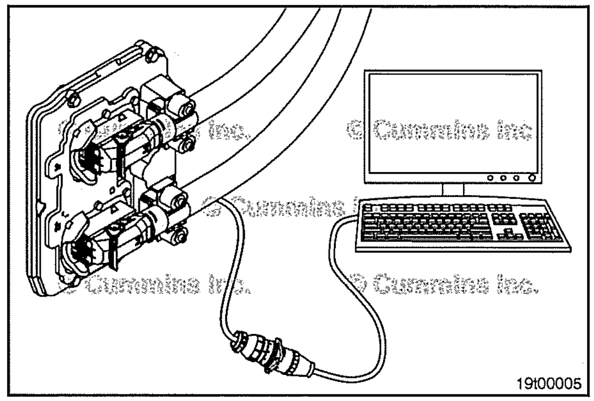
Turbocharger Compressor Intake Pressure/Temperature Sensor (019-466)

General Information

The turbocharger compressor intake pressure/temperature sensor is a combination sensor that monitors the temperature and pressure of the air entering the turbocharger.

The sensor is located in the air cleaner outlet or in the original equipment manufacturer (OEM) intake piping, in between the air cleaner and turbocharger.

Initial Check



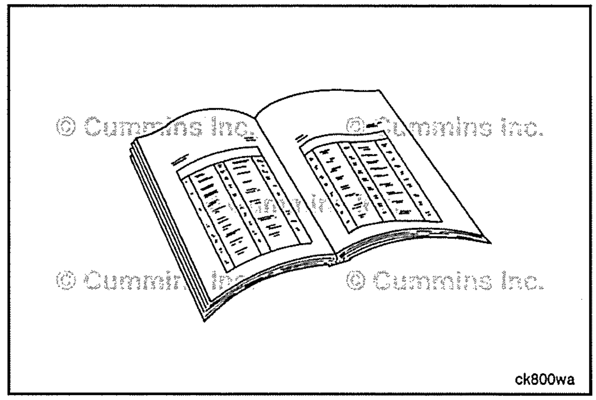
Use an electronic service tool to monitor the value of the turbocharger compressor intake pressure/temperature sensor with the key in the ON position and the engine off.

The value of the turbocharger compressor air intake temperature sensor should be checked when the engine is cold, and should read within 5.5°C or 10°F of the local ambient air temperature.

The value of the turbocharger compressor intake pressure should read within 1 kPa [0.3 in Hg] of the local barometric air pressure. Refer to Procedure 018-028 in Section V.

Replace the turbocharger compressor intake pressure/ temperature sensor if either value is out of specification.

Preparatory Steps

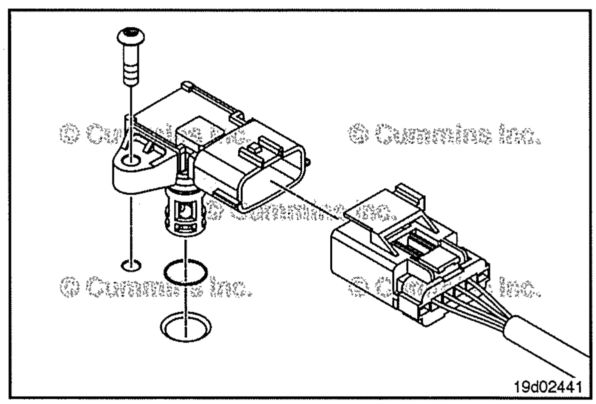


WARNING

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

- Disconnect the batteries. See equipment manufacturer service information.
- Clean the area around the turbocharger compressor intake pressure/temperature sensor.

Remove

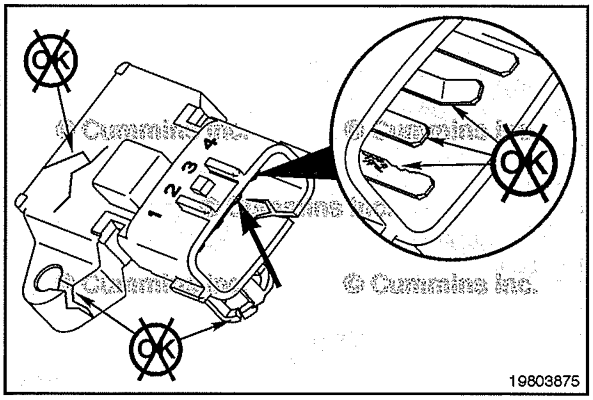


Disconnect the sensor connector from the engine harness.

Remove the mounting capscrew.

Remove the sensor from the engine by pulling straight up on the sensor.

Be careful **not** to damage the o-ring when removing the sensor.

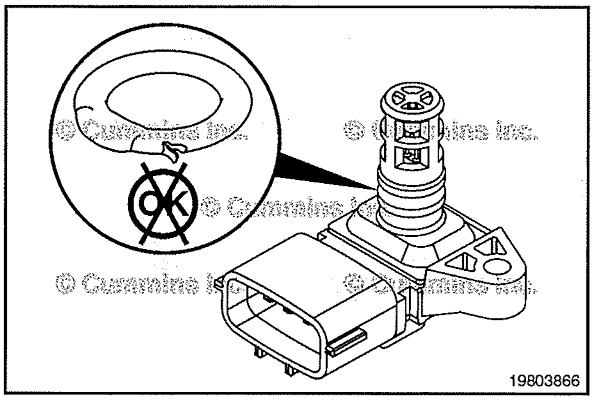


Clean and Inspect for Reuse

Inspect the engine harness connector and the turbocharger compressor intake pressure/temperature sensor for the following:

- Cracked or broken connector shell
- Missing or damaged connector seals
- Dirt, debris, or moisture in or on the connector pins
- Corroded, bent, broken, pushed back, or expanded pins.

Replace or repair the connector or turbocharger compressor intake pressure/temperature sensor as necessary.

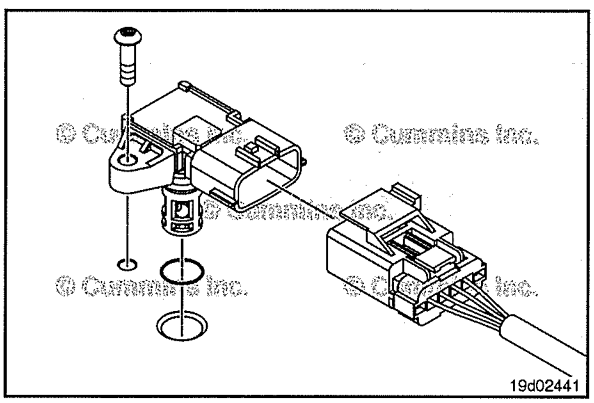


Inspect the engine harness connector and the turbocharger compressor intake pressure/temperature sensor for the following:

Inspect the turbocharger compressor intake pressure/ temperature sensor o-ring the following:

- Swollen o-ring
- Nicks or cuts in or on the o-ring.

Replace the o-ring if any damage is found.



Install

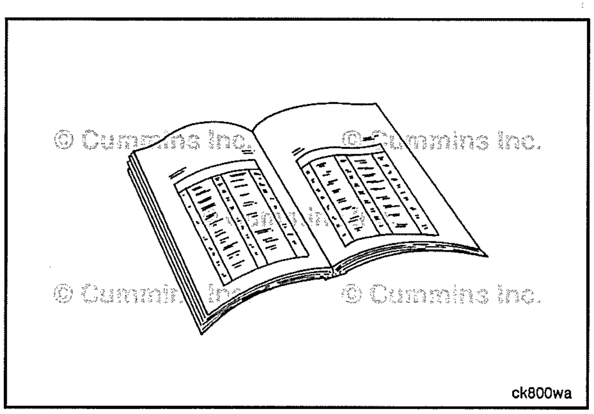
Lubricate the o-ring with clean engine oil before installation.

Install the turbocharger compressor intake pressure/ temperature sensor by pressing firmly on the top of the sensor until the o-ring is fully seated.

Install and tighten the mounting capscrew.

Torque Value: 7 N•m [62 in-lb]

Connect the engine harness to the turbocharger compressor intake pressure/temperature sensor.



Finishing Steps

WARNING

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

Aftertreatment Diesel Exhaust Fluid Quality Sensor (019-475)

General Information

The aftertreatment diesel exhaust fluid (DEF) quality sensor is part of the DEF tank head unit assembly.

The DEF quality sensor is original equipment manufacturer (OEM)-supplied. See equipment manufacturer service information for the location of the sensor. This procedure was written to be generic to multiple systems.

The DEF quality sensor is located in the DEF tank. See equipment manufacturer service information for the location of the DEF tank.

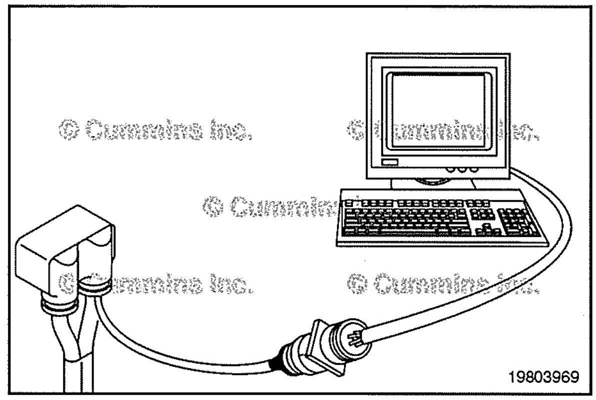
The aftertreatment DEF quality sensor monitors the fluid in the DEF tank and passes that information on to the engine control module (ECM).

The ECM uses this information to determine if the liquid in the tank is the proper concentration of DEF or a foreign substance.

The DEF quality sensor reading can be monitored using the Datalogger/Monitor function in INSITE™ electronic service tool.

The DEF concentration should read 32.5 ± 4 percent at keyswitch ON.

If the DEF concentration is **not** within specification, see the following procedure to manually verify the concentration of DEF. Refer to Procedure 011-056 in Section 11.



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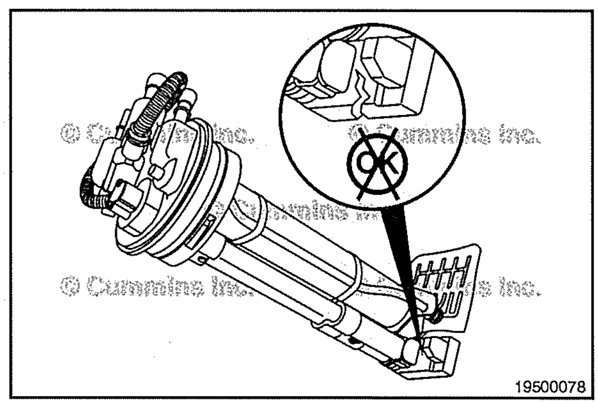
Inspect for Reuse

Inspect the aftertreatment DEF quality sensor for damaged or broken connector pins.

See equipment manufacturer service information for removal, installation, and inspection instructions.



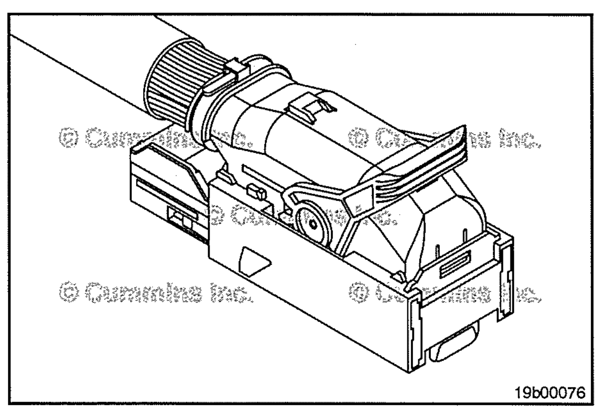
19500078

Delphi® 96 Way Engine Control Module Connector (019-505)

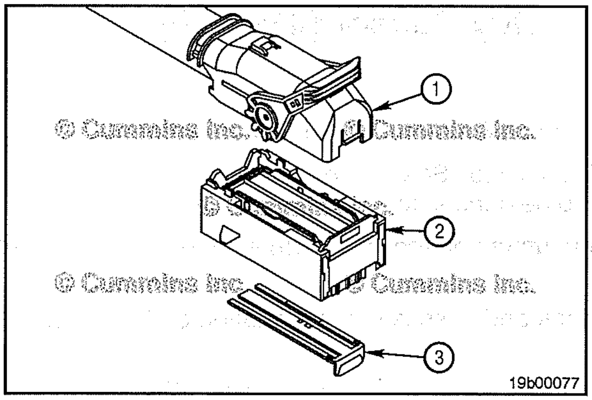
General Information

This connector is used to attach the engine wiring harness and the OEM harness to the engine control module (ECM).

NOTE: The engine harness connector and the OEM connector are keyed differently, so they can **not** be used interchangeably.

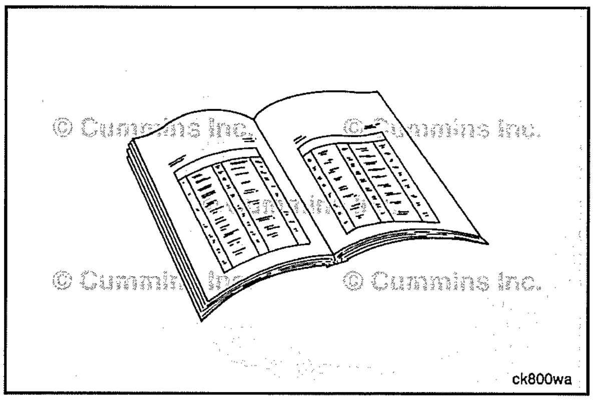


19500076



The Delphi® 96 Way ECM connector is made up of three components:

1 Backshell
2 Connector body
3 Locking comb.

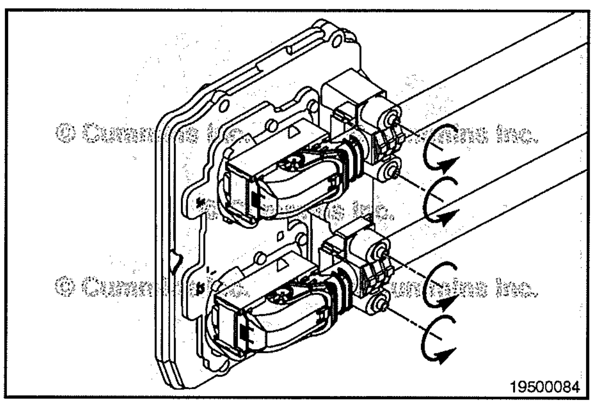


Preparatory Steps

WARNING

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

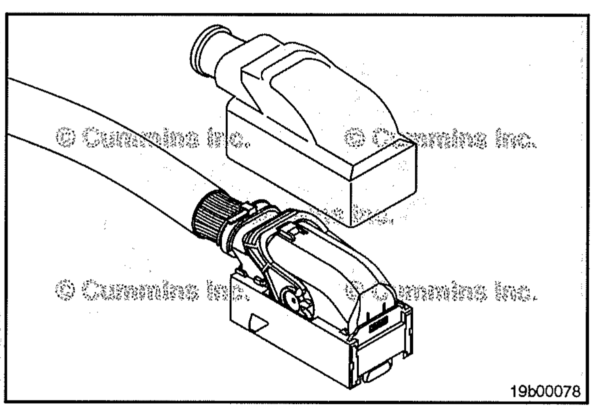
- Disconnect the batteries. Refer to the OEM service manual.



Remove

Unbolt the wire harness hold down clamp from the ECM.

NOTE: Do **not** remove wire ties securing the hold down clamp to the wire harness.



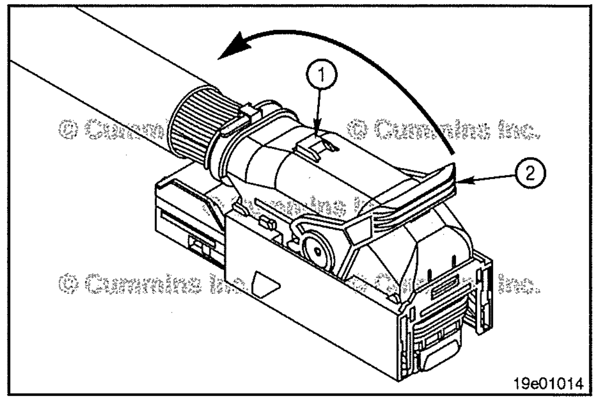
If equipped, fold the dust boot back to gain access to the ECM connector or remove it if necessary.

NOTE: If the dust boot is removed, the it **must** be re-installed at the conclusion of the repair.

CAUTION
Damage to the backshell will occur if the locking tab is not depressed prior to lifting of the lever.

Remove the connector from the ECM by pressing down on the locking tab (1) and pulling up on the lever (2).

NOTE: Do **not** close the lever after the connector has been removed from the ECM. Attempting to do so will cause damage.

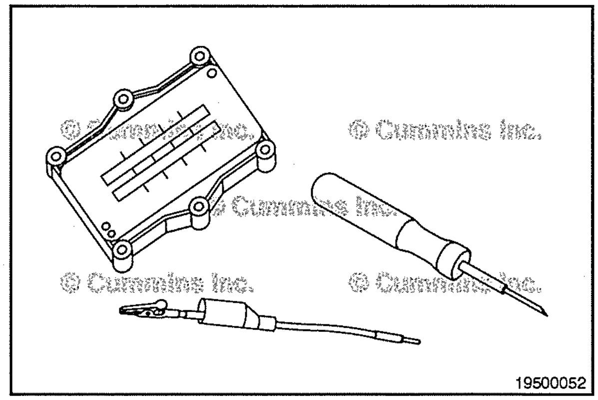


Test

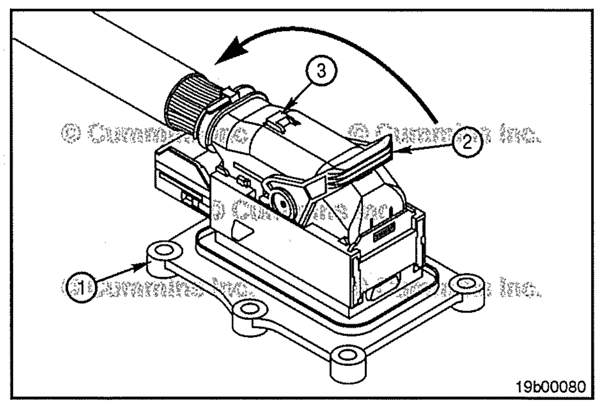
CAUTION
Do not insert test leads into the ECM connector terminals. Doing so may cause terminals to spread and cause intermittent electrical connections.

To perform pin-out diagnostic checks, use ECM connector electrical circuit tester, Part Number 2892510, and test lead, Part Number 3164113.

All diagnostic test leads, connector repair tools, and repair terminals can be found in CM2350 ECM Connector Repair Kit, Part Number 2892512.

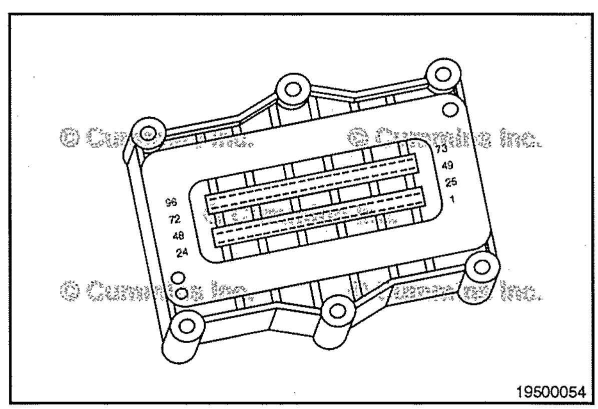


Attach the electrical circuit tester, Part Number 2892510, to the ECM (1) connector by placing the electrical circuit tester into the ECM connector and pulling back on the locking lever (2) until the connector is fully seated and the lever locking tab (3) is engaged.

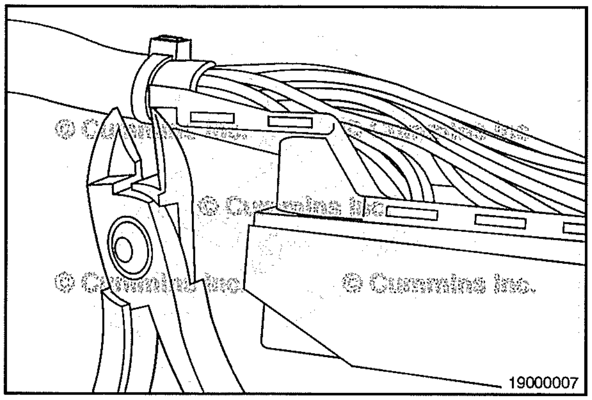


Use electrical circuit tester, Part Number 2892510, to help identify terminal number locations.

Reference the appropriate wiring diagram for circuit terminal locations.



Pin Replacement



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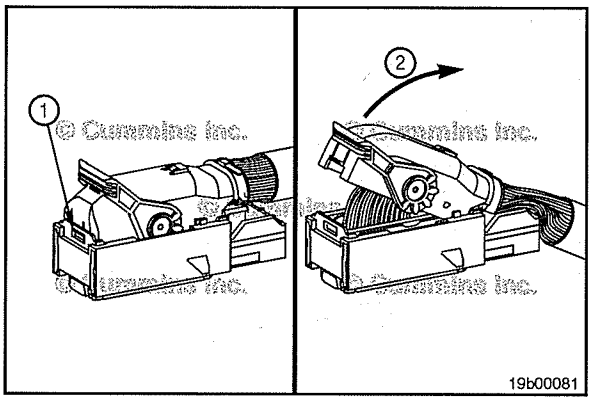
Cut the wire tie securing the wire bundle to the backshell.



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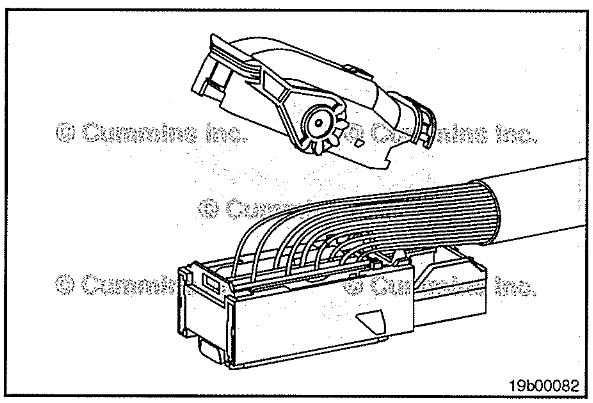
Remove the connector backshell by pressing in on the backshell locking tab (1) and pivot the front of the backshell upward (2).



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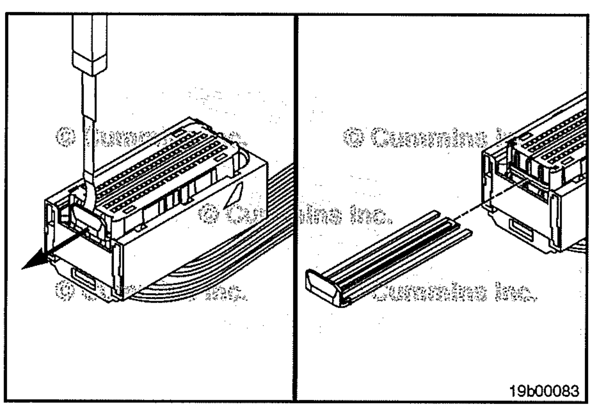
Pull the backshell forward, then upward to release the backshell mounting tabs from the connector body.



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Gently release the locking comb by using retainer removal tool, Part Number 4918919, to separate the locking comb from the connector body.

Fully remove the locking comb by hand.

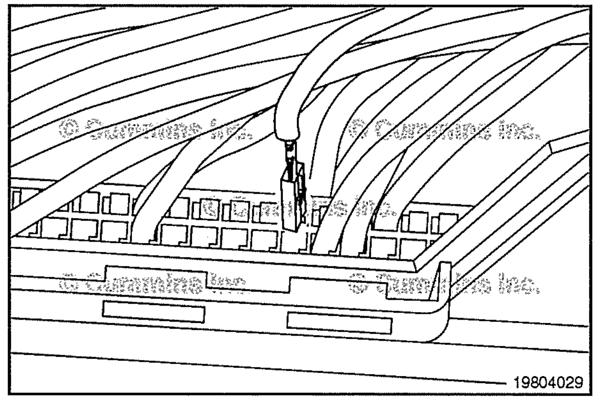
Removing Terminal

Replace one terminal wire at a time. If more than one terminal wire **must** be replaced, attach an identification tag to each wire removed.

If more than four terminals are damaged and need to be replaced, the engine wiring harness is to be replaced.

Reference the appropriate wiring diagram for terminal locations.

Reference the appropriate wiring harness repair kit in the Service Tools procedure in Section 19 for the correct repair wire.



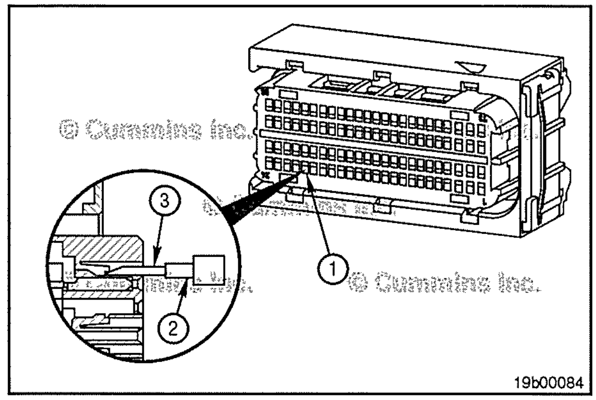
⚠CAUTION⚠

If the wire is difficult to remove, do not pull hard on the wire, otherwise, the locking tang of the terminal will stick or the terminal will pull off the wire and remain in the connector.

Insert terminal removal tool, Part Number 4918921, into the larger access cavity (1).

With the beveled side of the tool facing away from the terminal cavity (2), rotate the tool slightly to release the terminal from the locking tang (3).

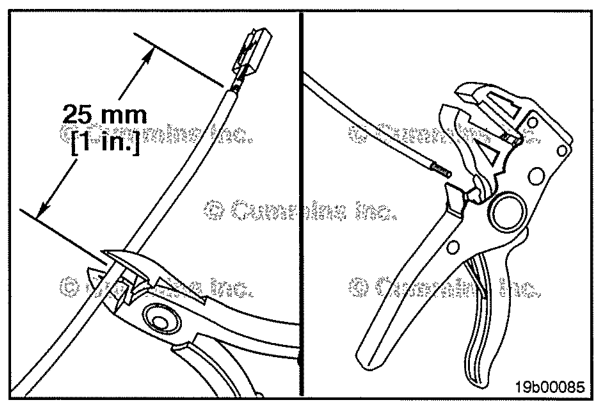
Carefully pull the wire from the connector. If it is difficult to remove, repeat the entire process.



Use wire cutters to remove 25 mm [1 in.] of the terminal and wire to be replaced.

Use wire stripping tool, Part Number 3400045, or equivalent, to remove 6 mm [¼ in.] of insulation from the wire.

NOTE: It will be necessary to remove the wire ties securing the wire harness hold down clamps to the wire harness. Wire ties **must** be replaced at the conclusion of the repair.

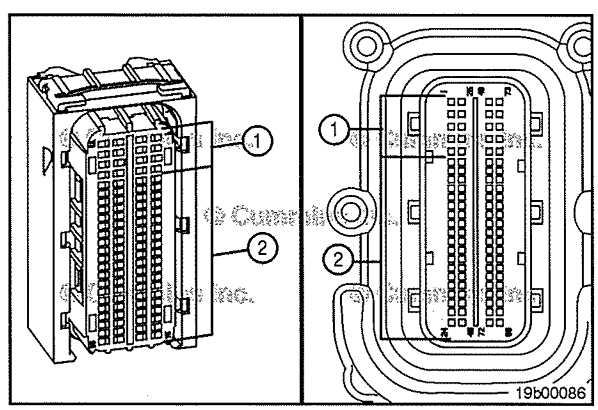


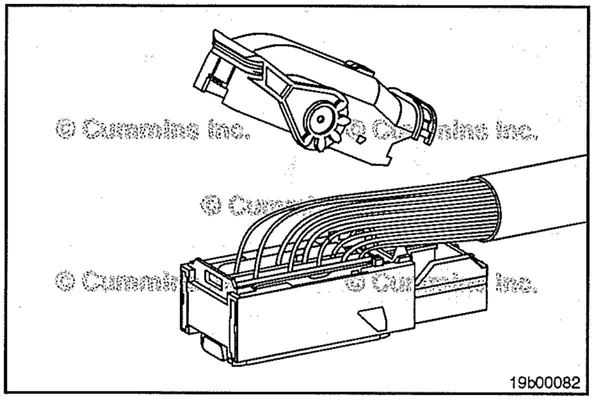
There are two electrical connector repair terminals available for the ECM connector.

Part Number 4918916, identified by a grey wire with a red stripe, is used to repair 16 gauge wires used in cavities 1-4, 25-28, 49-52, and 73-76 (1).

Part Number 2892507 is used to repair 20 gauge wires used in cavities 5-24, 29-48, 53-72, and 77-96 (2).

Reference CM2350 Wiring Harness Repair Kit, Part Number 5298734, for the appropriate repair terminal.

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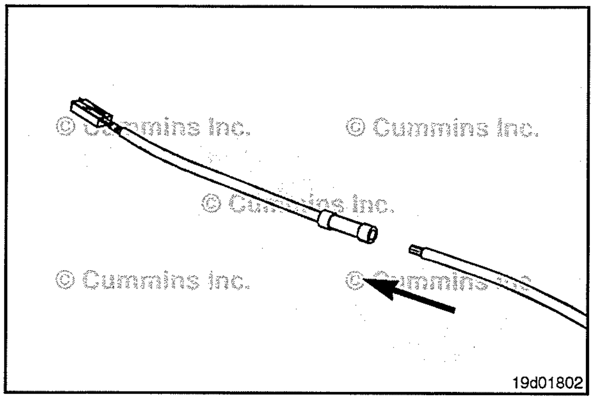
In some applications, there may **not** be enough clearance to route the repair terminal butt-splice connection into the wire harness convolute. The repair terminal will need to be cut to appropriate length to allow the butt-splice connection to be located under the backshell.

NOTE: The repair wire is 203mm [8 in] long.

Use a wire cutter to cut the electrical connector repair terminal to an appropriate length so that it can be attached to the original wire lead, using a butt-splice, under the connector backshell.

NOTE: If more than four terminals are damaged and need to be replaced, the wiring harness is to be replaced.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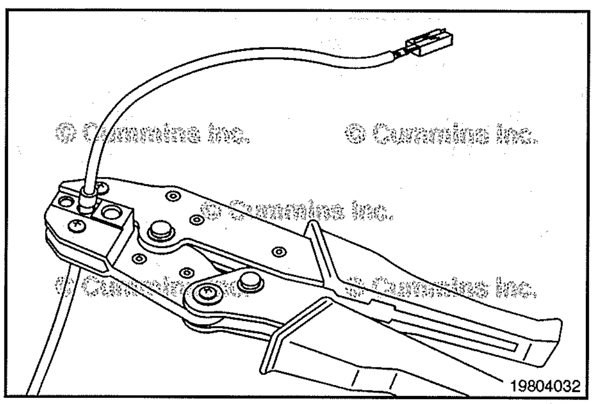
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

Install the repair wire on the bare wire.

Make sure the bare wire extends into the splice connector properly.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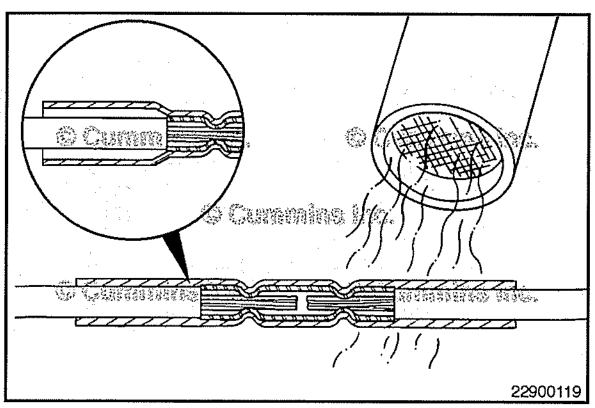
Use wire crimping tool, Part Number 3163109, or equivalent, to crimp the repair wire onto the bare wire.


22900119

Use Heat Gun, Part Number 3822860, or equivalent, to heat the shrink tubing around the wire.

The tubing will shrink and make the connection waterproof.

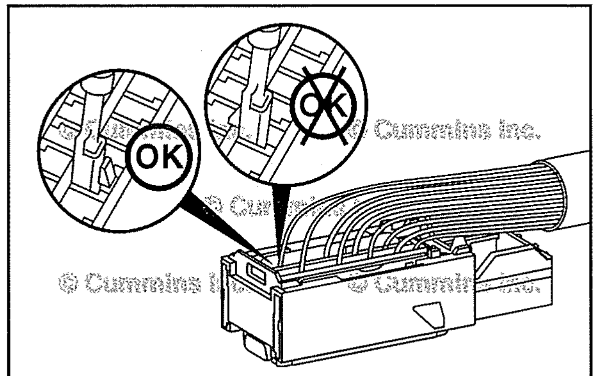
Inserting Terminal

The wire terminals have locating features that only allow the terminal to be inserted in one orientation.

Insert the wire from the top of the connector.

Push the wire into the connector until the terminal locks into place.

Pull on the wire gently to make sure the terminal is locked into the connector.



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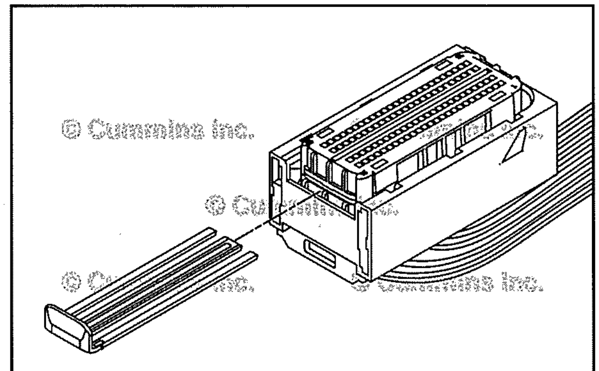
Insert the locking comb.

NOTE: The locking comb should slide into place without excessive force. If it is difficult to install the locking comb, check to ensure all pins are fully engaged.

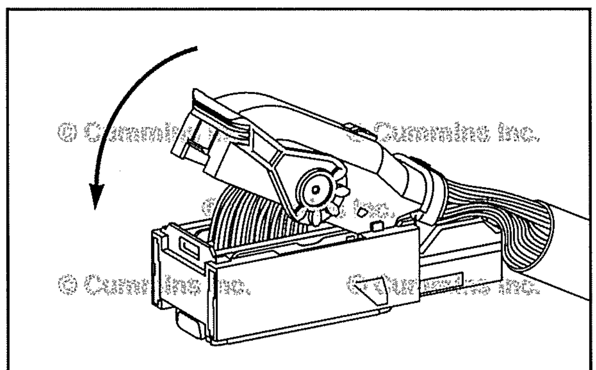


19b00088

NOTE: Make sure the lever on the backshell is in the open position before installing the backshell onto the connector body.

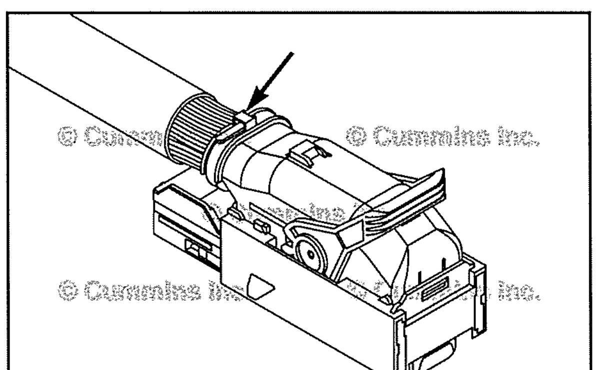
Position the wire bundle into place and install the backshell mounting tabs into the connector body.

Pivot the front of the backshell downward until the locking tab engages with the connector body.

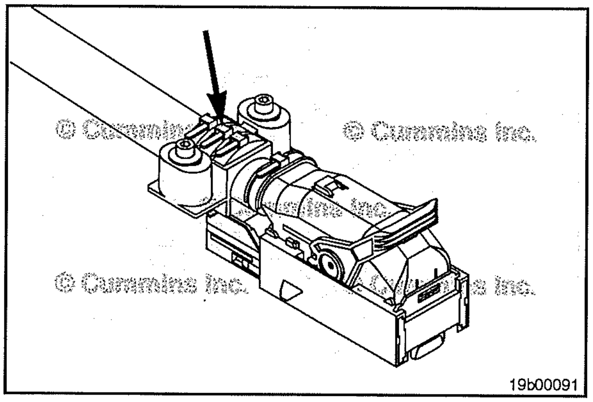


19b00089

Install a wire tie to secure the wire bundle to the connector backshell.

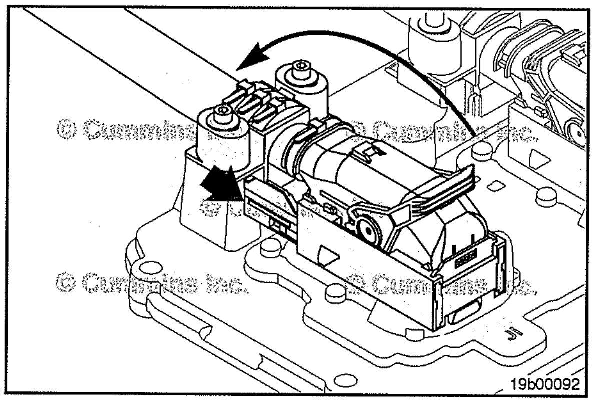


19b00090



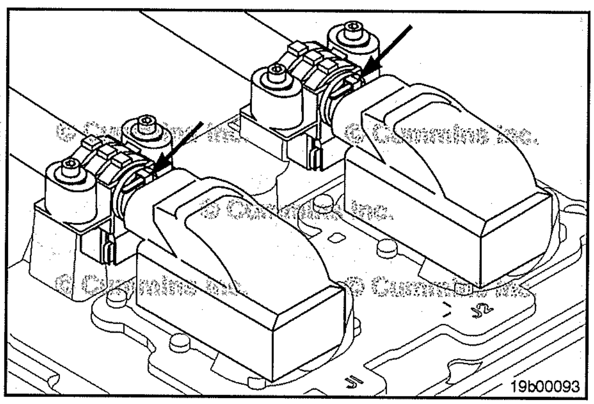
If the harness hold down clamps were removed from the harness, loosely re-attach the hold down clamps to the wire harness using wire ties.

Once the connector has been re-attached to the ECM and the hold down clamp has been attached to the ECM, the wire ties can be pulled tight, securing the hold down clamp to the wire harness.



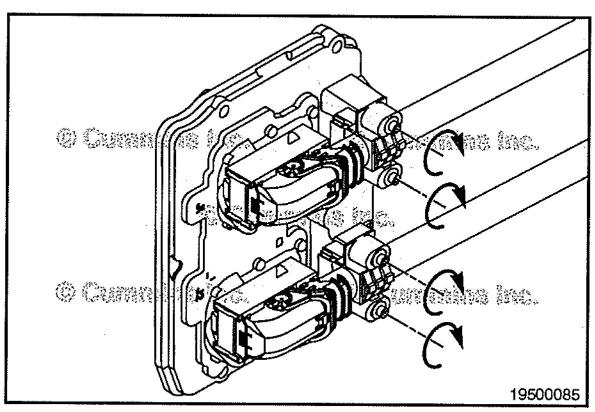
Install

Install the connector to the ECM by placing the connector into the ECM receptacle and pulling back on the locking lever until the connector is fully seated and the lever locking tab is engaged.



If equipped, fold the dust boot back into place over the ECM connector.

If the dust boot was removed, install it over the ECM connector and secure it to the harness using a wire tie.



⚠CAUTION⚠

Do not over-tighten the harness hold-down clamp mounting screws or damage to the ECM will occur.

Install the harness hold-down clamps.

Torque Value: 8 N•m [71 in-lb]

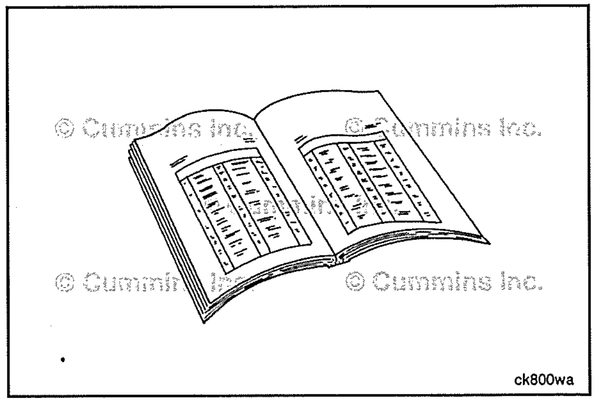
NOTE: If the wire ties securing the harness hold-down clamp to the wire harness were removed, new wire ties **must** be installed.

Finishing Steps

WARNING

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

- Connect the batteries. Refer to the OEM service manual.
- Operate the engine and check for loose components and fault codes.



ck800wa

Notes

Cummins Service Publications Electronic Book on DVD-ROM

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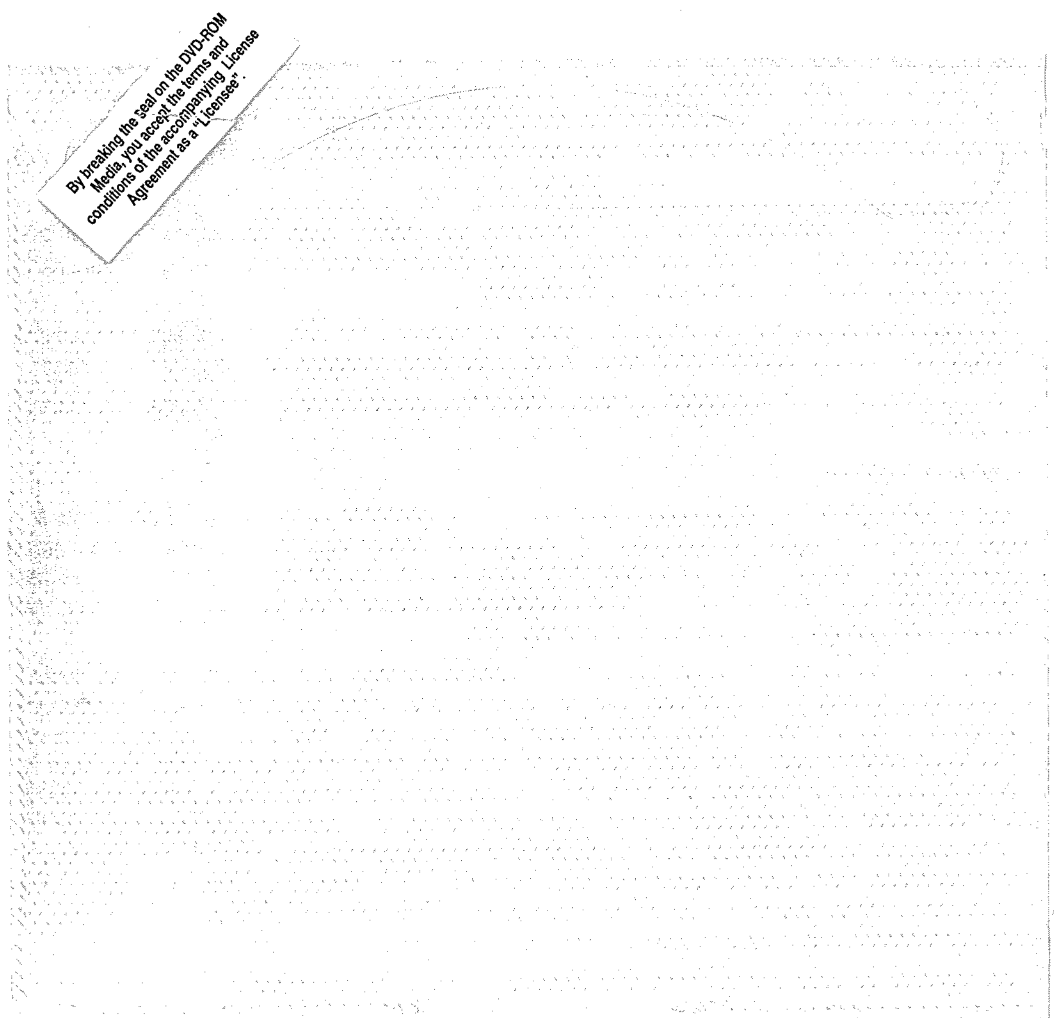

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- Microsoft Windows Auto-Play must be enabled on your computer (it is enabled by default when Windows is installed)
- DVD-ROM Drive
- Color Monitor with at least 800x600 resolution graphics
- Microsoft Windows XP Professional SP3, Microsoft Windows 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.
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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 by contacting your Cummins® distributor:

Bulletin Number	Title of Publication
4367323	QSG12 CM2350 G110 Service Manual
4367324	QSG12 CM2350 G110 Fault Code Troubleshooting Manual
4367325	QSG12 CM2350 G110 Wiring Diagram
4367322	QSG12 CM2350 G110 Operation and Maintenance Manual
4367321	QSG12 CM2350 G110 Owners Manual
3379000	Air for Your Engine
3379001	Fuel for Cummins® Engines
3666132	Cummins® Coolant Requirements and Maintenance
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 https://store.cummins.com
All Other Countries	Cummins Distributors or Dealers

Cummins Customized Parts Catalog

General Information

Cummins is pleased to announce the availability of a parts catalog compiled specifically for you. Unlike the generic versions of parts catalogs that support general high volume parts content; Cummins Customized catalogs contain only the new factory parts that were used to build your engine.

The catalog cover, as well as the content, is customized with you in mind. You can use it in your shop, at your worksite, or as a coffee table book in your RV or boat. The cover contains your name, company name, address, and telephone number.

This new catalog was designed to provide you with the exact information you need to order parts for your engine. This will be valuable for customers that do not have easy access to Cummins QuickServe Online.

Additional Features of the Customized Catalog include:

- Engine Configuration Data
- Table of Contents
- Separate Option and Parts Indexes
- Service Kits (when applicable)
- ReCon Part Numbers (when applicable)

Ordering the Customized Parts Catalog

Ordering by Telephone

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- International PDC orders are called into Iron Mountain at (++) 630-283-2420.
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Ordering On-Line

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

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

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Required information needed for your Customized Parts Catalog Order.

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

Unfortunately not all Cummins Engines can be supported by Customized Parts Catalogs. Engines older than 1984 or newer than 3 months may not have the necessary parts information to compile a catalog. We will contact you if this occurs and explain why we are unable to fill your order.

Customized Parts Catalogs are produced specifically for a single customer. This means they are not returnable for a refund. If we make an error and your catalog is not useable, we will correct that error by sending you a new catalog.

Notes

Section V - Specifications

Section Contents

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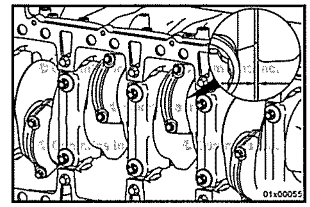
Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Engine Assembly - Group 00 - Specifications

Cylinder Liner Protrusion		0.06 mm	MIN	0.002 in
		0.12 mm	MAX	0.005 in
Connecting Rod Side Clearance		0.10 mm	MIN	0.004 in
		0.35 mm	MAX	0.014 in

Piston and Connecting Rod Assembly (001-054)

Connecting Rod Side Clearance		0.10 mm	MIN	0.004 in
		0.35 mm	MAX	0.014 in

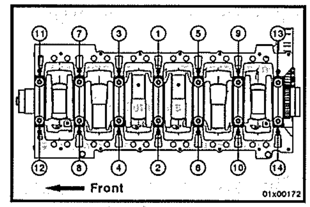


Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

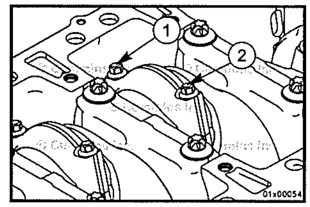
Engine Assembly - Group 00 - Torque Values

Bearings, Main (001-006)

120 N•m [89 ft-lb]
250 184 Angle 120 degrees.



Piston and Connecting Rod Assembly (001-054)



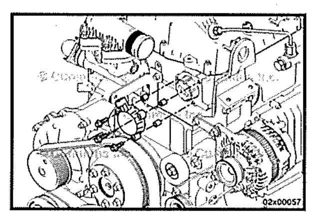
Torque Value:

Step 1	85 N•m	[63 ft-lb]
Step 2	Angle 60 degrees.	

28 N•m	[248 in-lb]
46 N•m	[34 ft-lb]
113 N•m	[83 ft-lb]
113 N•m	[83 ft-lb]
113 N•m	[83 ft-lb]
127 N•m	[94 ft-lb]
46 N•m	[34 ft-lb]
23 N•m	[204 in-lb]
65 N•m	[48 ft-lb]
23 N•m	[204 in-lb]
9.5 N•m	[84 in-lb]

Overhead Camshaft Timing Speed Ring (002-034)

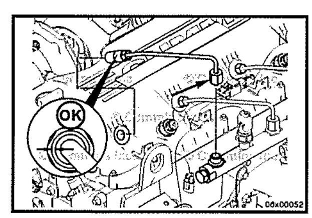
23 N•m [204 in-lb]



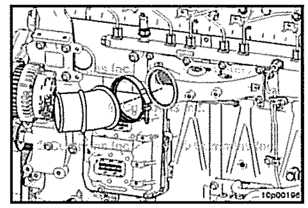
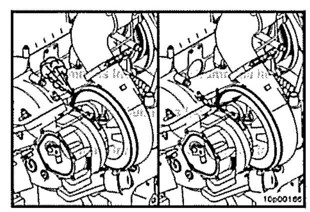
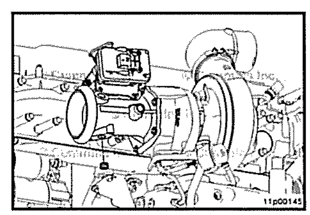
65 N•m	[48 ft-lb]
28 N•m	[248 in-lb]
65 N•m	[48 ft-lb]
2 N•m	[18 in-lb]
2 N•m	[18 in-lb]
2 N•m	[18 in-lb]
9.5 N•m	[84 in-lb]
9.5 N•m	[84 in-lb]
23 N•m	[204 in-lb]
23 N•m	[204 in-lb]
55 N•m	[41 ft-lb]
46 N•m	[36 ft-lb]
23 N•m	[204 in-lb]

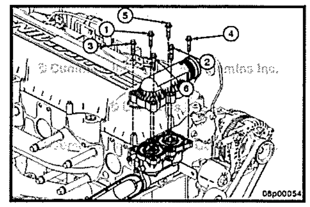
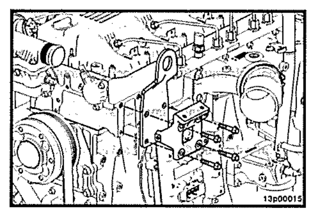
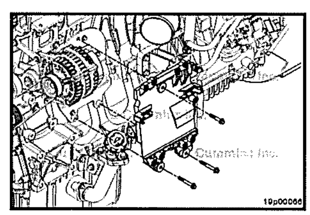
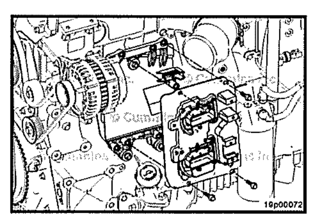
Injector Supply Lines (High Pressure) (006-051)

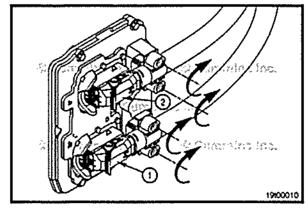
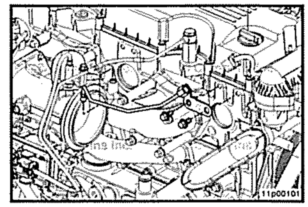
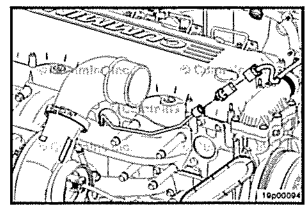
25 N•m [221 in-lb]
25 N•m [221 in-lb]



25 N•m [221 in-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
46 N•m [34 ft-lb]				
46 N•m [34 ft-lb]				
24 N•m [212 in-lb]				
34 N•m [25 ft-lb]				
20 N•m [177 in-lb]				
46 N•m [34 ft-lb]				
23 N•m [204 in-lb]				
Air Intake Connection (010-080)		8 N•m	[71 in-lb]	
8 N•m [71 in-lb]				
12 N•m [106 in-lb]				
80 N•m [59 ft-lb]				
80 N•m [59 ft-lb]				
45 N•m [33 ft-lb]				
35 N•m [26 ft-lb]				
35 N•m [26 ft-lb]				
55 N•m [41 ft-lb]				
35 N•m [26 ft-lb]				
35 N•m [26 ft-lb]				
80 N•m [59 ft-lb]				
23 N•m [204 in-lb]				
46 N•m [34 ft-lb]				
80 N•m [59 ft-lb]				
50 N•m [37 ft-lb]				
81 N•m [60 ft-lb]				
Turbocharger (010-033)		8 N•m	[71 ft-lb]	
25 N•m [18 ft-lb]				
Exhaust Pressure Regulator (011-105)		50 N•m	[37 ft-lb]	
45 N•m [34 ft-lb]				
41 N•m [30 ft-lb]				
8 N•m [71 in-lb]				
35 N•m [26 ft-lb]				
18 N•m [159 in-lb]				
18 N•m [159 in-lb]				
16 N•m [142 in-lb]				
35 N•m [26 ft-lb]				
35 N•m [26 ft-lb]				
18 N•m [159 in-lb]				
16 N•m [142 in-lb]				

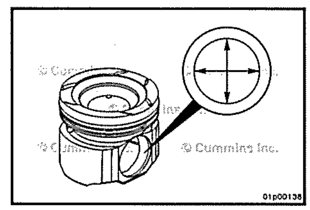
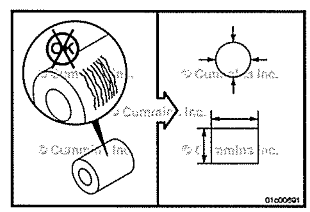
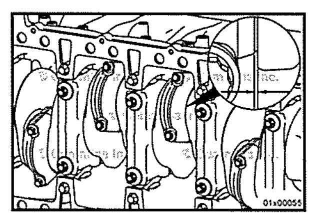
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
35 N•m [26 ft-lb]				
35 N•m [26 ft-lb]				
45 N•m [34 ft-lb]				
8 N•m [71 in-lb]				
35 N•m [26 ft-lb]				
18 N•m [159 in-lb]				
18 N•m [159 in-lb]				
16 N•m [142 in-lb]				
35 N•m [26 ft-lb]				
18 N•m [159 in-lb]				
16 N•m [142 in-lb]				
35 N•m [26 ft-lb]				
23 N•m [204 in-lb]				
18 N•m [159 in-lb]				
7.4 N•m [65 in-lb]				
23 N•m [204 in-lb]				
7.4 N•m [65 in-lb]				
Coolant Thermostat (008-013)		18 N•m	[159 in-lb]	
46 N•m [34 ft-lb]				
46 N•m [34 ft-lb]				
65 N•m [48 ft-lb]				
Charging System Alternator Bracket (013-003)		46 N•m	[34 ft-lb]	
23 N•m [204 in-lb]				
46 N•m [34 ft-lb]				
46 N•m [34 ft-lb]				
55 N•m [41 ft-lb]				
55 N•m [41 ft-lb]				
23 N•m [204 in-lb]				
Engine Control Module Mounting Bracket (019-421)		23 N•m	[204 in-lb]	
Engine Control Module (019-031)		7.4 N•m	[65 in-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
		8 to 10 N•m	[71 to 89 in-lb]	
7 N•m [62 in-lb]				
Exhaust Gas Pressure Sensor Tube (011-027)		46 N•m 16 N•m	[34 ft-lb] [142 in-lb]	
Exhaust Gas Pressure Sensor (019-376) Exhaust Gas Pressure Sensor		14 N•m	[124 in-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Cylinder Block - Group 01 - Specifications

Connecting Rod Side Clearance	0.10 mm	MIN	0.004 in
	0.35 mm	MAX	0.014 in
Main Bearing Dimensions Standard	2.950 mm	MIN	0.116 in
	2.966 mm	MAX	0.117 in
Crankshaft End Clearance - New or Reground	0.175 mm	MIN	0.007 in
	0.425 mm	MAX	0.017 in
Connecting Rod Crankshaft Bore Inside Diameter	94.980 mm	MIN	3.739 in
	95.006 mm	MAX	3.740 in
Connecting Rod Piston Pin Bushing Inside Diameter	58.047 mm	MIN	2.285 in
	58.023 mm	MAX	2.284 in
Crankshaft Connecting Rod Journal Outside Diameter	89.987 mm	MIN	3.543 in
	90.013 mm	MAX	3.544 in
Crankshaft Main Bearing Journal Outside Diameter	111.987 mm	MIN	4.409 in
	112.013 mm	MAX	4.410 in
Crankshaft Thrust Face Width	45.975 mm	MIN	1.810 in
	46.050 mm	MAX	1.813 in
Crankshaft Pilot Outside Diameter	29.987 mm	MIN	1.181 in
	30.013 mm	MAX	1.182 in
Total Indicator Runout	0.23 mm	MAX	0.009 in
Adjacent Journal Runout	0.08 mm	MAX	0.003 in
Rear Oil Seal Flange Total Indicator Runout	0.13 mm	MAX	0.005 in
Front Oil Seal Flange Diameter Runout	0.025 mm	MAX	0.001 in
Cylinder Block Liner Ledge Inside Diameter	138.525 mm	MAX	5.454 in
Main Bearing Bore Inside Diameter (Capscrews Tightened to Specification)	117.99 mm	MIN	4.645 in
	118.015 mm	MAX	4.646 in
Cylinder Liner Protrusion	0.06 mm	MIN	0.002 in
	0.12 mm	MAX	0.005 in
Max Cylinder Liner Pitting Depth	1.40 mm	MAX	0.055 in

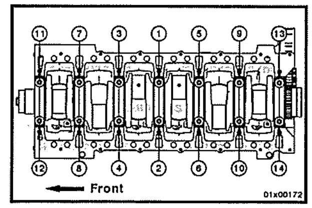
Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.	
Cylinder Liner Inside Diameter		132.00 mm	MIN	5.1966 in	
		132.04 mm	MAX	5.1984 in	
Cylinder Block Upper Liner Bore Inside Diameter (A)		145.475 mm	MIN	5.727 in	
		145.525 mm	MAX	5.729 in	
Cylinder Block Liner Seal Seat Bore Inside Diameter (B)		138.475 mm	MIN	5.452 in	
		138.525 mm	MAX	5.454 in	
Cylinder Liner Press Fit Outside Diameter (A)		137.95 mm	MIN	5.43 in	
		138.45 mm	MAX	5.45 in	
Cylinder Liner Protrusion		0.06 mm	MIN	0.002 in	
		0.12 mm	MAX	0.005 in	
Piston (001-043)					
Pin Bore Inside Diameter		58.1240 mm	MIN	2.2883 in	
		58.1090 mm	MAX	2.2877 in	
Piston Pin Outside Diameter		58.0035 mm	MIN	2.2836 in	
		57.9965 mm	MAX	2.2833 in	
Piston Pin Length		90.38 mm	MIN	3.56 in	
		89.62 mm	MAX	3.53 in	
Piston and Connecting Rod Assembly (001-054)					
Connecting Rod Side Clearance		0.10 mm	MIN	0.004 in	
		0.35 mm	MAX	0.014 in	
Crankshaft Speed/Position Sensor Air Gap		0.25 mm	MIN	0.01 in	
		1.50 mm	MAX	0.06 in	
Camshaft gear to camshaft idler gear backlash		0.24 mm	MIN	0.009 in	
		0.30 mm	MAX	0.012 in	
REPTO idler gear to crankshaft idler gear backlash		0.12 mm	MIN	0.005 in	
		0.215 mm	MAX	0.008 in	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Cylinder Block - Group 01 - Torque Values

Bearings, Main (001-006)

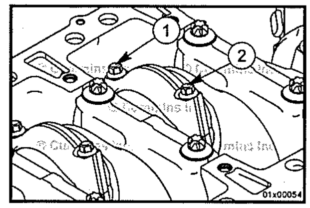
120 N•m [89 ft-lb]
250 184 Angle 120 degrees.



120 89 250 184 Rotate 120 degrees.

23 N•m	[204 in-lb]
281 N•m	[207 ft-lb]
28 N•m	[248 in-lb]

Piston and Connecting Rod Assembly (001-054)



Torque Value:

Step 1	85 N•m	[63 ft-lb]
Step 2	Angle 60 degrees.	

46 N•m	[34 ft-lb]
113 N•m	[83 ft-lb]
113 N•m	[83 ft-lb]
113 N•m	[83 ft-lb]

Cylinder Head - Group 02 - Specifications

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.
Valve to Valve Seat Vacuum		508 mm Hg	MIN	20 in Hg
		685 mm Hg	MAX	27 in Hg
Camshaft Bore Diameter without Camshaft Installed		55.720 mm	MAX	2.194 in
Journal Diameter Numbers 1 to 5		55.56 mm	MIN	2.187 in
		55.60 mm	MAX	2.189 in
Valve Camshaft End Clearance		0.50 mm	MAX	0.020 in

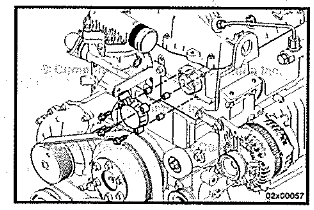
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Cylinder Head - Group 02 - Torque Values

46 N•m	[34 ft-lb]
54 N•m	[40 ft-lb]
46 N•m	[34 ft-lb]
9.5 N•m	[84 in-lb]
23 N•m	[204 in-lb]
65 N•m	[48 ft-lb]
9.5 N•m	[84 in-lb]

Overhead Camshaft Timing Speed Ring (002-034)

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
		23 N•m	[204 in-lb]



Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Rocker Levers - Group 03 - Specifications

Rocker Lever Bore		30.01 mm	MAX	1.181 in
Rocker Lever Shaft		29.95 mm	MIN	1.179 in

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Rocker Levers - Group 03 - Torque Values

28 N•m	[248 in-lb]
65 N•m	[48 ft-lb]
9.5 N•m	[84 in-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Fuel System - Group 05 - Specifications

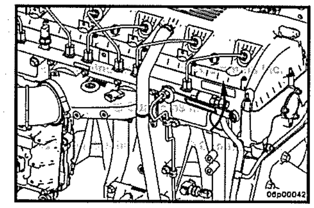
Gear Pump Pressure at High Idle		517 kPa	MIN	75 psi
Gear Pump Pressure at Cranking		69 kPa	MIN	10 psi
Fuel Filter Restriction		138 kPa	MAX	20 psi

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

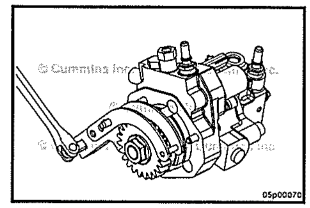
Fuel System - Group 05 - Torque Values

Fuel Pump (005-016)

		25 N•m	[221 in-lb]



		100 N•m	[74 ft-lb]



23 N•m	[204 in-lb]
9.5 N•m	[84 in-lb]
25 N•m	[221 in-lb]
81 N•m	[60 ft-lb]
25 N•m	[221 in-lb]
25 N•m	[221 in-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Injectors and Fuel Lines - Group 06 - Specifications

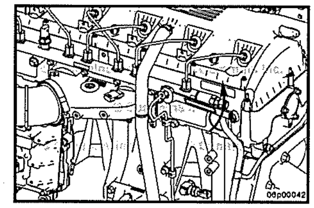
Fuel Drain Line Restriction		13.5 kPa	MAX	4 in Hg
Fuel Inlet Restriction		254 mm Hg	MAX	10 in Hg

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	

Injectors and Fuel Lines - Group 06 - Torque Values

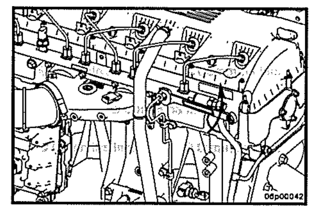
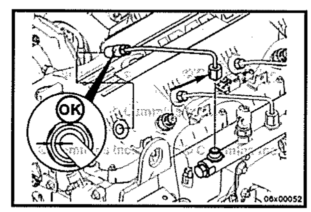
24 N•m	[212 in-lb]
34 N•m	[25 ft-lb]
20 N•m	[177 in-lb]
46 N•m	[34 ft-lb]
27 N•m	[239 in-lb]
46 N•m	[34 ft-lb]

Injector (006-026)

		25 N•m	[221 in-lb]	

65 N•m	[48 ft-lb]
2 N•m	[18 in-lb]

Injector Supply Lines (High Pressure) (006-051)

		25 N•m	[221 in-lb]	
		25 N•m 25 N•m	[221 in-lb] [221 in-lb]	

25 N•m	[221 in-lb]
46 N•m	[36 ft-lb]
25 N•m	[221 in-lb]
25 N•m	[221 in-lb]
46 N•m	[34 ft-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Lubricating Oil System - Group 07 - Specifications

Force Required to Compress Spring to 55.67 mm [2.19 in]		311.2 N	MIN	70 lbf
		344 N	MAX	77.3 lbf

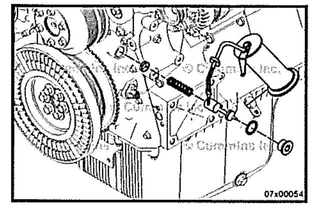
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Lubricating Oil System - Group 07 - Torque Values

55 N•m	[41 ft-lb]
7 N•m	[62 in-lb]
18 N•m	[159 in-lb]
68 N•m	[50 ft-lb]
70 N•m	[52 ft-lb]
23 N•m	[204 in-lb]
55 N•m	[41 ft-lb]

Lubricating Oil Pressure Regulator (Main Rifle) (007-029)

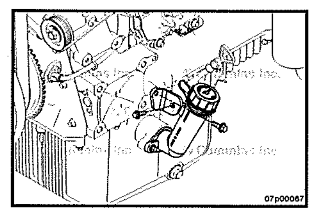
60 N•m	[44 ft-lb]



23 N•m	[204 in-lb]
55 N•m	[41 ft-lb]
50 N•m	[37 ft-lb]
23 N•m	[204 in-lb]
46 N•m	[34 ft-lb]
68 N•m	[50 ft-lb]
26 N•m	[230 in-lb]
23 N•m	[204 in-lb]
23 N•m	[204 in-lb]
23 N•m	[204 in-lb]
46 N•m	[34 ft-lb]
23 N•m	[17 ft-lb]

Lubricating Oil Fill Tube (007-065)

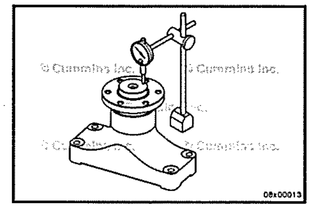
46 N•m	[407 in-lb]
23 N•m	[203 in-lb]



Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Cooling System - Group 08 - Specifications

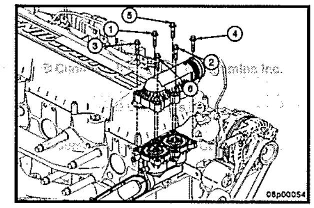
Fan Hub, Belt Driven (008-036)				
Fan Hub End Play		0.15 mm	MAX	0.006 in



Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Cooling System - Group 08 - Torque Values

68 N•m	[50 ft-lb]		
Coolant Thermostat (008-013)			
		18 N•m	[159 in-lb]



23 N•m	[204 in-lb]
7.4 N•m	[65 in-lb]
46 N•m	[34 ft-lb]
55 N•m	[41 ft-lb]
55 N•m	[41 ft-lb]
46 N•m	[34 ft-lb]
7.4 N•m	[65 in-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Drive Units - Group 09 - Specifications

Pin Diameter Requirements		4.5 mm	MIN	0.18 in
		5.5 mm	MAX	0.22 in

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Drive Units - Group 09 - Torque Values

46 N•m	[34 ft-lb]
180 N•m	[133 ft-lb]
23 N•m	[204 in-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Air Intake System - Group 10 - Specifications

Turbocharger Axial Movement		0.025 mm	MIN	0.001 in
		0.127 mm	MAX	0.005 in
Turbocharger Wastegate Rod Travel at 205 kPa [30 psi]		0.33 mm	MIN	0.013 in
		1.27 mm	MAX	0.050 in

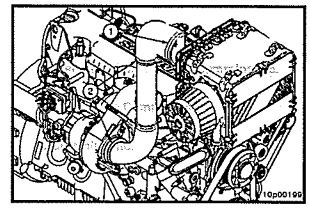
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Air Intake System - Group 10 - Torque Values

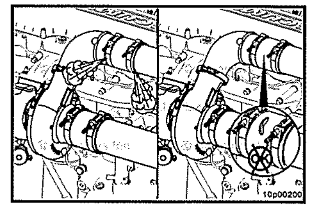
8 N•m [71 in-lb]

Air Leaks, Air Intake and Exhaust Systems (010-024)

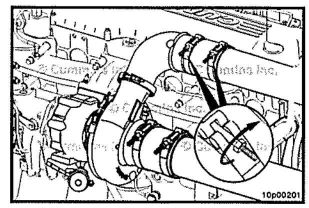
4.5 N•m [40 in-lb]
8 N•m [71 in-lb]



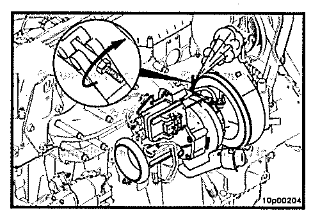
11 N•m [97 in-lb]



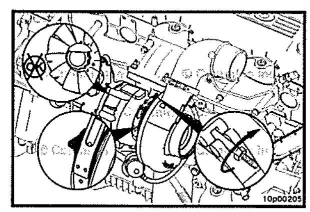
11 N•m [97 in-lb]



8.5 N•m [75 in-lb]



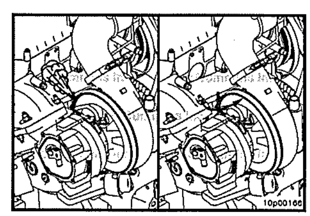
11 N•m [97 in-lb]



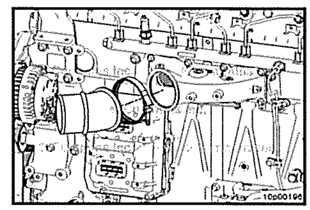
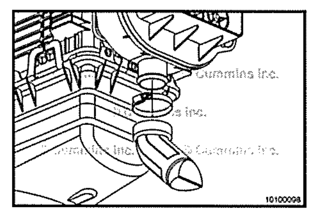
5.6 N•m [50 in-lb]
5.6 N•m [50 in-lb]
81 N•m [60 ft-lb]

Turbocharger (010-033)

8 N•m [71 ft-lb]



45 N•m [34 ft-lb]
41 N•m [30 ft-lb]
8 N•m [71 in-lb]
35 N•m [26 ft-lb]
18 N•m [159 in-lb]
18 N•m [159 in-lb]
16 N•m [142 in-lb]

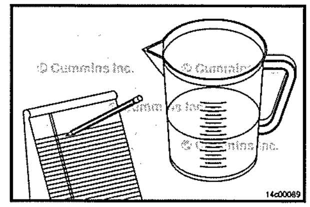
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
35 N•m [26 ft-lb]				
35 N•m [26 ft-lb]				
18 N•m [159 in-lb]				
16 N•m [142 in-lb]				
35 N•m [26 ft-lb]				
35 N•m [26 ft-lb]				
45 N•m [34 ft-lb]				
8 N•m [71 in-lb]				
35 N•m [26 ft-lb]				
18 N•m [159 in-lb]				
18 N•m [159 in-lb]				
16 N•m [142 in-lb]				
35 N•m [26 ft-lb]				
18 N•m [159 in-lb]				
16 N•m [142 in-lb]				
35 N•m [26 ft-lb]				
23 N•m [204 in-lb]				
18 N•m [159 in-lb]				
8.5 N•m [75 in-lb]				
23 N•m [204 in-lb]				
Air Intake Connection (010-080)		8 N•m	[71 in-lb]	
Dust Ejection Valve (010-146)		5 N•m	[44 in-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Exhaust System - Group 11 - Specifications

Exhaust Manifold Flatness		0.10 mm	MAX	0.004 in

Aftertreatment Diesel Exhaust Fluid Dosing Unit Override Test (011-063)



Aftertreatment Diesel Exhaust Fluid Dosing Valve Volume Specifications		270 ml	MIN	9.1 fl-oz
		330 ml	MAX	11.2 fl-oz

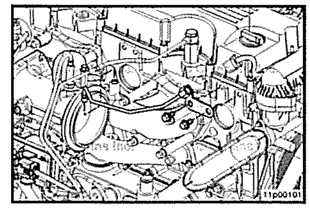
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Exhaust System - Group 11 - Torque Values

50 N•m [37 ft-lb]

Exhaust Gas Pressure Sensor Tube (011-027)

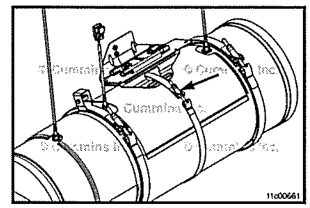
46 N•m [34 ft-lb]
16 N•m [142 in-lb]



14 N•m [124 in-lb]
55 N•m [41 ft-lb]
20 N•m [177 in-lb]

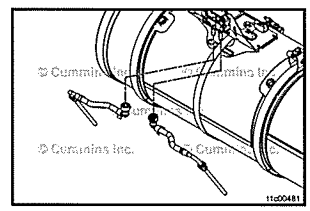
Aftertreatment Diesel Particulate Filter Differential Pressure Sensor Mounting Bracket (011-046)

7 N•m [62 in-lb]



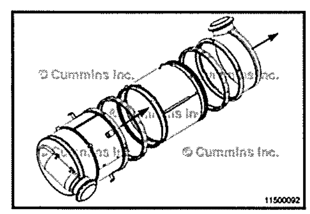
Aftertreatment Diesel Particulate Filter Differential Pressure Sensor Tubes (011-047)

31 N•m [23 ft-lb]
17 N•m [150 in-lb]
14 N•m [124 in-lb]



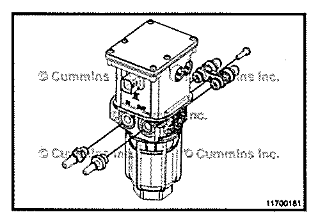
Aftertreatment Diesel Oxidation Catalyst (011-049)

V-Band Clamp
20 N•m [177 in-lb]
13.5 N•m [119 in-lb]

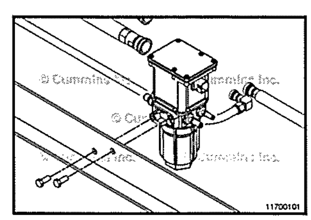


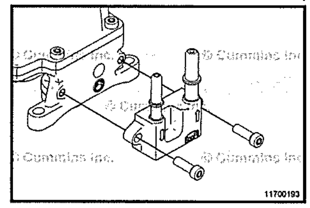
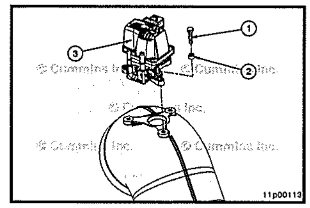
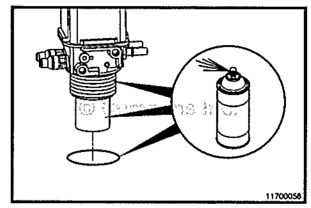
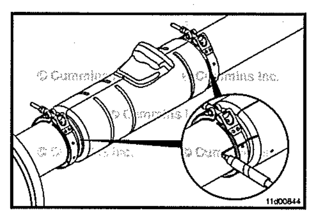
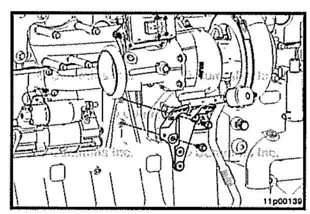
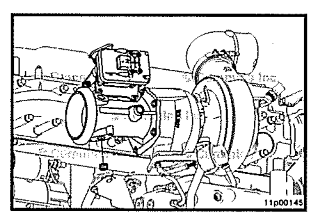
Aftertreatment Diesel Exhaust Fluid Dosing Unit (011-058)

Inlet Connector
14 N•m [124 in-lb]
20 N•m [177 in-lb]
6 N•m [53 in-lb]



18 N•m [159 in-lb]



Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
Aftertreatment Diesel Exhaust Fluid Dosing Valve (011-059)		8 N•m	[71 in-lb]	
		10 N•m	[89 in-lb]	
Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter (011-060)		80 N•m	[59 ft-lb]	
Aftertreatment Decomposition Tube (011-062) V-Band Clamps		14 N•m	[124 in-lb]	
20 N•m	[177 in-lb]			
7 N•m	[62 in-lb]			
Aftertreatment Intake NOx Sensor Bracket (011-079) Aftertreatment Intake NOx Sensor Bracket Capscrew		47 N•m	[35 ft-lb]	
25 N•m	[18 ft-lb]			
Exhaust Pressure Regulator (011-105)		50 N•m	[37 ft-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Compressed Air System - Group 12 - Torque Values

35 N•m	[26 ft-lb]
35 N•m	[26 ft-lb]
55 N•m	[41 ft-lb]
35 N•m	[26 ft-lb]
35 N•m	[26 ft-lb]
12 N•m	[106 in-lb]
80 N•m	[59 ft-lb]
80 N•m	[59 ft-lb]
45 N•m	[33 ft-lb]

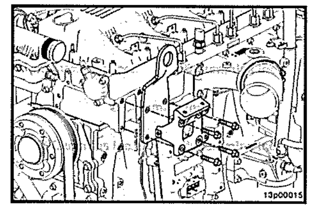
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Electrical Equipment - Group 13 - Torque Values

46 N•m [34 ft-lb]
65 N•m [48 ft-lb]

Charging System Alternator Bracket (013-003)

		46 N•m	[34 ft-lb]



80 N•m [59 ft-lb]
46 N•m [34 ft-lb]
46 N•m [34 ft-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.
Engine Testing - Group 14 - Specifications				
Fuel Filter Restriction Pressure Gauge Capacity		1379 kPa	MIN	200 psi

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Engine Testing - Group 14 - Torque Values

68 N•m	[50 ft-lb]
68 N•m	[50 ft-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Mounting Adaptations - Group 16 - Specifications

Flywheel Total Indicator Reading		0.127 mm	MAX	0.0050 in

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Mounting Adaptations - Group 16 - Torque Values

80 N•m	[59 ft-lb]
127 N•m	[94 ft-lb]
127 N•m	[94 ft-lb]
127 N•m	[94 ft-lb]
127 N•m	[94 ft-lb]

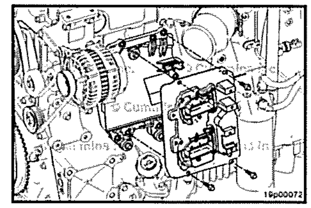
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	

Electronic Controls - Group 19 - Torque Values

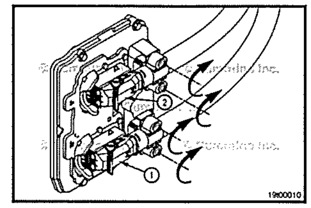
20 N•m [177 in-lb]

Engine Control Module (019-031)

7.4 N•m [65 in-lb]



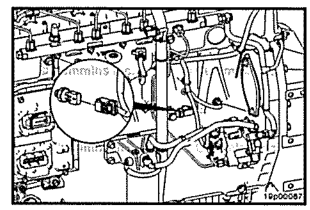
8 to 10 N•m [71 to 89 in-lb]



2 N•m [18 in-lb]
2 N•m [18 in-lb]
9.5 N•m [84 in-lb]

Engine Oil Pressure Sensor/Switch (019-066)

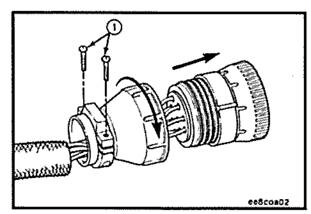
20 N•m [177 in-lb]



20 N•m [177 in-lb]
25 N•m [221 in-lb]
47 N•m [35 ft-lb]
5.6 N•m [50 in-lb]
3 N•m [27 in-lb]

Deutsch HD10 Connector Series (019-207)

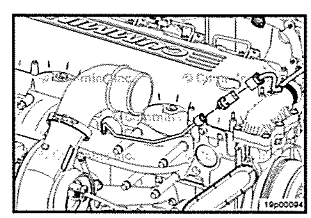
1 N•m [9 in-lb]



7.4 N•m [65 in-lb]
7.4 N•m [65 in-lb]

Exhaust Gas Pressure Sensor (019-376)

Exhaust Gas Pressure Sensor 14 N•m [124 in-lb]

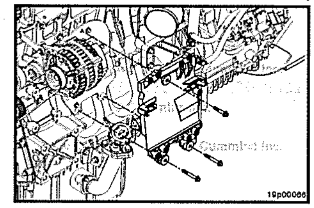


23 N•m [204 in-lb]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

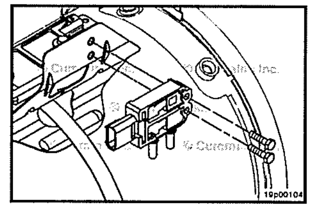
Engine Control Module Mounting Bracket (019-421)

23 N•m [204 in-lb]



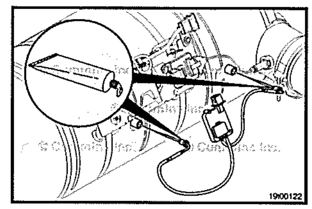
Aftertreatment Diesel Particulate Filter Differential Pressure Sensor (019-443)

14 N•m [124 in-lb]



Aftertreatment Exhaust Gas Temperature Sensor (019-449)

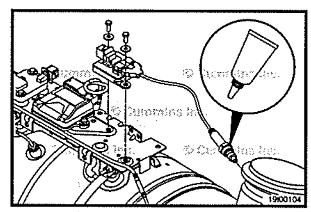
30 N•m [22 ft-lb]



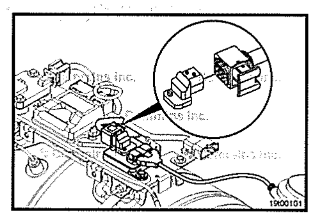
13.6 N•m [120 in-lb]

Aftertreatment Outlet NOx Sensor (019-451)

50 N•m [37 ft-lb]



10 N•m [89 in-lb]



50 N•m	[37 ft-lb]
4.4 N•m	[39 in-lb]
18 N•m	[159 in-lb]
7 N•m	[62 in-lb]
8 N•m	[71 in-lb]

General Engine

Specifications

Horsepower	Reference engine dataplate
Engine Speed @ Maximum Output	Reference engine dataplate
Bore and Stroke	132 mm [5.197 in] x 144 mm [5.669 in]
Displacement	11.8 liters [720 C.I.D.]
Firing Order	1-5-3-6-2-4
Engine Weight (dry weight with standard accessories)	795 kg [1753 lb]
Engine Weight (wet weight with standard accessories)	831 kg [1832 lb]
Crankshaft Rotation (viewed from the front of the engine)	**Clockwise**

Fuel System

Specifications

Maximum Fuel Drain Line Pressure
Rated Power.......525 mm-Hg [21 in-Hg]
Maximum Fuel Inlet Restriction
At Gear Pump Inlet (Dirty Filter, Loaded Condition).......254 mm-Hg [10 in-Hg]
At OEM Connection (Dirty Filter, Loaded Condition).......203 mm-Hg [8 in-Hg]
Minimum Gear Pump Pressure
During Cranking Condition.......375 mm-Hg [14.7 in-Hg]
During Rated Condition.......483 kPa [70 psi]
Maximum Filter Pressure-Drop.......138 kPa [20 psi]
Minimum Engine Cranking Speed.......100 rpm

Lubricating Oil System

Specifications

Oil Pressure:

Low idle (minimum allowed)....124 kPa [18 psi]
At rated (minimum allowed)....207 kPa [30 psi]
High Pressure dump valve opening pressure range....1034 kPa [150 psi]
Main rifle regulating valve opening pressure range....241 kPa [35 psi]
Oil filter differential pressure to open bypass....758 kPa [110 psi]

Oil Capacity of Standard Engine:

Pan **only** ....9 gal to high
High to Low (on dipstick)....34 liters [9 gal]
Maximum Oil Temperature:....136°C [277°F]

Cooling System

Specifications

Coolant capacity(engine only)....14.4 liters [15.2 quarts]
Standard modulating low thermostat....82°C [180°F]
Standard modulating high thermostat (fully open)....94°C [202°F]
Maximum allowed water outlet temperature....97°C [207°F]
Minimum recommended operating temperature....70°C [158°F]
Minimum recommended pressure cap....50 kPa [7 psi]

Air Intake System

Specifications

Maximum Intake Restriction

Maximum Intake Restriction (Clean Air Filter Element)....381 mm H_2O [15.0 in H_2O]

Maximum Intake Restriction (Dirty Air Filter Element)....635 mm H_2O [25.0 in H_2O]

Maximum Temperature Rise (At Ambient Temperature above 0°C [32°F])

Between Ambient Air and Engine Inlet Air....11°C [20°F]

Maximum Allowable Pressure Drop

Across Charge Air Cooler....102 mm Hg [4.0 in Hg]

Exhaust System

Specifications

Maximum Back Pressure at Turbocharger:..40 kPa 300 mm Hg [5.8 psi 11.8 in Hg]
Exhaust Pipe Normally Acceptable Inside Diameter...127 mm [5.0 in]

Electrical System

Specifications

Minimum Recommended Battery Capacity			
System Voltage	Application	Ambient Temperatures (-18°C [0°F])	
		Cold Cranking Amperes	Reserve Capacity[1] Amperes
12 VDC	Industrial	1875	580
24 VDC[2]	Industrial	1250	360

1 The number of plates within a given battery size determines reserve capacity. Reserve capacity is the number of minutes a battery at 26.7°C [80°F] can be discharged at 25 amperes and maintain a voltage of 10.5 VDC for a 12 VDC battery. Reserve capacity is aimed at a vehicle whose charging system is **not** functional and all electrical loads are running off of battery without aid of the alternator. Cold cranking amperes determines the length of time sustained cranking can occur.

2 CCA ratings are based on two 12 VDC batteries in series.

A minimum of 9 VDC continuous, 6 VDC at engine cranking at the OEM connector is required to power up the engine control module.

Maximum Starting Circuit Resistance
Battery Cable Size..........According to the starter manufacturer recommendations for maximum starting resistance.
Minimum Ambient Air Temperature
Without Starting Aid........-17.8°C [0°F]
Minimum Cranking Speed
Without Starting Aid........110 rpm

Compressed Air System

Specifications

This section is for the Wabco™ 318 Single Boost Air Compressor.

Cylinders....................1
Compressor Swept Volume @ 2100 ERPM/1MPa....................14.0 liters per sec [29.7 cfm]
Piston Displacement....................318 cc [19.4 C.I.D.]
Bore....................85 mm [3.35 in]
Stroke....................56 mm [2.2 in]
Speed....................1.5 x Engine Speed
Cooling....................Engine Coolant
Lubrication....................Engine Lubricating Oil
Plumbing Line Sizes:
Coolant Inlet and Outlet (pipe fitting)....................½-14 NPTF
Air Inlet (inside diameter)....................¾ -14 NPTF
Air Outlet (minimum inside diameter)....................M26 x 1.5
Unloader Port....................M10 x 1
Governor Mounting (direct)....................M8 x 1.25
Height, Overall (approximate)....................284mm [11.2 in]
Width, Overall (approximate)....................154 mm [6.1 in]
Length, Overall (approximate)....................164 mm [6.5 in]
Weight (approximate)....................13.613 Kg [30.0 lb]

NOTE: In applications where duty cycles average 10 percent or more or air pressures are above 862 kPa [125 psi], use a discharge line with a minimum inside diameter of 15.9 mm [0.625 in] for single-cylinder compressors and 25.4 mm [1.00 in] for twin-cylinder compressors to prevent carbon buildup. Examples of these applications are as follows: refuse trucks, pickup and delivery trucks, transit buses, and equipment with high accessory air usage.

Engine Testing

Specifications

Engine Blowby Specifications - with 8.99 mm [0.354 in] orifice..67.3 cm H_2O [26.5 in H_2O]

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

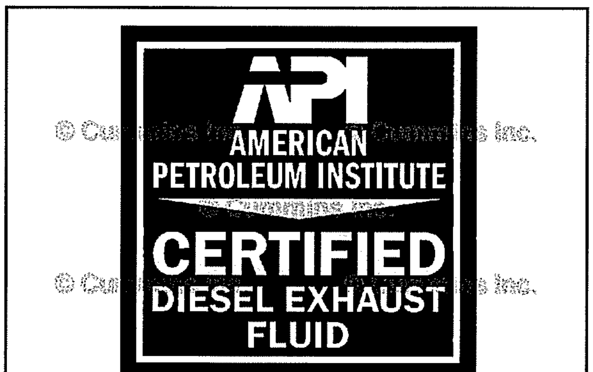
Never attempt to create Diesel Exhaust Fluid by mixing agricultural grade urea with water. Agricultural grade urea does not meet the necessary specifications required and the aftertreatment system may be damaged.

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.



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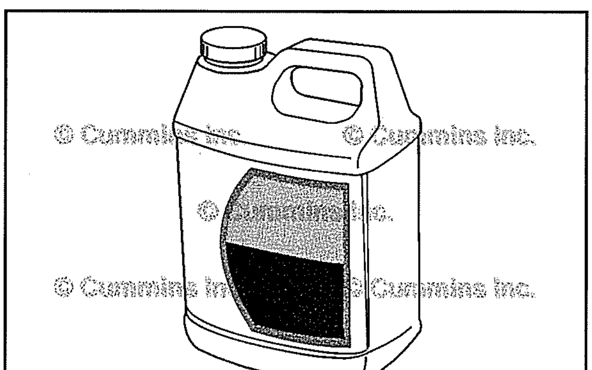
For engines using SCR operating in the United States and Canada, it is also strongly recommended that the Diesel Exhaust Fluid (DEF) used be certified by the American Petroleum Institute (API). This would be indicated by a symbol on the container/dispensing system as shown.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To 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.

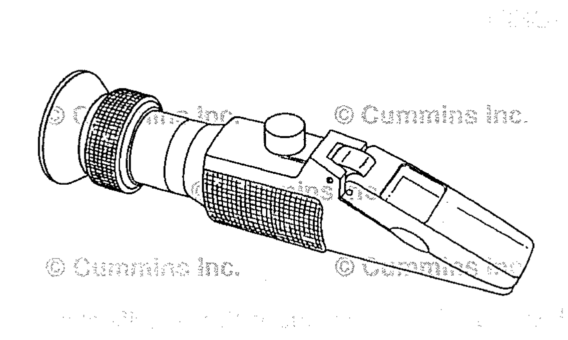
NOTE: Spilled Diesel Exhaust Fluid if left to dry or wiped away with a cloth only will leave a white residue. Failure to clean the spilled Diesel Exhaust Fluid may result in an incorrectly diagnosed leak of the Diesel Exhaust Fluid Dosing system.

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.



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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.

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.

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

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

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.					

Capscrew Markings and Torque Values

General Information

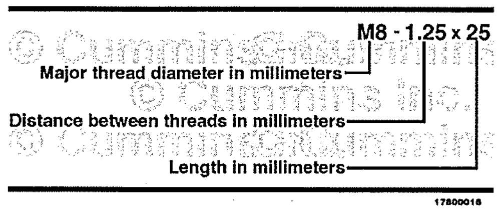
⚠CAUTION⚠

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.

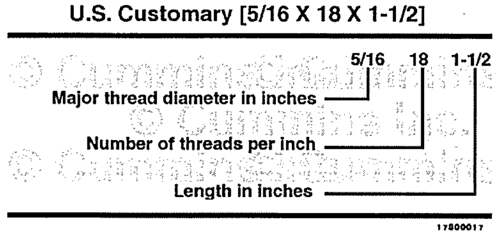
The following examples indicate how capscrews are identified:

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.

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



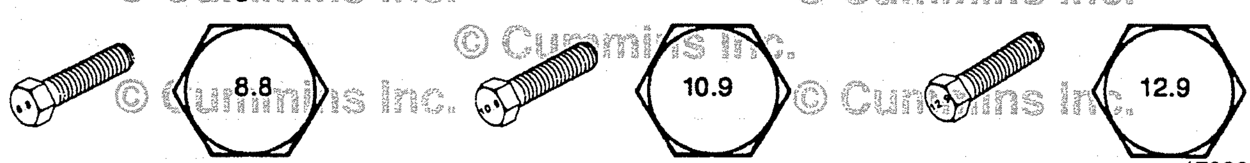
- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.

Capscrew Markings and Torque Values - Metric

Commercial Steel Class

8.8 | 10.9 | 12.9

Capscrew Head Markings



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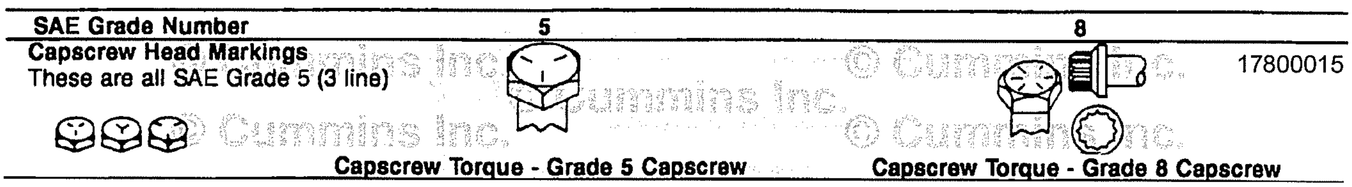
Capscrew Grade	8.8				10.9				12.9			
Material	Cast Iron		Aluminum		Cast Iron		Aluminum		Cast Iron		Aluminum	
Capscrew Body Diameter [mm]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]
6	9	5	7	4	13	10	7	4	14	9	7	4

Capscrew Grade	8.8				10.9				12.9			
Material	Cast Iron		Aluminum		Cast Iron		Aluminum		Cast Iron		Aluminum	
Capscrew Body Diameter [mm]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]
7	14	9	11	7	18	14	11	7	23	18	11	7
8	23	17	18	14	33	25	18	14	40	29	18	14
10	45	33	30	25	65	50	30	25	70	50	30	25
12	80	60	55	40	115	85	55	40	125	95	55	40
14	125	90	90	65	180	133	90	65	195	145	90	65
16	195	140	140	100	280	200	140	100	290	210	140	100
18	280	200	180	135	390	285	180	135	400	290	180	135
20	400	290	—	—	550	400	—	—	—	—	—	—

Capscrew Markings and Torque Values - U.S. Customary



Capscrew Grade	5				8			
Material	Cast Iron		Aluminum		Cast Iron		Aluminum	
Capscrew Body Diameter [in] and T.P.I.	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [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

Capscrew Grade	5				8			
Material	Cast Iron		Aluminum		Cast Iron		Aluminum	
Capscrew Body Diameter [in] and T.P.I.	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]	Torque [N•m]	Torque [ft-lb]
1 - 8	720	530	570	420	1100	820	570	420
1 - 14	800	590	650	480	1200	890	650	480

Pipe Plug Torque Values

Torque Table

Size		Torque		Torque	
Thread	Actual Thread O.D.	In Aluminum Components		In Cast Iron or Steel Components	
in	**in**	**N•m**	**ft-lb**	**N•m**	**ft-lb**
1/16	0.32	5	45 in-lb	15	10
1/8	0.41	15	10	20	15
1/4	0.54	20	15	25	20
3/8	0.68	25	20	35	25
1/2	0.85	35	25	55	40
3/4	1.05	45	35	75	55
1	1.32	60	45	95	70
1-1/4	1.66	75	55	115	85
1-1/2	1.90	85	65	135	100

Tap-Drill Chart - U.S. Customary and Metric

General Information

NOTE ON SELECTING TAP-DRILL SIZES: The tap drill sizes shown on this card give the theoretical tap drill size for approximately 60% and 75% of full thread depth. Generally, it is recommended that drill sizes be selected in the 60% range as these sizes will provide about 90% of the potential holding power. Drill sizes in the 75% range are recommended for shallow hole tapping (less than 1 1/2 times the hole diameter) in soft metals and mild steel.

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

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

Tap Size		Drill
60%	75%	Size
		7.50mm
		19/64
		7.60mm
		N
		7.70mm
	M9x1.25	7.75mm
		7.80mm
		7.90mm
	3/8-16	5/16
M9x1.25	M9x1	8.00mm
		O
		8.10mm
M9x1		8.20mm
		P
		8.25mm
		8.30mm
3/8-16	1/8-27NPT	21/64
		8.40mm
	3/8-24	Q
	M10x1.5	8.50mm
		8.60mm
		R
3/8-24		8.70mm
1/8-27NPT		11/32
	M10x1.25	8.75mm
M10x1.5		8.80mm
		S
		8.90mm
M10x1.25	M10x1	9.00mm
		T
		9.10mm
		23/64
M10x1		9.20mm
		9.30mm
	7/16-14	U
		9.40mm
	M11x1.5	9.50mm
		3/8
		V
		9.60mm
		9.70mm
		9.75mm
M11x1.5		9.80mm
7/16-14		W
		9.90mm
	7/16-20	25/64
		10.00mm
7/16-20		X
	M12x1.75	10.20mm
		Y
		13/32
		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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Barometric Pressure at Altitude

Specifications

Barometric Pressure at Altitude					
Pressure				Altitude	
kPa	PSI	mm Hg	in Hg	m	ft.
103.2	14.96	773.9	30.47	-152	-500
101.3	14.69	760.0	29.92	0	0
99.5	14.43	746.3	29.38	152	500
97.7	14.17	733.0	28.86	305	1000
96.0	13.92	719.8	28.34	458	1500
94.2	13.66	706.6	27.82	610	2000
92.5	13.42	693.9	27.32	762	2500
90.8	13.17	681.2	26.82	914	3000
89.2	12.93	668.8	26.33	1067	3500
87.5	12.69	656.3	25.84	1219	4000
85.9	12.46	644.3	25.37	1372	4500
84.3	12.23	632.2	24.89	1524	5000
82.8	12.01	620.7	24.44	1677	5500
81.2	11.78	609.1	23.98	1829	6000
79.7	11.56	597.8	23.54	1982	6500
78.2	11.34	586.5	23.09	2134	7000
76.7	11.13	575.5	22.66	2286	7500
75.2	10.91	564.4	22.22	2438	8000
73.8	10.71	553.8	21.80	2591	8500
72.4	10.50	543.1	21.38	2743	9000
71.1	10.31	532.8	20.98	2896	9500
69.7	10.11	522.5	20.57	3048	10,000
67.1	9.73	502.8	19.80	3353	11,000
64.4	9.34	483.1	19.02	3658	12,000
62.0	8.99	464.7	18.30	3963	13,000
59.5	8.63	446.3	17.57	4267	14,000
57.2	8.30	429.0	16.89	4572	15,000
54.9	7.96	411.7	16.21	4877	16,000