



# Service Manual QSF3.8 CM2350 F107 Volume 2

THIS  
PRINTED  
CUMMINS MANUAL  
INCLUDES  
A COMPANION  
DVD-ROM  
VERSION

**SYMPTOM: COOLANT TEMPERATURE ABOVE NORMAL**

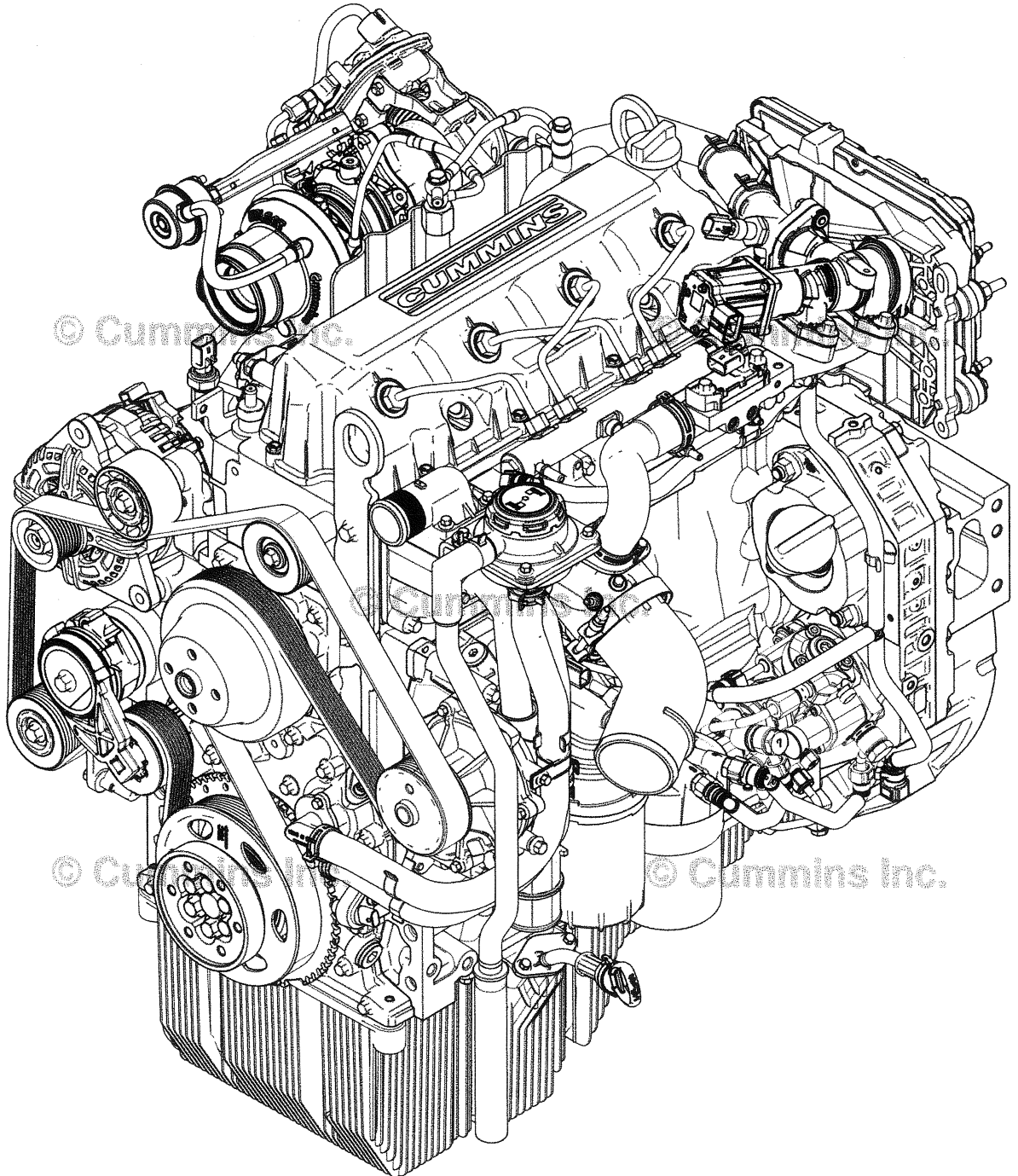
Cause	Correction
Low Coolant Level	Add Coolant. Refer to Section
Collapsed Radiator Hose	
Engine Lubricating Oil Level is too High or Low	
Engine is Receiving too Much Fuel	
Dirty Engine (Exterior)	
Loose Fan Drive Belt	
Radiator Shut Opening Closed	
Temperature Sensor Faulty	
Water Pump Faulty	
Thermostat Faulty	

Continued





**Service Manual  
QSF3.8 CM2350 F107  
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.

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# Section i - Introduction

## Section Contents

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## About the Manual

### General Information

This Service Manual is intended to aid in determining the cause of engine related problems and to provide recommended repair procedures. Additionally the manual is intended to aid mechanics in disassembly, inspecting parts for reuse, rebuilding and assembly of components.

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

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

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



## How to Use the Manual

### General Information

This manual is 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 environmental 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.

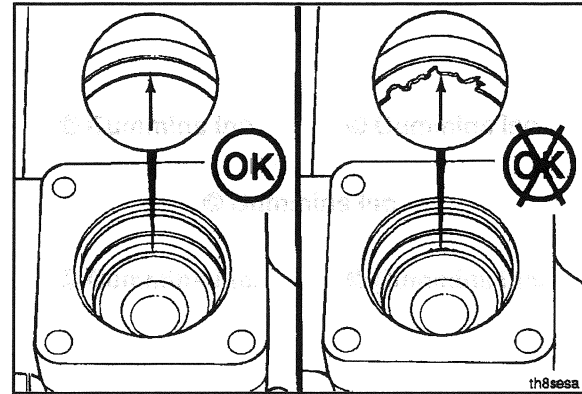


The component weighs 23kg [50 lbs] or more. To reduce the possibility of personal injury, use a hoist or get assistance to lift the component.

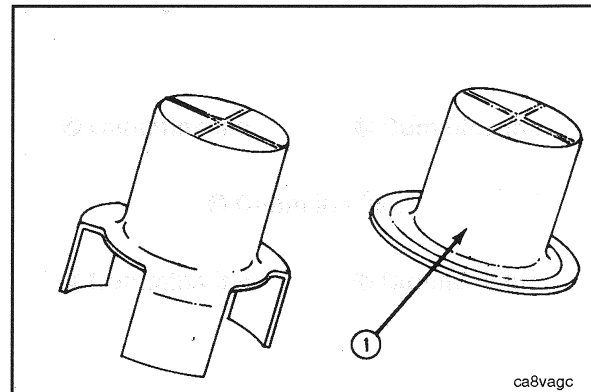
## Illustrations

### 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



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

Read and understand all of the safety precautions and warnings before performing any repair. This list contains the general safety precautions that **must** be followed to provide personal safety. Special safety precautions are included in the procedures when they apply.

- Work in an area surrounding the product that is dry, well lit, ventilated, free from clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.
- **Always** wear protective glasses and protective shoes when working.
- Rotating parts can cause cuts, mutilation or strangulation.
- Do **not** wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery (negative [-] cable first) and discharge any capacitors before beginning any repair work. Disconnect the air starting motor if equipped to prevent accidental engine starting. Put a "Do **Not** Operate" tag in the operator's compartment or on the controls.
- Use **ONLY** the proper engine barring techniques for manually rotating the engine. Do **not** attempt to rotate the crankshaft by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before slowly loosening the filler cap to relieve the pressure from the cooling system.
- **Always** use blocks or proper stands to support the product before performing any service work. Do **not** work on anything that is supported **ONLY** by lifting jacks or a hoist.
- Relieve all pressure in the air, oil, fuel, and cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do **not** check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.
- To reduce the possibility of suffocation and frostbite, wear protective clothing and **ONLY** disconnect liquid refrigerant (Freon) lines in a well ventilated area. To protect the environment, liquid refrigerant systems **must** be properly emptied and filled using equipment that prevents the release of refrigerant gas (fluorocarbons) into the atmosphere. Federal law requires capturing and recycling refrigerant.
- To reduce the possibility of personal injury, use a hoist or get assistance when lifting components that weigh 23 kg [50 lb] or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. **Always** use a spreader bar when necessary. The lifting hooks **must not** be side-loaded.
- Corrosion inhibitor, a component of SCA and lubricating oil, contains alkali. Do **not** get the substance in eyes. Avoid prolonged or repeated contact with skin. Do **not** swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. **IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.**
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and **must** be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. **KEEP OUT OF REACH OF CHILDREN.**
- To reduce the possibility of burns, be alert for hot parts on products that have just been turned off, exhaust gas flow, and hot fluids in lines, tubes, and compartments.
- **Always** use tools that are in good condition. Make sure you understand how to use the tools before performing any service work. Use **ONLY** genuine Cummins® or Cummins ReCon® replacement parts.
- **Always** use the same fastener part number (or equivalent) when replacing fasteners. Do **not** use a fastener of lesser quality if replacements are necessary.
- When necessary, the removal and replacement of any guards covering rotating components, drives, and/or belts should only be carried out by a trained technician. Before removing any guards the engine **must** be turned off and any starting mechanisms **must** be isolated. All fasteners **must** be replaced on re-fitting the guards.
- Do **not** perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.

- Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil.
- Do **not** connect the jumper starting or battery charging cables to any ignition or governor control wiring. This can cause electrical damage to the ignition or governor.
- **Always** torque fasteners and fuel connections to the required specifications. Overtightening or undertightening can allow leakage. This is critical to the natural gas and liquefied petroleum gas fuel and air systems.
- **Always** test for fuel leaks as instructed, as odorant can fade.
- Close the manual fuel valves prior to performing maintenance and repairs, and when storing the vehicle inside.
- Coolant is toxic. If **not** reused, dispose of in accordance with local environmental regulations.
- The catalyst reagent contains urea. Do **not** get the substance in your eyes. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Avoid prolonged contact with skin. In case of contact, immediately wash skin with soap and water. Do **not** swallow internally. In the event the catalyst reagent is ingested, contact a physician immediately.
- The catalyst substrate contains Vanadium Pentoxide. Vanadium Pentoxide has been determined by the State of California to cause cancer. Always wear protective gloves and eye protection when handling the catalyst assembly. Do not get the catalyst material in your eyes. In Case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Avoid prolonged contact with skin. In case of contact, immediately wash skin with soap and water.
- The Catalyst substrate contains Vanadium Pentoxide. Vanadium Pentoxide has been determined by the State of California to cause cancer. In the event the catalyst is being replaced, dispose of in accordance with local regulations.
- California Proposition 65 Warning - Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.



## General Repair Instructions

### General Information

This 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.



**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

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- 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.



**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



**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.



**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.**



**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** use 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 or 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.

<b>ANSI</b>	American National Standards Institute
<b>API</b>	American Petroleum Institute
<b>ASTM</b>	American Society of Testing and Materials
<b>ATDC</b>	After Top Dead Center
<b>BTU</b>	British Thermal Unit
<b>BTDC</b>	Before Top Dead Center
<b>°C</b>	Celsius
<b>CAN</b>	Controller Area Network
<b>CO</b>	Carbon Monoxide
<b>CCA</b>	Cold Cranking Amperes
<b>CARB</b>	California Air Resources Board
<b>C.I.B.</b>	Customer Interface Box
<b>C.I.D.</b>	Cubic Inch Displacement
<b>CNG</b>	Compressed Natural Gas
<b>CPL</b>	Control Parts List
<b>cSt</b>	Centistokes
<b>DEF</b>	Diesel Exhaust Fluid
<b>DOC</b>	Diesel Oxidation Catalyst
<b>DPF</b>	Diesel Particulate Filter
<b>ECM</b>	Engine Control Module
<b>EFC</b>	Electronic Fuel Control
<b>EGR</b>	Exhaust Gas Recirculation
<b>EPA</b>	Environmental Protection Agency
<b>°F</b>	Fahrenheit
<b>ft-lb</b>	Foot-Pound Force
<b>FMI</b>	Failure Mode Identifier
<b>GVW</b>	Gross Vehicle Weight
<b>Hg</b>	Mercury
<b>hp</b>	Horsepower
<b>H<sub>2</sub>O</b>	Water
<b>inHg</b>	Inches of Mercury
<b>in H<sub>2</sub>O</b>	Inches of Water
<b>ICM</b>	Ignition Control Module
<b>IEC</b>	International Electrotechnical Commission
<b>km/l</b>	Kilometers per Liter
<b>kPa</b>	Kilopascal
<b>LNG</b>	Liquid Natural Gas
<b>LPG</b>	Liquified Petroleum Gas
<b>LTA</b>	Low Temperature Aftercooling
<b>MCRS</b>	Modular Common Rail System
<b>MIL</b>	Malfunction Indicator Lamp
<b>MPa</b>	Megapascal
<b>mph</b>	Miles Per Hour
<b>mpq</b>	Miles Per Quart
<b>N•m</b>	Newton-meter



<b>NOx</b>	Mono-Nitrogen Oxides
<b>NG</b>	Natural Gas
<b>O2</b>	Oxygen
<b>OBD</b>	On-Board Diagnostics
<b>OEM</b>	Original Equipment Manufacturer
<b>OSHA</b>	Occupational Safety and Health Administration
<b>PID</b>	Parameter Identification Descriptions
<b>ppm</b>	Parts Per Million
<b>psi</b>	Pounds Per Square Inch
<b>PTO</b>	Power Takeoff
<b>REPTO</b>	Rear Power Take Off
<b>RGT</b>	Rear Gear Train
<b>rpm</b>	Revolutions Per Minute
<b>SAE</b>	Society of Automotive Engineers
<b>SCA</b>	Supplemental Coolant Additive
<b>SCR</b>	Selective Catalytic Reduction
<b>STC</b>	Step Timing Control
<b>SID</b>	Subsystem Identification Descriptions
<b>TDC</b>	Top Dead Center
<b>VDC</b>	Volts of Direct Current
<b>VGT</b>	Variable Geometry Turbocharger
<b>VS</b>	Variable Speed
<b>VSS</b>	Vehicle Speed Sensor

# Section 8 - Cooling System - Group 08

## Section Contents

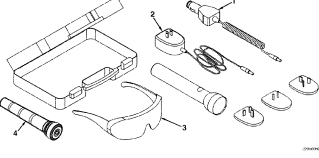
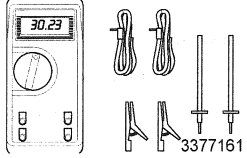
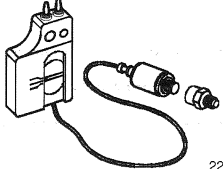
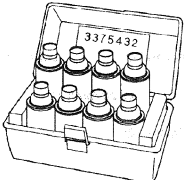
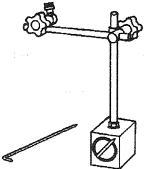
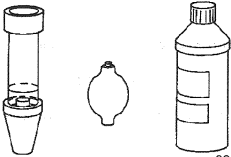
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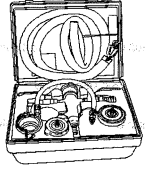
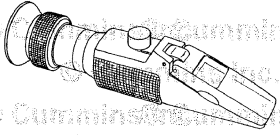
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## Service Tools

### 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
2892320	<p align="center"><b>Black Light Lamp</b></p> <p>Used with cordless "True UV" light that will detect the presence of fluorescent dye additive to detect leaks in all engine fluid systems (lubricating oil, coolant, and fuel).</p>	
3164489	<p align="center"><b>Multimeter</b></p> <p>Used to measure electrical circuits: Voltage (volts), resistance (ohms), and current (amps). 3164489 - Automotive meter with built in temperature adapter and tachometer.</p>	
3164491	<p align="center"><b>Pressure/Vacuum Module</b></p> <p>Used to measure fuel pressure and restriction. Use with multimeter, Part Number 3164488 or 3164489.</p>	
3375432	<p align="center"><b>Crack Detection Kit</b></p> <p>Used to detect cracks in engine components.</p>	
3377399	<p align="center"><b>Magnetic Base Indicator Holder</b></p> <p>Used in conjunction with Dial Indicator. Metric - Part Number 3824564. SAE - Part Number 4918289.</p>	
3822985	<p align="center"><b>Combustion Gas Leak Tester</b></p> <p>Used to test for combustion gases in the cooling system.</p>	

Tool No.	Tool Description	Tool Illustration
<p><b>3824319</b></p>	<p align="center"><b>Coolant Dam/Pressure Tester</b></p> <p>Using shop air pressure the coolant dam creates a vacuum, holding the coolant in with little or no coolant loss.</p>	 <p align="right">22d00167</p>
<p><b>CC-2806</b></p>	<p align="center"><b>Refractometer</b></p> <p>The Fleetguard® refractometer is used to check the freeze point protection in ethylene glycol and propylene glycol coolants.</p>	 <p align="right">rs8tda</p>

## Drive Belt, Cooling Fan (008-002)

### General Information

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

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

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

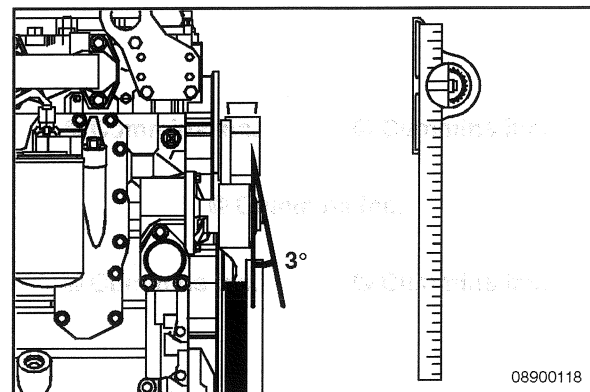
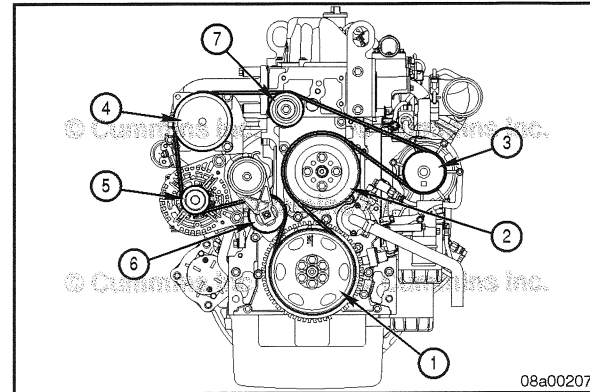
- 1 Crankshaft pulley/Vibration damper
- 2 Fan pulley
- 3 Water pump pulley
- 4 Refrigerant compressor pulley
- 5 Alternator pulley
- 6 Tensioner idler pulley
- 7 Idler pulley.

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

A worn belt tensioner or misaligned pulley can cause a belt to "walk" off.

To check pulley alignment, use Cummins® Pulley Alignment Fixture, Part Number 3163524. If **not** available, this measurement can be taken with a straight-edge and an inclinometer.

Maximum pulley misalignment is 3 degrees. Repair, adjust, or replace misaligned components as necessary.

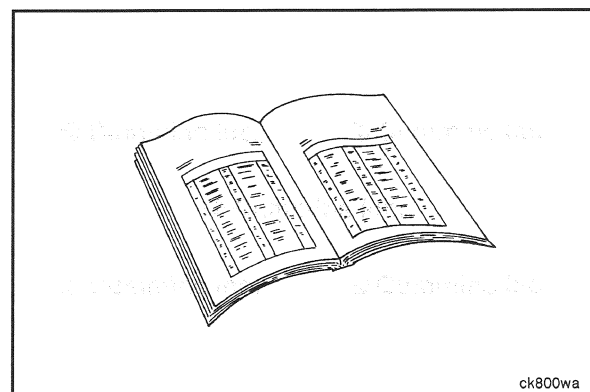


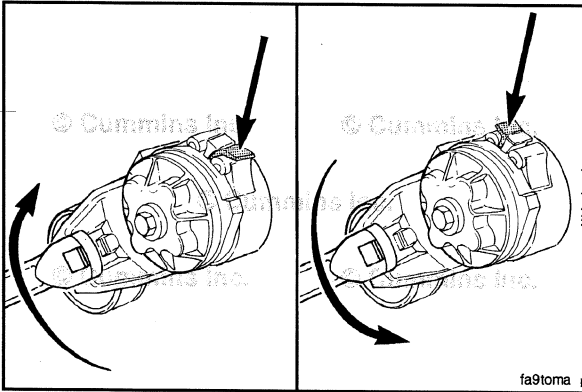
### Preparatory Steps

#### ▲ 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.



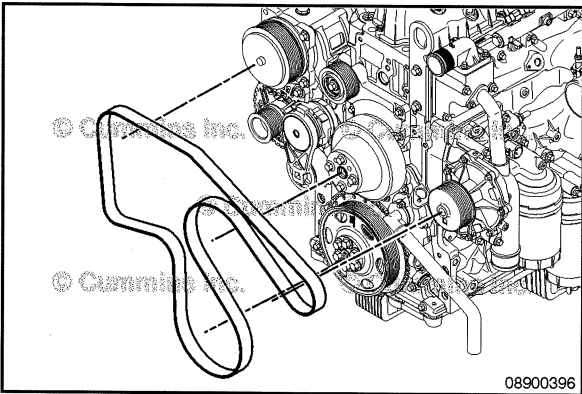


### Remove

#### ⚠ CAUTION ⚠

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

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



#### ⚠ CAUTION ⚠

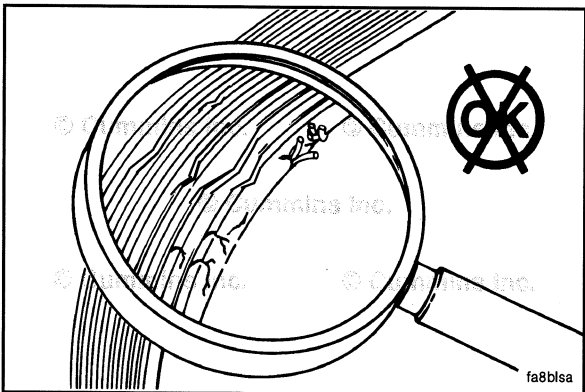
Applying excessive force in the opposite direction of windup or after the tensioner has been wound up to the positive stop can cause the tensioner arm to break.

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

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

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

Remove the belt.

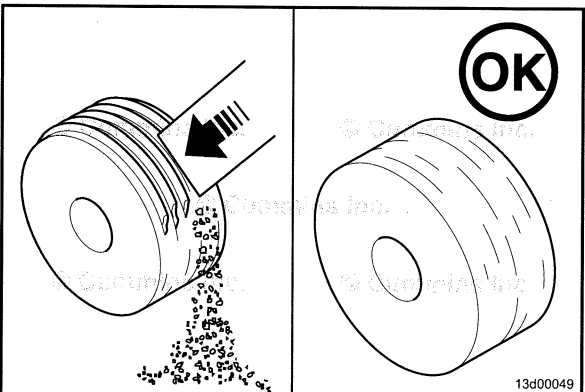


### Clean and Inspect for Reuse

Inspect the drive belt for:

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

Replace the belt if any damage is found.



Inspect the idler and drive pulleys for wear or cracks.

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



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

Clean, check, and reuse idlers with a buildup of dirt, rather than replacing.

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

## Install

### ⚠ CAUTION ⚠

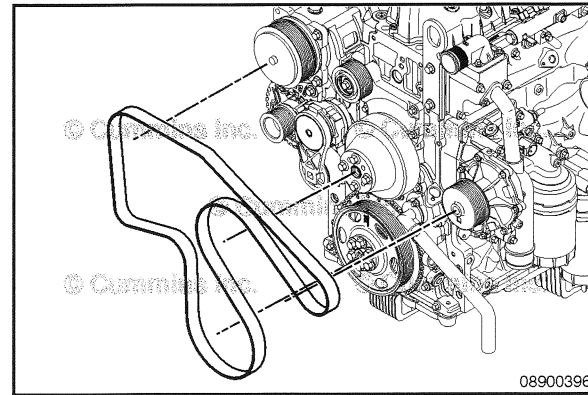
The belt tensioner is spring-loaded and must be pivoted away from the drive belt. Pivoting in the wrong direction can result in damage to the belt tensioner.

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

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

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.

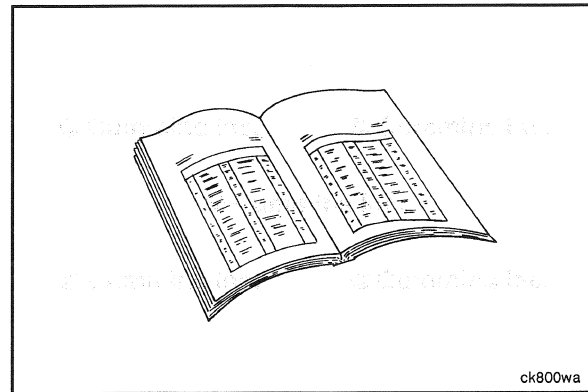


## Finishing Steps

### ⚠ 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 belt squeal. Excessive belt squeal indicates belt slippage.
- If belt squeal is present, check the routing of the belt to make sure the belt is installed correctly on each pulley.



## Coolant Bypass Tube (008-005)

### Preparatory Steps

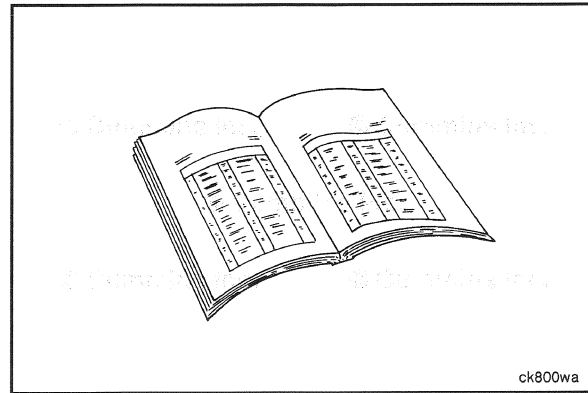
### ⚠ WARNING ⚠

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.

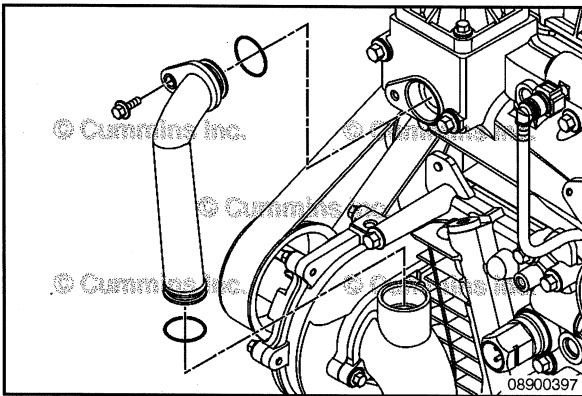
### ⚠ WARNING ⚠

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

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





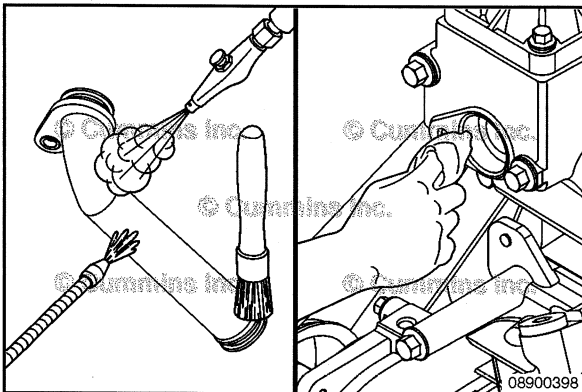


### Remove

Remove the mounting capscrew from the thermostat housing.

Remove the coolant bypass tube.

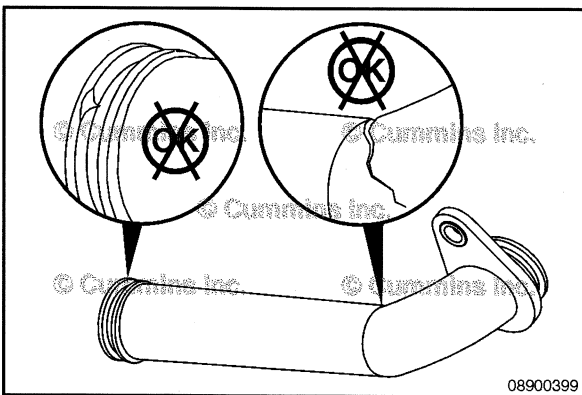
Remove and discard the o-ring.



### Clean and Inspect for Reuse

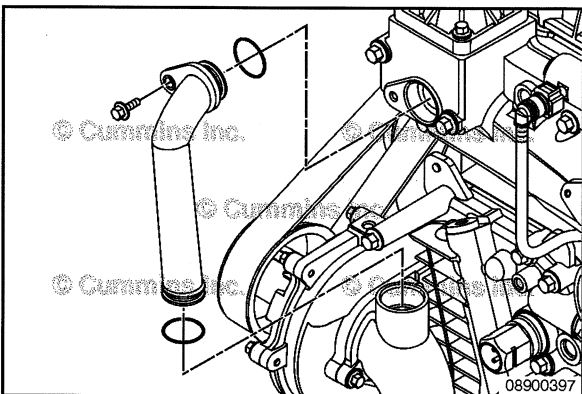
Clean the coolant bypass tube and thermostat housing mounting surface.

Clean the o-ring groove.



Inspect the coolant bypass tube for cracks or other damage.

Inspect the o-ring groove for burrs or nicks that will cut the o-ring.



### Install

Install a new o-ring on the coolant bypass tube.

Install the coolant bypass tube.

Tighten the capscrew.

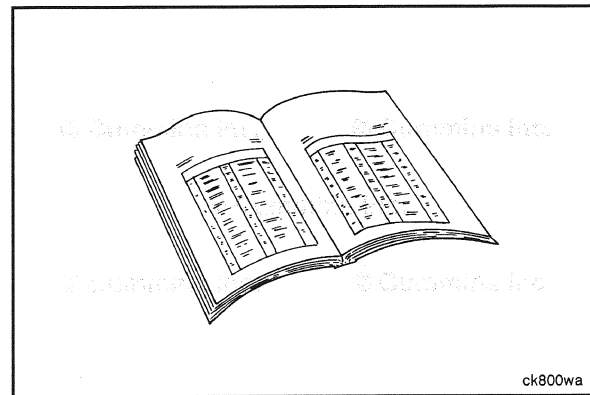


### Torque Value:

Coolant Bypass Tube Capscrew 24 N•m [ 212 in-lb ]

## Finishing Steps

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



## Coolant Heater (008-011)

### 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.

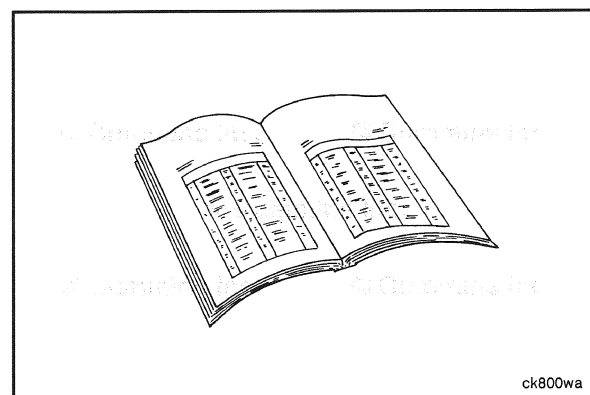
#### **⚠ WARNING ⚠**

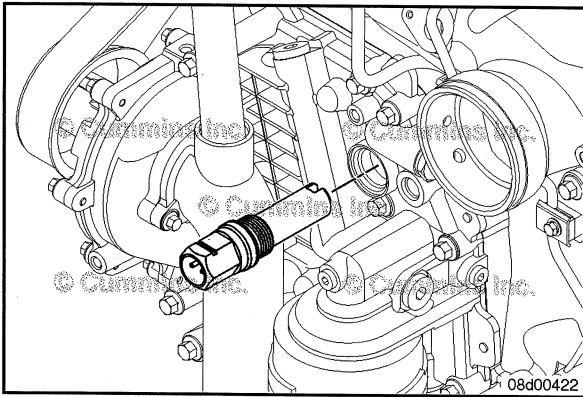
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

#### **⚠ CAUTION ⚠**

Use caution when draining the coolant system that coolant is not spilled or drained into the bilge area. The coolant must be discarded in accordance with local environmental regulations.

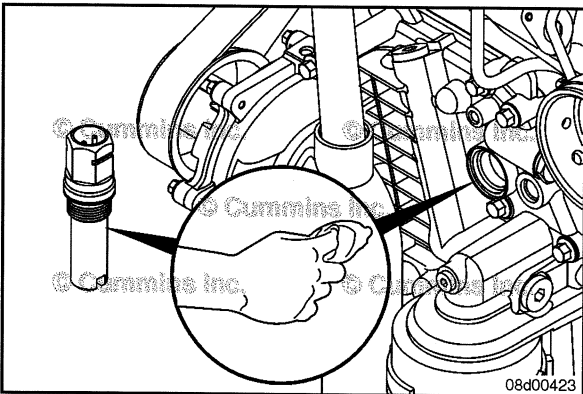
- Disconnect the batteries. See equipment manufacturer service information.
- Drain the engine cooling system. Refer to Procedure 008-018 in Section 8.
- Disconnect the coolant heater electrical cord.





### Remove

Remove the coolant heater from the oil cooler module.



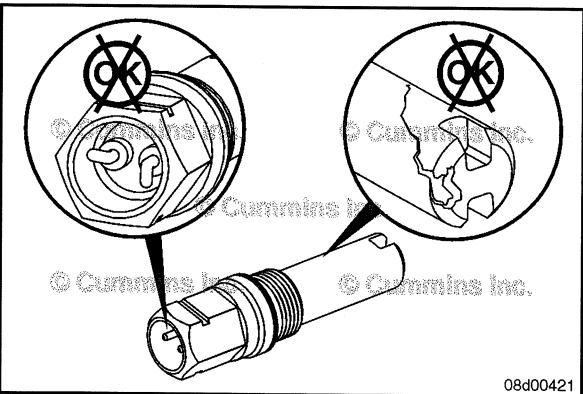
### Clean and Inspect for Reuse

Clean the cup plug bore (or hole) thoroughly with a clean rag.



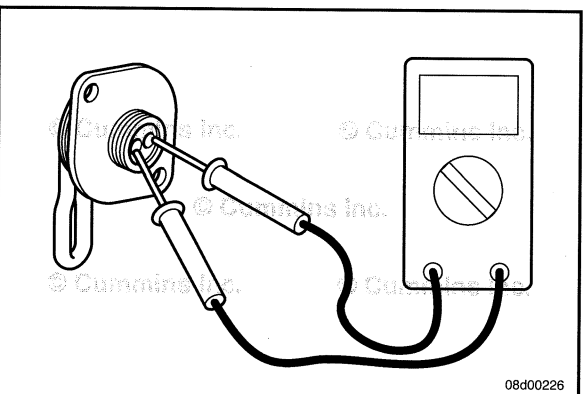
Make sure there are no burrs, metal shavings, or sharp edges that can possibly cut the o-ring.

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.



Check the coolant heater for cracks on the element.

Check the o-ring for cracks.



### ⚠ WARNING ⚠

To reduce the possibility of personal injury, do not touch the electrical supply wires or component while the testing procedure is in action.

Test the coolant heater resistance. The resistance **must** read between minimum 18.2 to maximum 21.1 ohms.

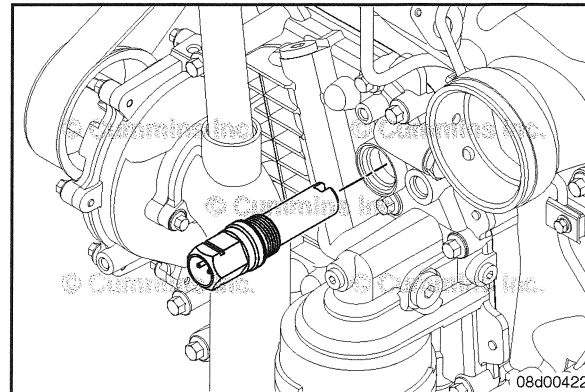
Coolant Heater Resistance (ohms)	
MIN	MAX
18.2 ohms	21.1 c

## Install

Apply pipe sealant, Cummins® Part Number 3375066, to threads of the heater.

Install the heater and tighten.

**Torque Value:** 55 N•m [ 41 ft-lb ]



## Finishing Steps

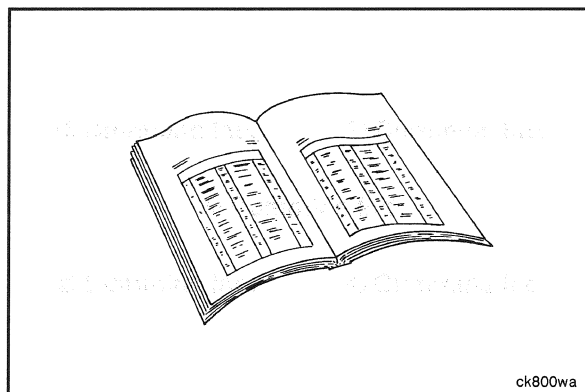
### ⚠ WARNING ⚠

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

### ⚠ WARNING ⚠

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.

- Attach the coolant heater electrical cord.
- Fill the engine cooling system. Refer to Procedure 008-018 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate engine and check for leaks.

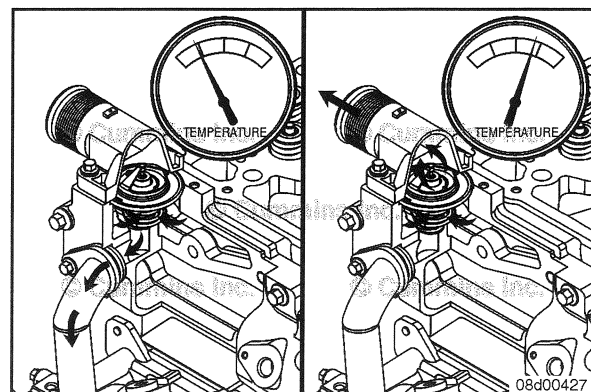


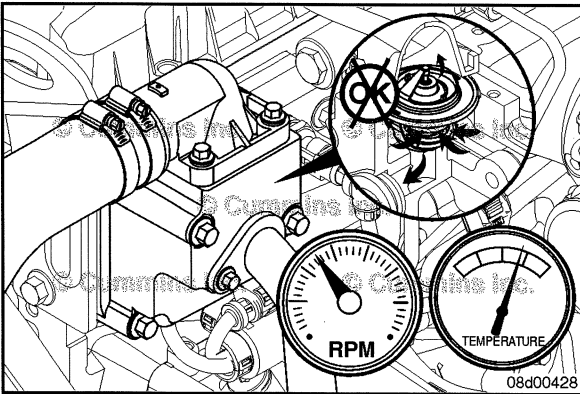
## Coolant Thermostat (008-013)

### General Information

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

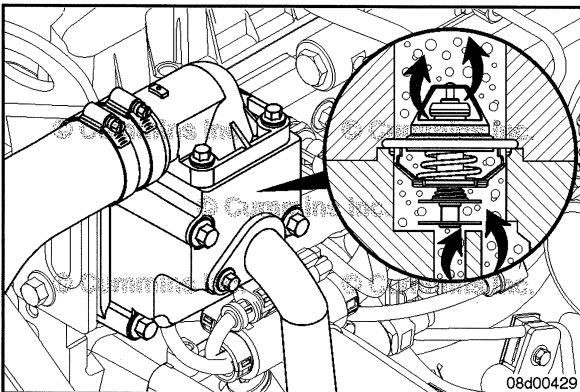
An incorrect or malfunctioning thermostat can cause the engine to run too hot or too cold.





**⚠ CAUTION ⚠**

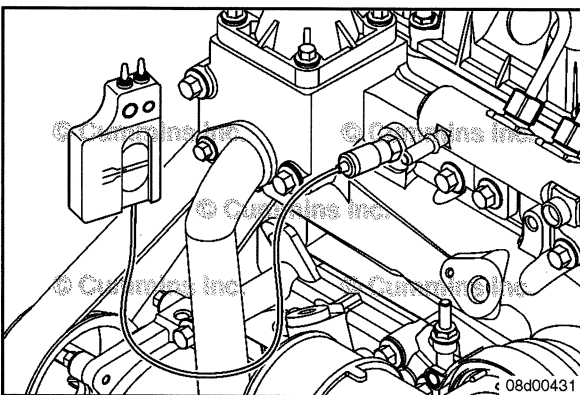
Never operate the engine without a thermostat. Without a thermostat, the path of least resistance for the coolant is through the bypass to the water pump inlet. This can cause the engine to overheat.



**⚠ CAUTION ⚠**

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

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

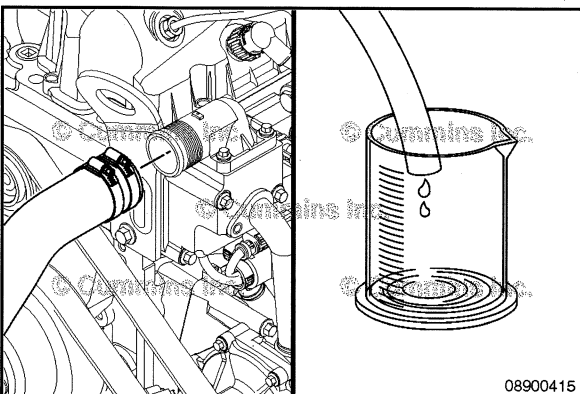


**Leak Test**

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 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.



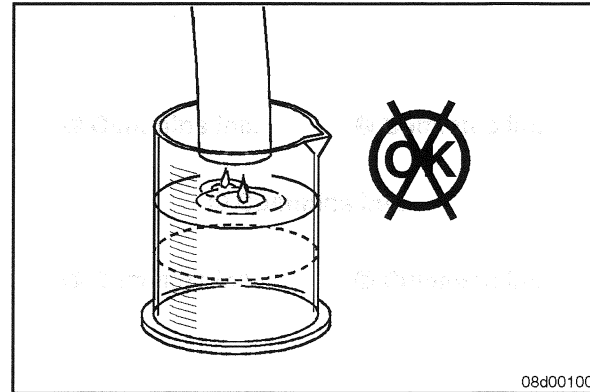
Disconnect the radiator top hose from the water outlet connection.

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 thermostat. See the Measurement step of this procedure for nominal opening temperature.) If the 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 [3.3 fl oz].

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

### Preparatory Steps

#### ⚠ WARNING ⚠

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



#### ⚠ WARNING ⚠

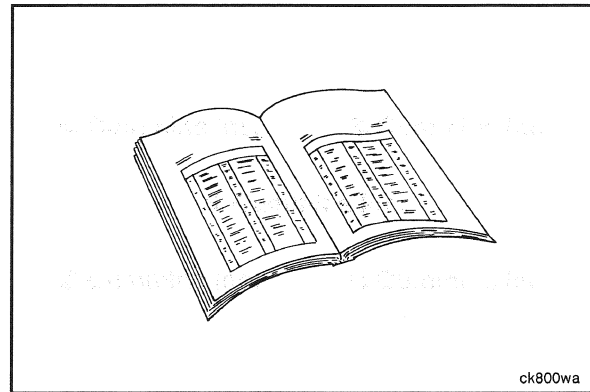
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

#### ⚠ 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.

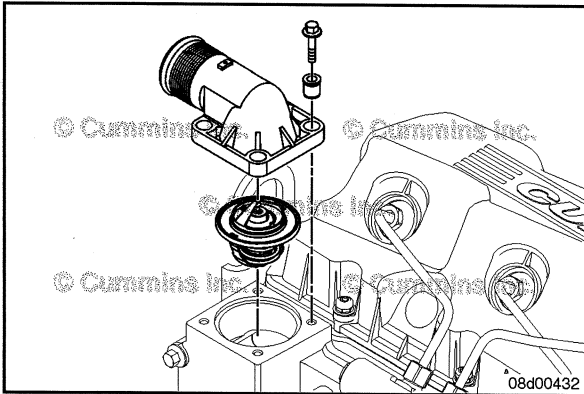
#### ⚠ CAUTION ⚠

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.



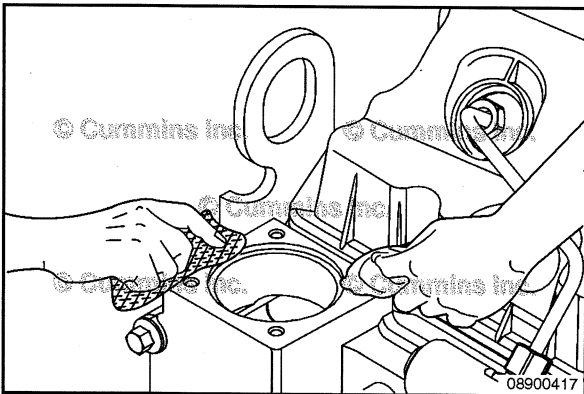
ck800wa

- Disconnect the batteries. See equipment manufacturer service information.
- Drain the coolant below the level of the thermostat. Refer to Procedure 008-018 in Section 7.
- Disconnect the upper radiator hose from the water outlet connection. See equipment manufacturer service information.



### Remove

Remove the water outlet connection cap screws.  
Remove the water outlet connection.  
Remove the thermostat.

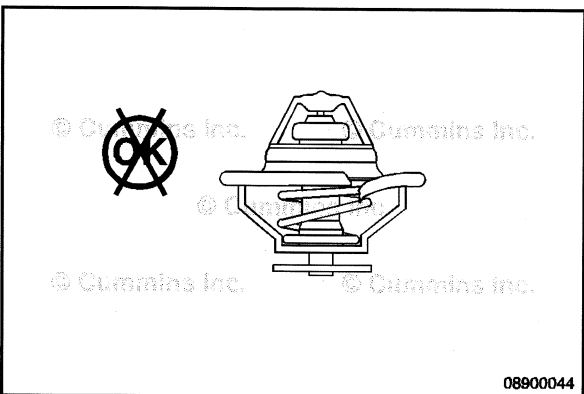


### Clean and Inspect for Reuse

#### ⚠ CAUTION ⚠

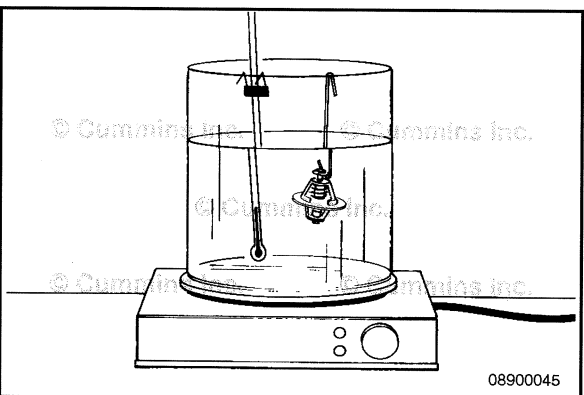
Do not let any debris fall into the thermostat cavity when cleaning the gasket surfaces. Damage to the cooling system and engine can occur.

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



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

Replace the thermostat if any damage is found.



### Measure

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

**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:

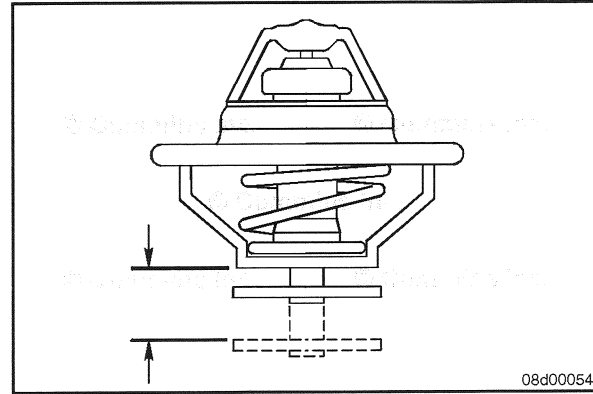
**NOTE:** The nominal operating temperature is stamped on the thermostat. To verify the correct temperature range thermostat is installed, make sure to reference the appropriate Part Information resources.

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

82°C [180°F] Nominal Temperature Thermostat

**Thermostat Opening Temperature**

	°C		°F
Initial Opening	79	MIN	175
	83	MAX	182
Fully Opened	95	MAX	203



08d00054

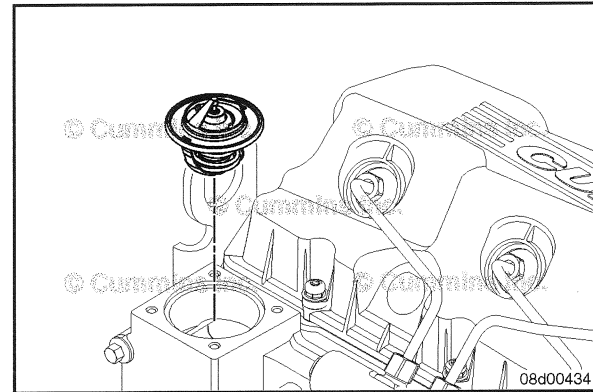
**Install**

**⚠ CAUTION ⚠**

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

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

Install the thermostat into the thermostat housing.

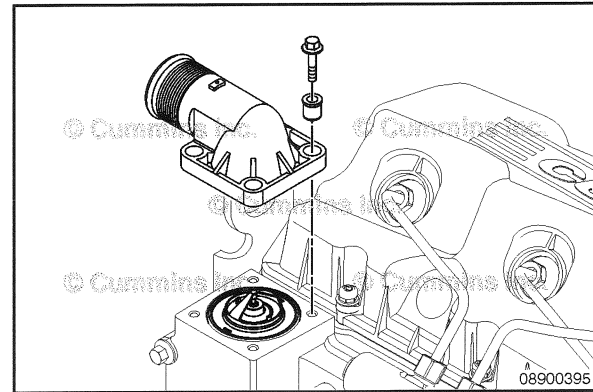


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Install the water outlet connection and mounting capscrews.

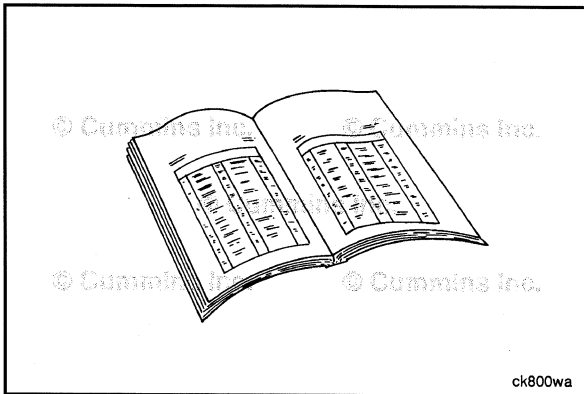
Tighten the capscrews.

**Torque Value:** 7 N•m [ 62 in-lb ]



08900395





## Finishing Steps

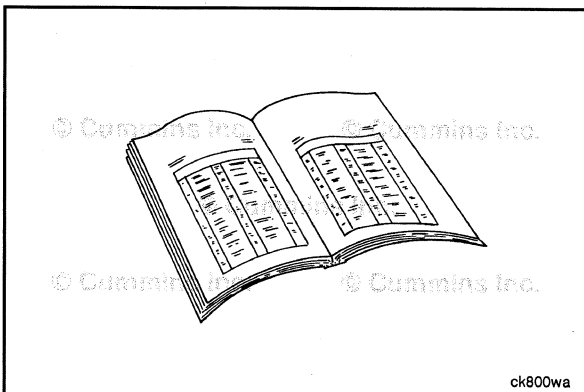
### ▲WARNING▲

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.

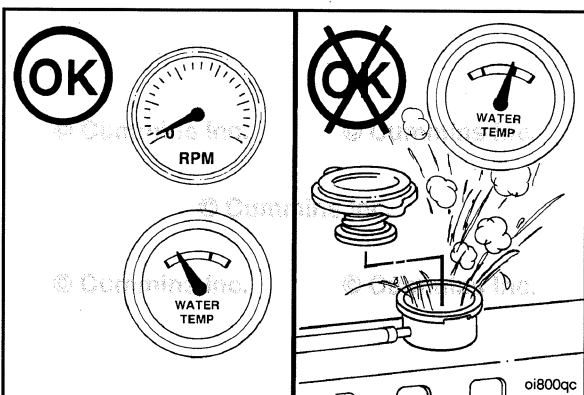
- Connect the upper radiator hose to the water outlet connection. See equipment manufacturer service information.
- Fill the cooling system. Refer to Procedure 008-018 in Section 7.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



## Coolant Thermostat Housing (008-014) General Information

This thermostat housing is cast into the intake manifold.

If the thermostat housing is damaged, the intake manifold **must** be replaced. Refer to Procedure 010-023 in Section 10.



## 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.

**NOTE:** In the event of a water pump or exhaust gas recirculation (EGR) cooler malfunction, check the coolant level switch or sensor for proper operation. See equipment manufacturer service information for operational checks and repairs.

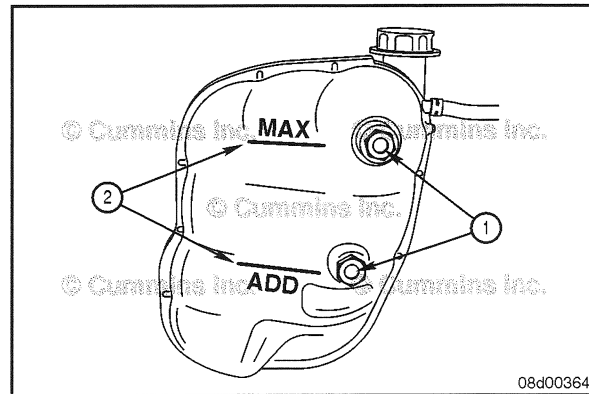
On applications that use a coolant recovery system, check to make sure the coolant is at the appropriate level on the coolant recovery tank, for the engine temperature.

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.

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

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

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



**Maintenance Check**

**⚠ CAUTION ⚠**

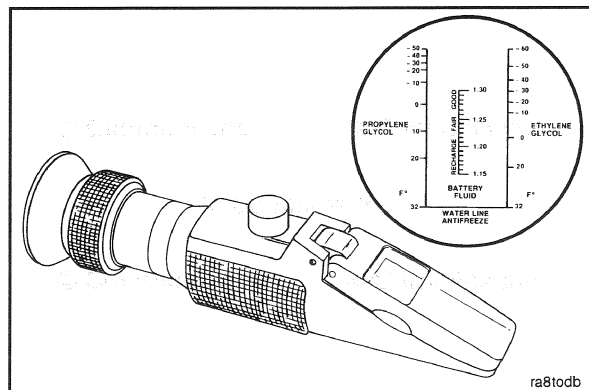
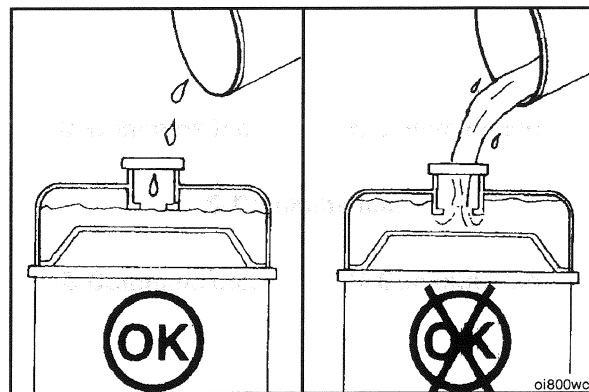
Over-concentration of antifreeze or use of high silicate antifreeze can cause damage to the engine.

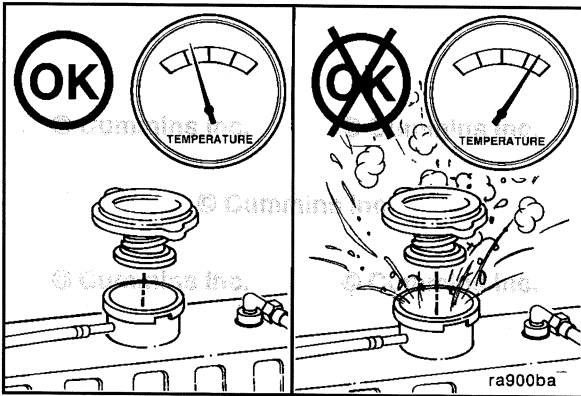
Check the antifreeze concentration. Use a mixture of 50-percent water and 50-percent ethylene glycol or propylene glycol-base antifreeze to protect the engine to -32°C [-25°F] year-around.

The Fleetguard™ refractometer, Part Number CC-2806, provides a reliable, easy to read, and accurate measurement of freeze point protection and glycol (antifreeze) concentration.

Antifreeze is essential in every climate as it broadens the operating temperature by lowering the coolant freeze point and by raising its boiling point.

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



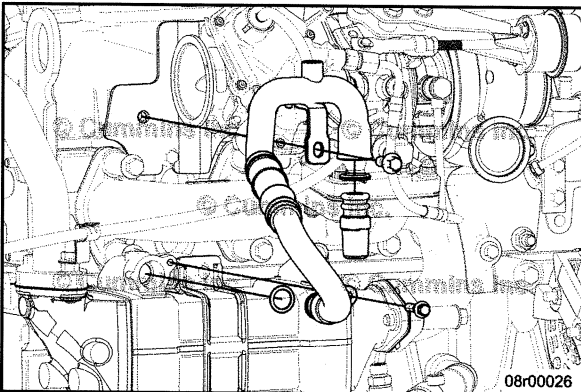


### Drain

#### ⚠ WARNING ⚠

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

Remove the radiator/expansion tank cap.

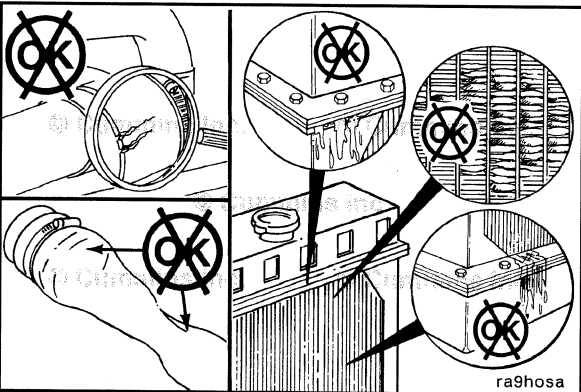


#### ⚠ WARNING ⚠

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

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

**NOTE:** On applications with an EGR system, disconnect the EGR cooler coolant return line to make sure the coolant is drained from the EGR cooler.



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.

**NOTE:** If coolant has been contaminated, the cooling system should be flushed.

## Flush

### ⚠CAUTION⚠

The cooling 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 make sure air is vented during the fill process:

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

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

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

Restore™ is a heavy-duty cooling system cleaner that removes corrosion products, silica gel, and other deposits. The performance of Restore™ is dependent on time, temperature, and concentration levels. An extremely scaled or flow-restricted system, for example, can require higher concentrations of 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.

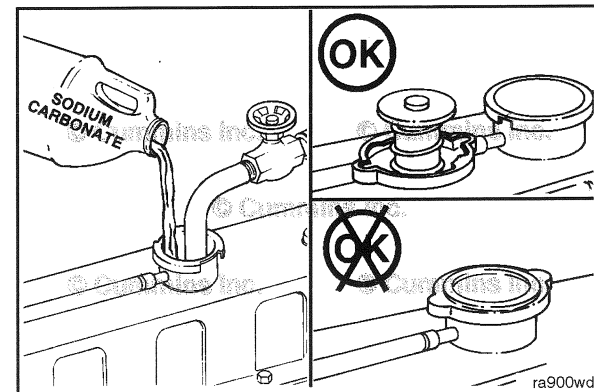
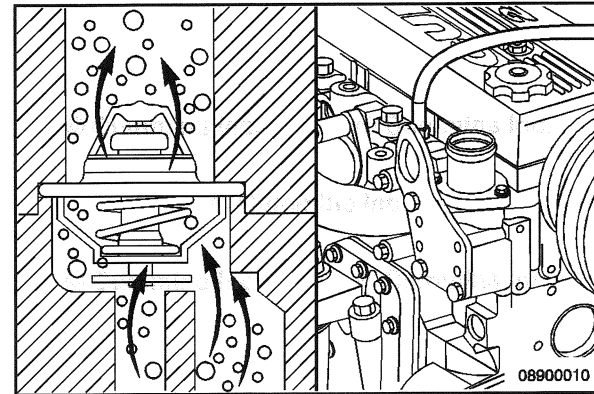
Close the radiator drain valve.

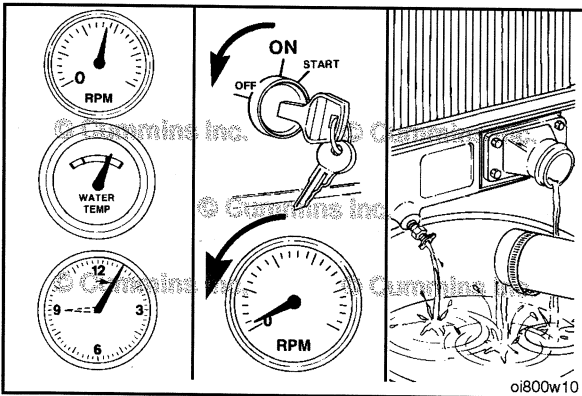
Install the plug in the water inlet connection.

Install the EGR coolant return connection.

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

**NOTE:** Adequate venting is provided for a fill rate of 11 liters [3 gal] per minute.

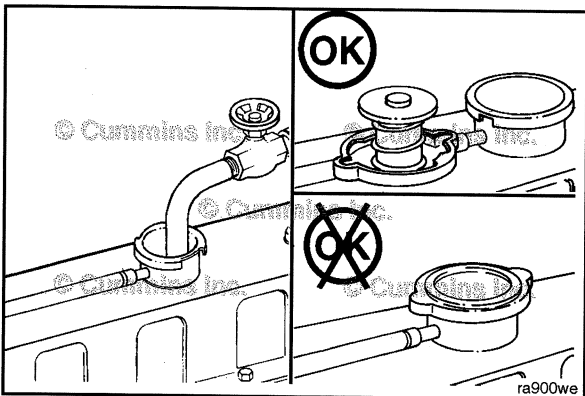




**⚠ WARNING ⚠**  
Coolant is toxic. Keep away from children and pets. Dispose of in accordance with local environmental regulations.

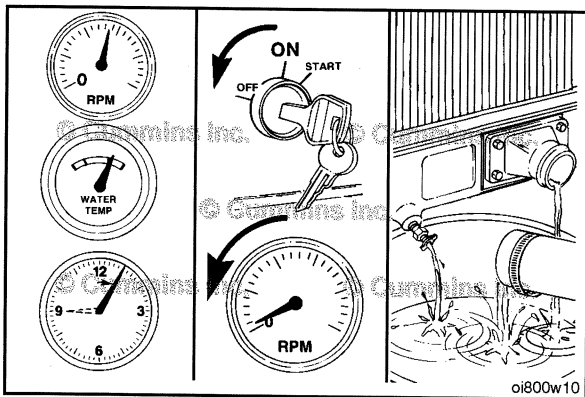
Operate the engine for 5 minutes with the coolant temperature above 80°C [176°F].

Shut the engine off, and drain the cooling system.



Fill the cooling system with clean water.

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



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

Shut the engine off, and drain the cooling system.

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

## Fill

### ⚠CAUTION⚠

The cooling 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 make sure air is vented during the fill process:

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

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

### ⚠CAUTION⚠

Before topping off the cooling system, allow the system temperature to cool to ambient. This will allow an adequate amount of coolant to be available to the water pump during all periods of operation.

### ⚠CAUTION⚠

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

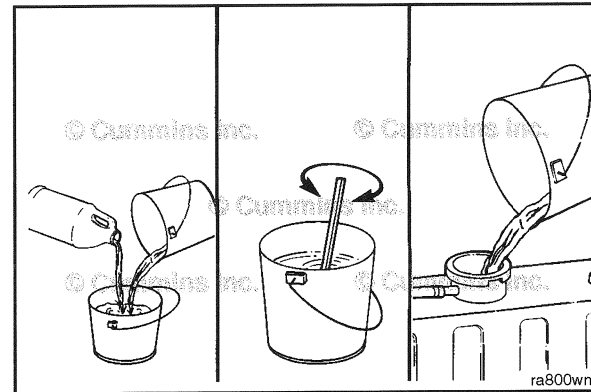
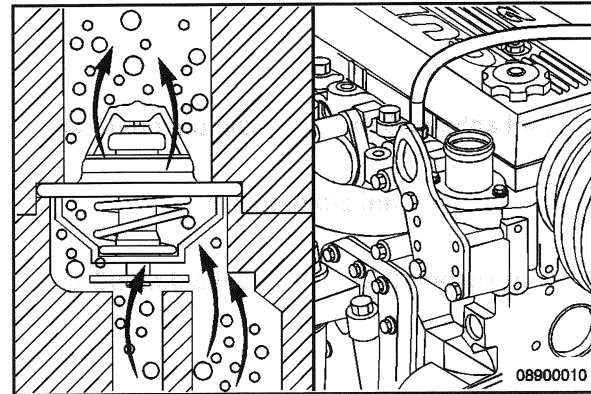
### ⚠CAUTION⚠

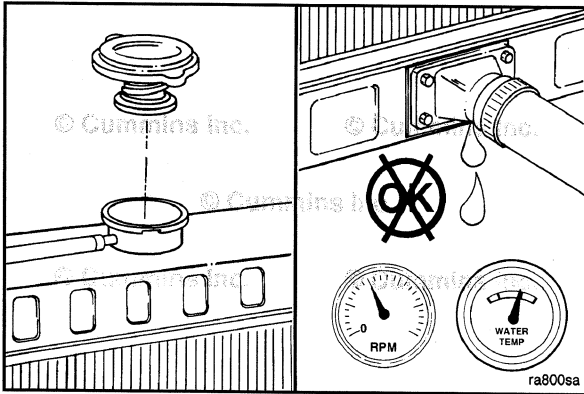
Do not use water alone for coolant. Damage from corrosion can severely damage the engine cooling system.

Use a mixture of 50-percent water and 50-percent ethylene glycol or propylene glycol antifreeze to fill the cooling system.

Reference the Cummins® Coolant Requirements and Maintenance, Bulletin 3666132, for engine coolant specifications.

Use the following procedure 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 [122°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

**▲ WARNING ▲**

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

Install the pressure cap.

Operate the engine until it reaches a temperature of 80°C [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 equipped.

TEMPERATURE			PRESSURE			RADIATOR "W" LINE STARTS GETTING HOT	FAN KICKS ON	SHUTTERS OPEN
THERMOSTAT HOUSING	BLOCK	CAB GAUGE	BLOCK	THERMOSTAT HOUSING				
	140							
	145							
	150							
	155							
160								
165								
170								
175								
180								
	185							
	190							
MONITOR	195							
FAN OPERATION	200							
See * Below	205							
	195							

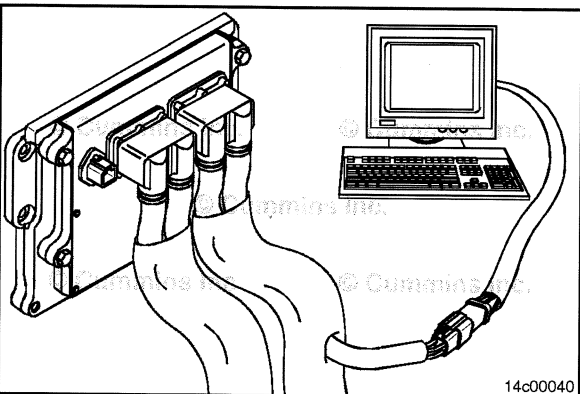


**Cooling System Diagnostics (008-020)  
General Information**

**NOTE:** At the end of this procedure, a worksheet is provided to record any measured values taken during troubleshooting. The worksheet will help in gathering and analyzing the data.

The following procedure covers common troubleshooting steps to help identify:

- Engine overheat causes. Reference the Initial Check section of this procedure.
- External and internal coolant leaks/loss. Reference the Pressure Test section of this procedure.
- Combustion gas leaks into the cooling system. Reference the Test section of this procedure.



**Initial Check**

Connect INSITE™ electronic service tool to the vehicle data link.

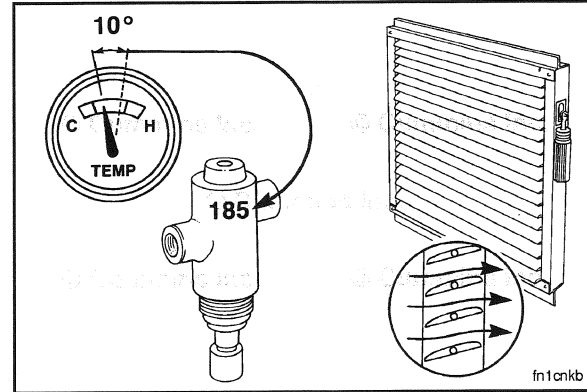
Turn the keyswitch to the ON position.

Monitor the coolant temperature with the electronic service tool.

**QSF3.8 CM2350 F107**  
**Section 8 - Cooling System - Group 08**

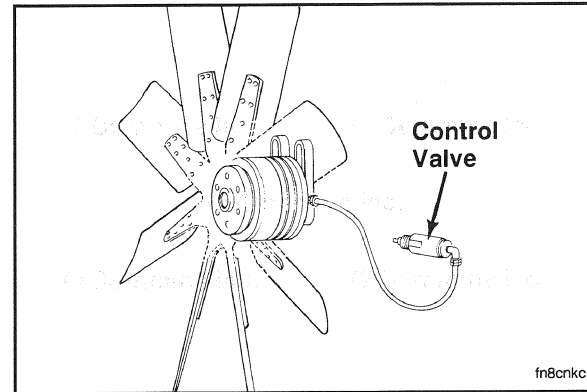
Check the coolant temperature when the shutters are opened. Compare this value to what is stamped on the shutter control.

Cummins Inc. recommends that the shutters open at 85°C [185°F].



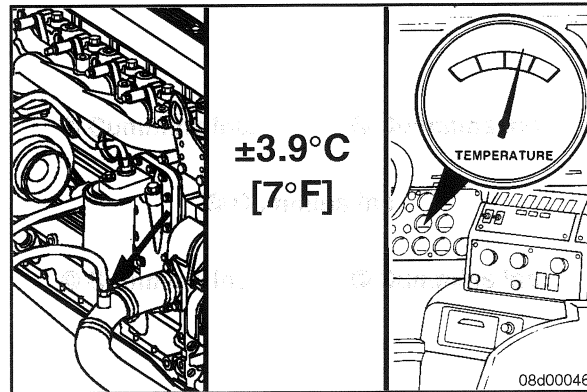
Check the coolant temperature when the fan is engaged. Compare this value to what is stamped on the fan control.

Cummins Inc. recommends that the fan engage at 96°C [205°F].

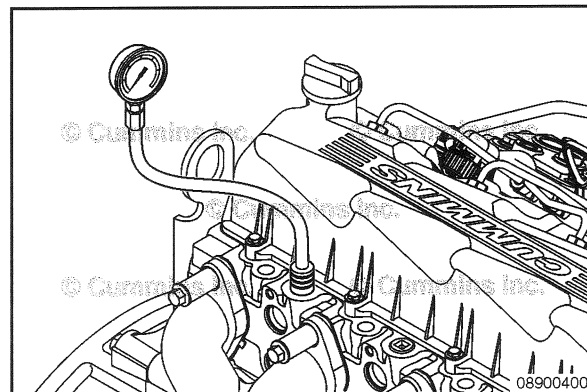


Monitor coolant temperature with electronic service tool and compare the cab temperature gauge reading. Replace the cab temperature gauge if it is **not** within the manufacturer's specifications of the correct reading.

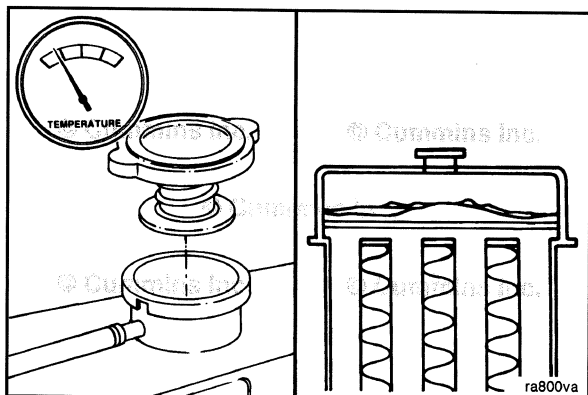
If no manufacturer's specifications are available, replace the gauge if it is **not** within  $\pm 3.9^\circ\text{C}$  [7°F] of the correct reading.



Measure the coolant pressure at a coolant tap on the cylinder head.

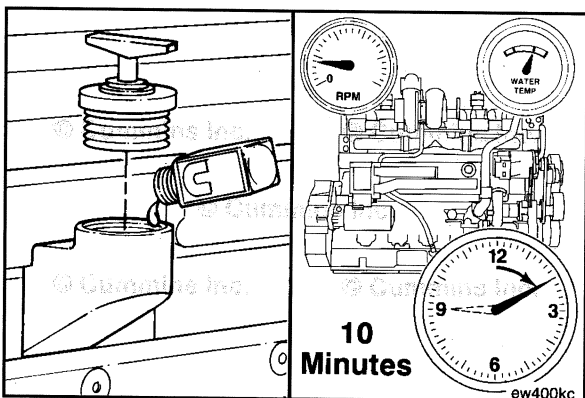






### Pressure Test

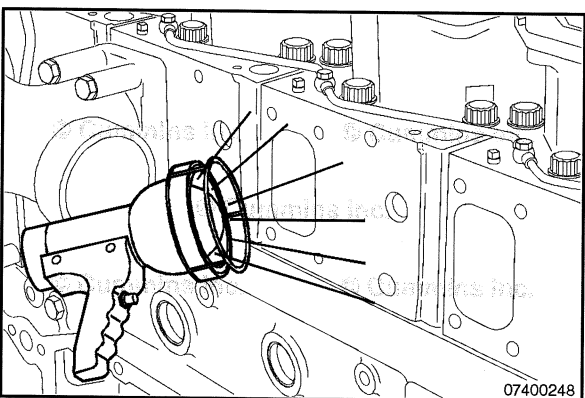
Check the coolant level and fill if necessary. Refer to Procedure 008-018 in Section 8.



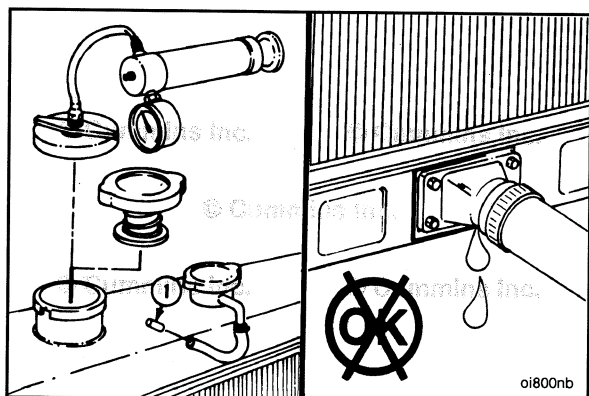
To aid in determining the location of the coolant leak, it may be necessary to add fluorescent tracer, Cummins® Part Number 3377438, to the coolant.

Add one unit of fluorescent tracer to each 38 liters [10 U.S. gallons] 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.



Use a high intensity black light, Cummins® Part Number 2892320, 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.

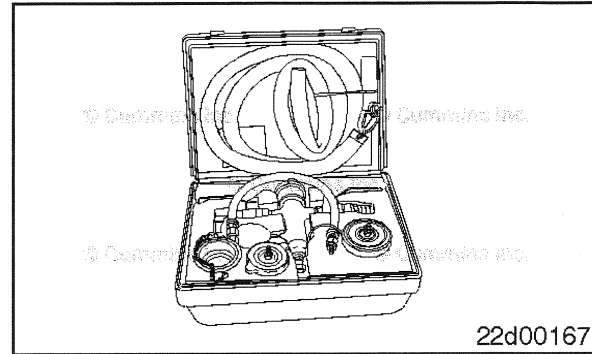
If the radiator is equipped with a pressure relief valve, plug the overflow line (1).

Install the pressure tester on the radiator fill neck or surge tank, if equipped, and apply air pressure.

**Air Pressure 138 kPa [ 20 psi ]**

**QSF3.8 CM2350 F107**  
**Section 8 - Cooling System - Group 08**

The Coolant Dam™/Pressure Tester service tool, Cummins® 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.

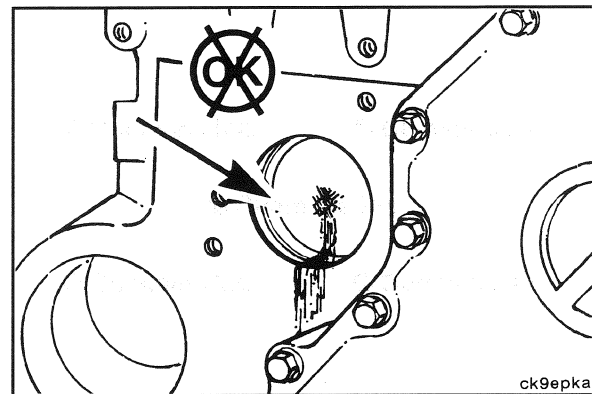


For external coolant leaks, inspect the exterior of the engine for coolant leaks and repair if necessary.



Pay close attention to areas around the:

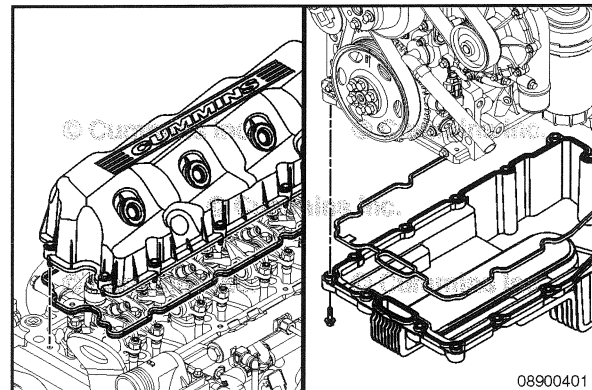
- Lubricating oil cooler housing. Refer to Procedure 007-003 in Section 7.
- Cup plugs and pipe plugs. Refer to Procedure 017-002 and Refer to Procedure 017-007 in Section 17.



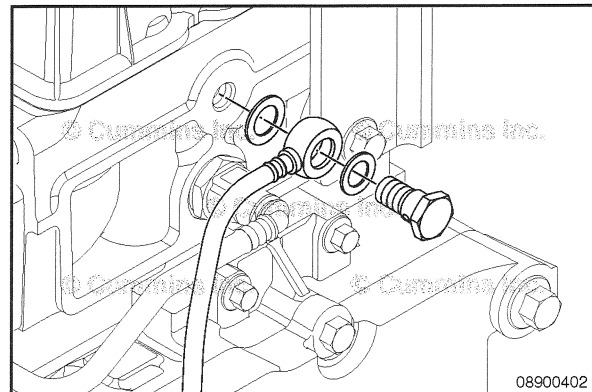
For internal coolant leaks, inspect the interior of the engine. It may be necessary to remove the following components to look for signs of a coolant leak.

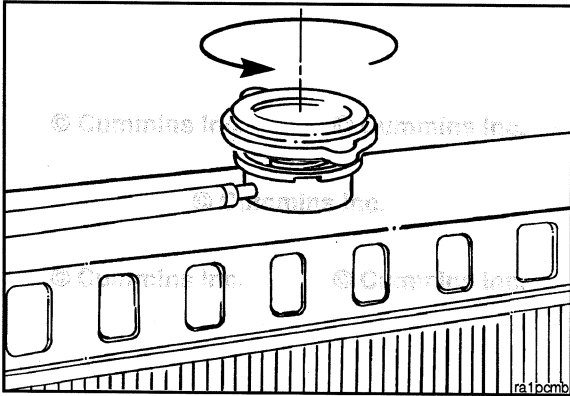


- Rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Lubricating oil pan. Refer to Procedure 007-025 in Section 7.



For suspected fuel in the coolant/coolant in the fuel, disconnect the fuel drain connection at the rear of the cylinder head. Refer to Procedure 006-013 in Section 6.

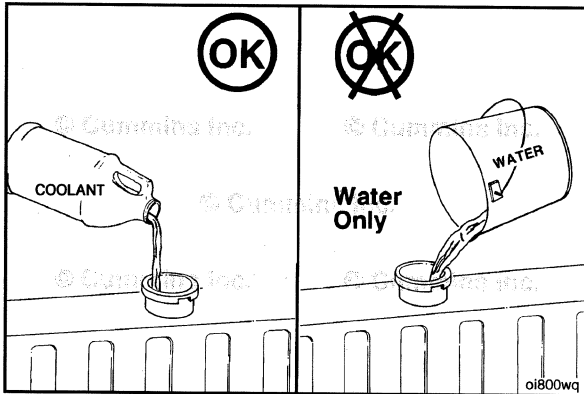




### Test

**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.

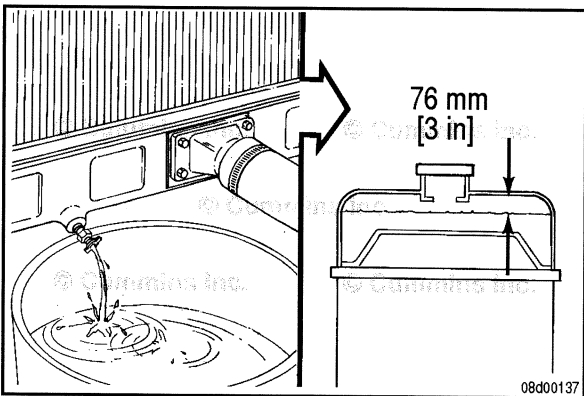
Remove the radiator cap, and leave it off for the following test.



### Combustion Gas Leak

Use combustion gas tester, Cummins® 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.

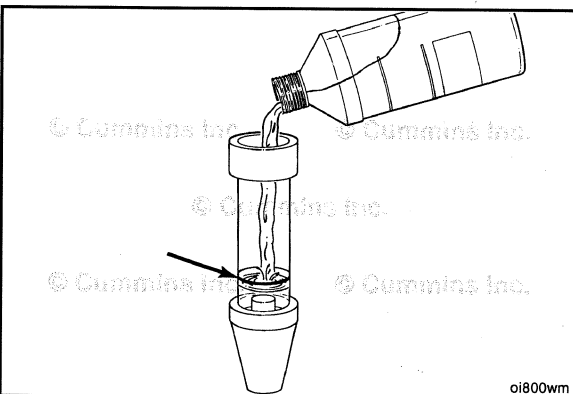


### WARNING

**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. Refer to Procedure 008-018 in Section 8.

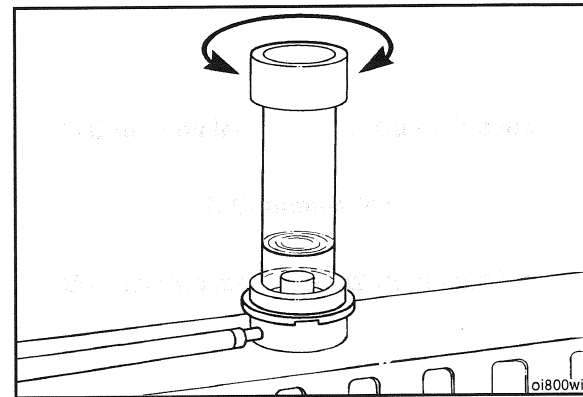
If the coolant is above this point, the coolant can contaminate the test fluid, causing the test to be ineffective.



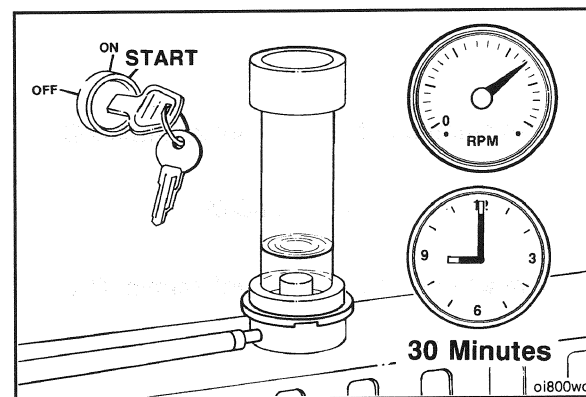
Pour the test fluid into the combustion gas leak test instrument until it is up to the yellow fill line on the instrument.

**QSF3.8 CM2350 F107**  
**Section 8 - Cooling System - Group 08**

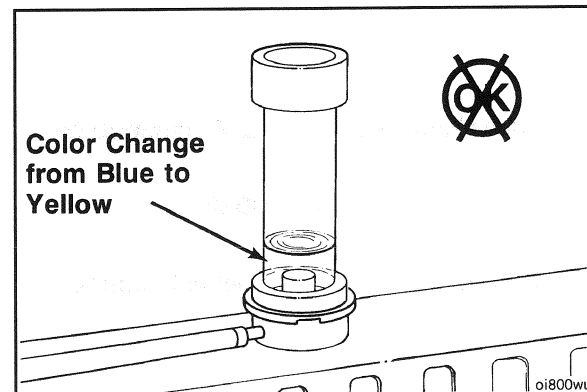
Insert the rubber tip of the combustion gas leak test instrument into the radiator fill neck. Hold the instrument down firmly and turn back and forth to make certain that an airtight seal is formed between the tester and the radiator fill neck.



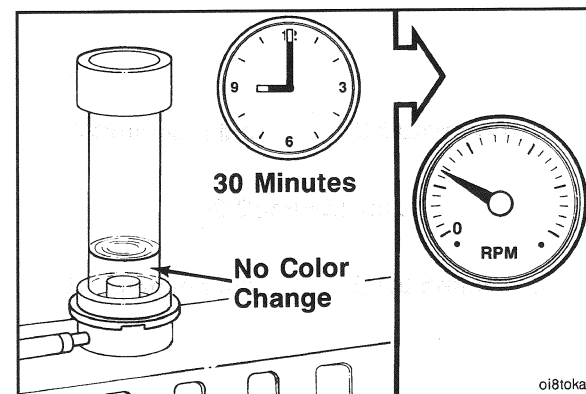
Start the engine and run at high idle for approximately 30 minutes. Monitor the engine temperature and color of the test fluid during engine operation. Do **not** allow the engine temperature to exceed 100°C [212°F] during the test.

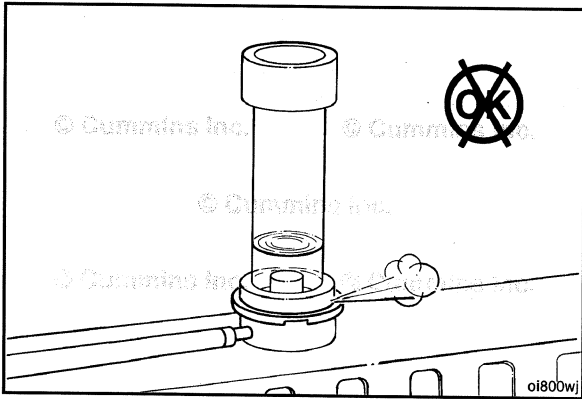


If the color of the test fluid changes from blue to yellow or green anytime during the test, combustion gases are leaking into the cooling system. Discontinue the test if the color of test fluid changes from blue to yellow or green.

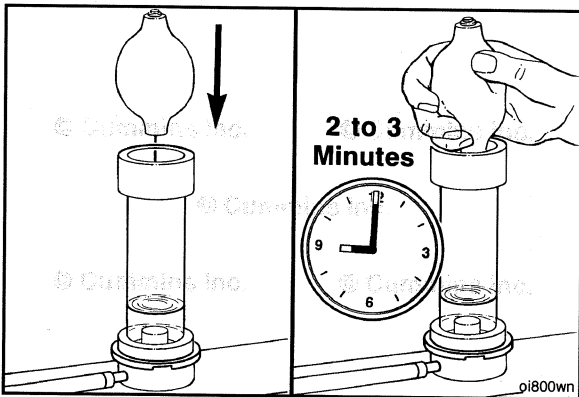


If the color of the test fluid does **not** change from blue to yellow or green during the 30-minute test period, return the engine to low idle.



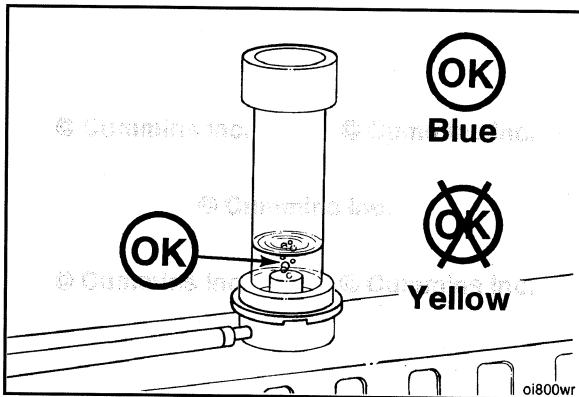


Check the test instrument to make sure it is firmly sealed in the radiator fill neck.

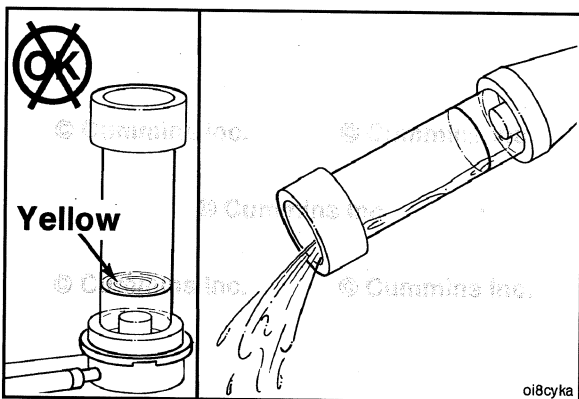


Insert the tip of the rubber ball into the hole in the top of the test instrument. Squeeze the rubber ball 2 to 3 minutes to draw air from the radiator through the test fluid.

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.



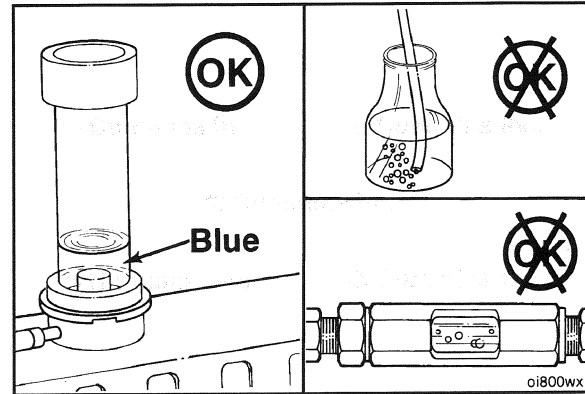
**NOTE:** Discard the tester fluid if it has indicated positive.

A positive result from the combustion gas leak tester indicates the following:

- Cylinder head gasket or cylinder head casting leakage. Refer to Procedure 002-004 in Section 2.

A negative result from the combustion gas leak tester, coupled with a continuous flow of air bubbles from the previous test, indicates the following:

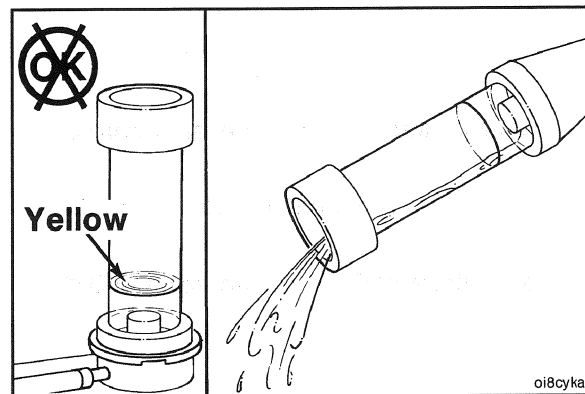
- Defective fan, shutter, or heater air control valve.
- Air entrained due to a bad radiator check valve or incorrect fill.



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.

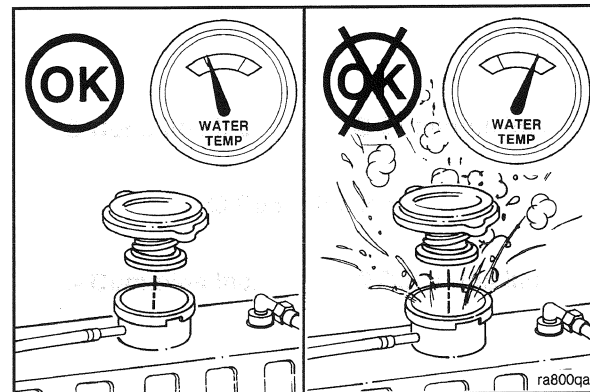


**Overflow Method**



**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.

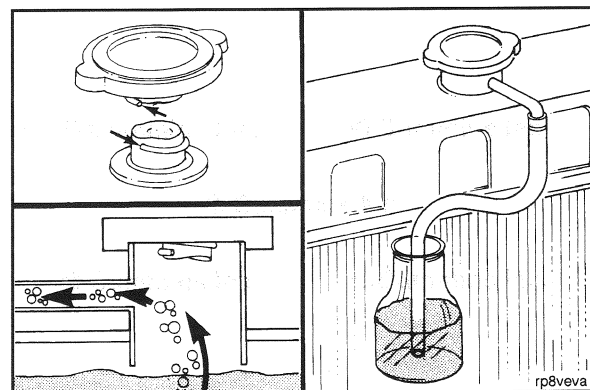


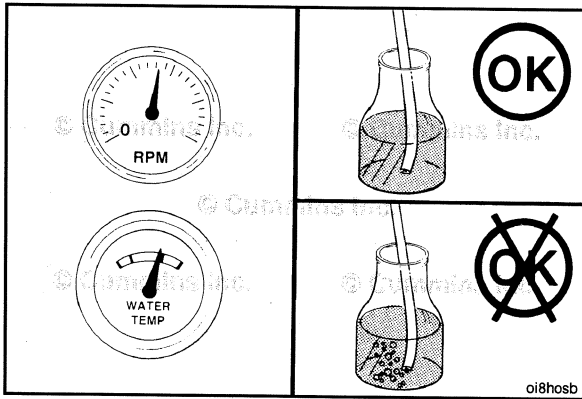
**NOTE:** The pressure cap **must** be tightly sealed in the top of the radiator fill neck.

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 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.

**Worksheet**

Fill in the blanks with the test data as the test is being run. Record the cylinder head coolant pressure and cab gauge coolant temperature reading at each of the thermostat housing temperature points listed on the left side of the matrix below. Mark when the radiator line gets hot, when the fan starts operating, and when the shutters open.

Coolant Temperature	Pressure					
	Cab Gauge	Cylinder Head	Radiator "In Line" Starts Getting Hot	Fan Starts Operating	Shutters Open	Notes
140						Engine at high idle throughout test
145						Monitor for air throughout test
150						
155						Start monitoring radiator "in" line
160						
165						
170						
175						
180						
185						
190						
195						
200						
205						Cool engine down

## Fan Clutch, On-Off (008-027)



### General Information

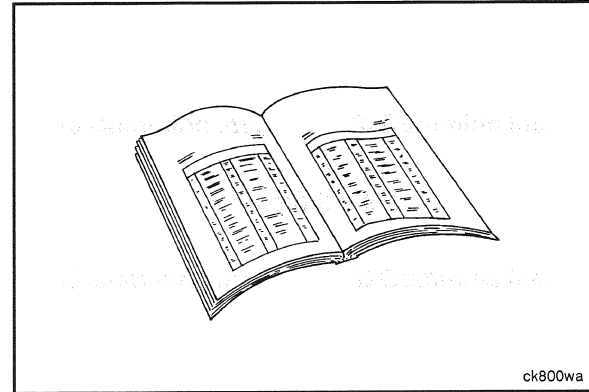
All fan clutches can be controlled by the engine control module (ECM). The ECM monitors coolant temperature and intake manifold temperature to determine when to engage the cooling fan. Some applications have additional sensors monitored by the ECM for fan control (for example, air conditioner pressure and transmission temperature). These are various fan clutch types such as:

- Air engaged
- Air disengaged
- Electric
- Viscous
- On-off.

See equipment manufacturer service information to determine fan clutch type.

The ECM is capable of using either a zero ("0") VDC or 12/24-VDC signal to engage the fan clutch. The exact enable logic can be selected in the Features and Parameters section of INSITE™ electronic service tool.

See equipment manufacturer service information for fan clutch troubleshooting and repair information.



## Fan Hub, Belt Driven (008-036)



### Preparatory Steps

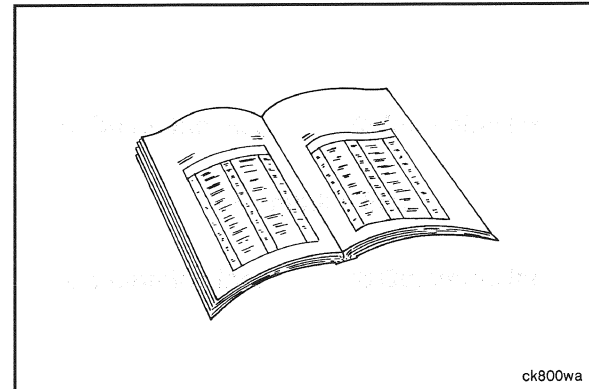
#### ▲ WARNING ▲

**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.**

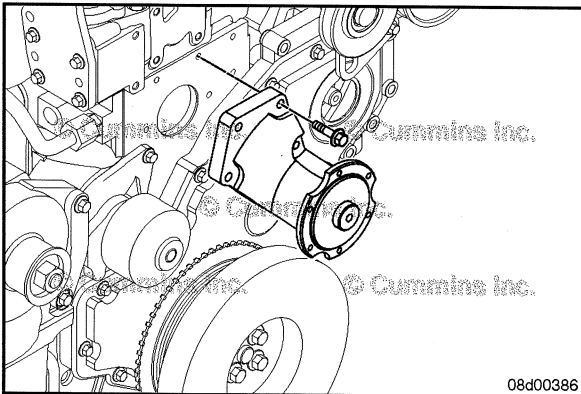
- Disconnect the batteries. See equipment manufacturer service information.
- Remove the drive belt. Refer to Procedure 008-002 in Section 8.

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

- If required, remove the cooling fan. See equipment manufacturer service information for instructions.
- Remove the fan pulley and spacer. Refer to Procedure 008-039 in Section 8.



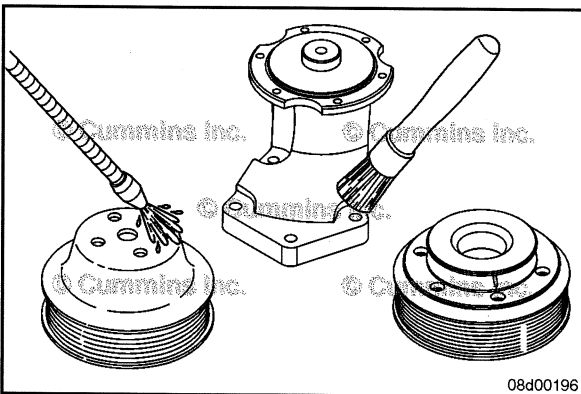




### Remove

**NOTE:** There are many available fan hub configurations. Be sure to note the location, orientation, and mounting pattern of the hub prior to removal from the engine.

Remove the four capscrews and the fan hub.



### 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 ⚠

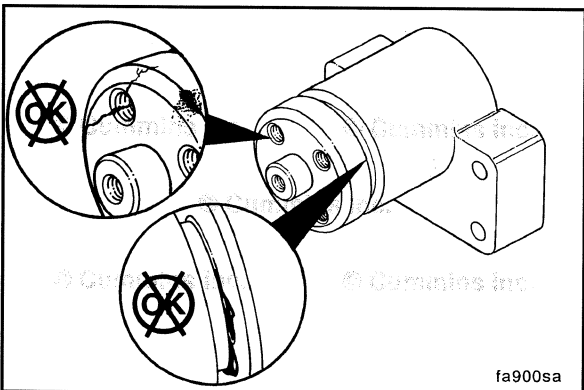
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

#### ⚠ 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.



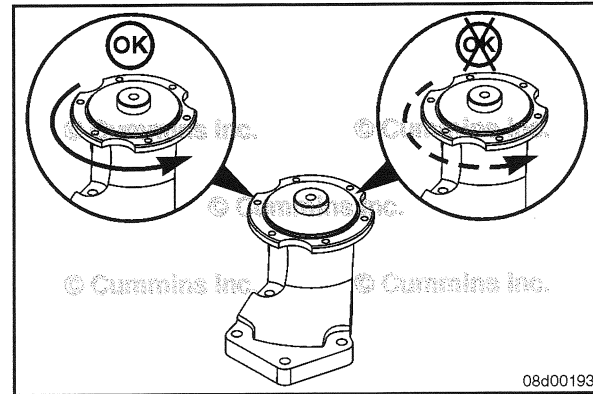
Inspect the fan hub for indications of oil seal leakage.

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.

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.



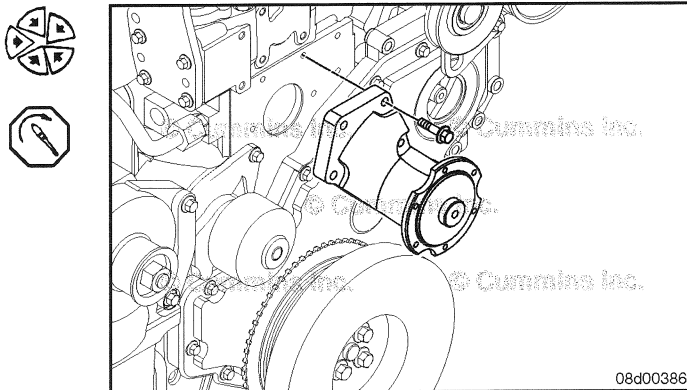
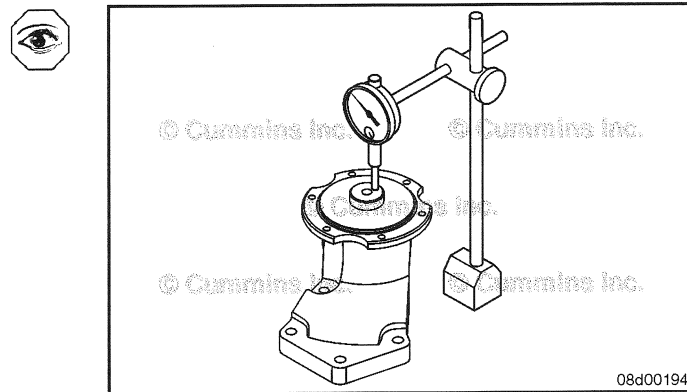
Inspect the fan hub bearing for wear.  
 The bearing **must** have a minimal amount of side-to-side or end clearance movement.  
 Replace the fan hub if there is more than 0.15 mm [0.006 in] of end clearance in the fan hub.

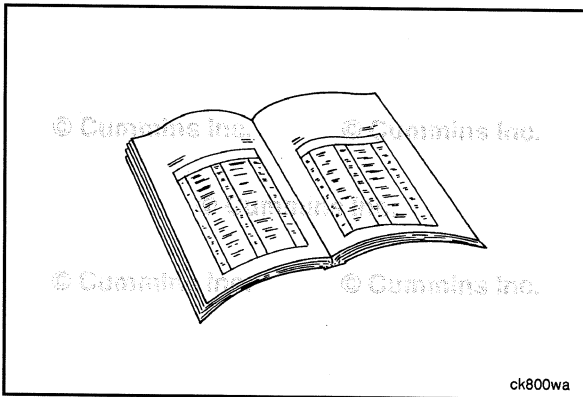
Fan Hub End Clearance		
mm		in
0.15	MAX	0.006

**NOTE:** Some fan hub assemblies can be rebuilt with new bearings and related components. Check for part availability before disassembling the fan hub.

**Install**

Install the fan hub and four capscrews.  
**Torque Value:** 32 N•m [ 24 ft-lb ]





## Finishing Steps

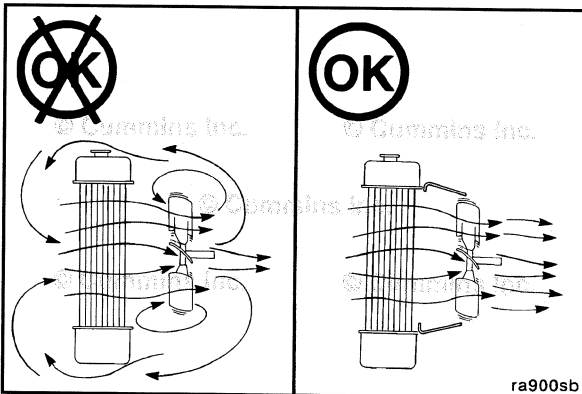
### ⚠ WARNING ⚠



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 008-039 in Section 8.
- If removed, 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.

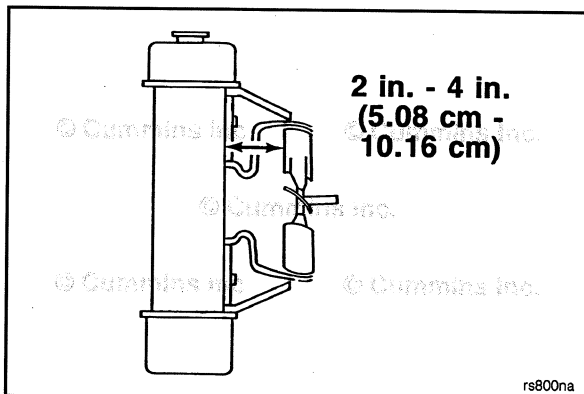


## Fan Shroud Assembly (008-038)

### Remove



Remove the fan shroud. See equipment manufacturer service information.



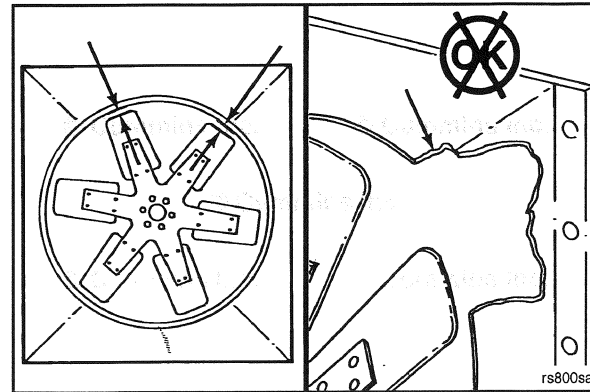
## Inspect for Reuse

Inspect the fan shroud for proper fan clearance.

Check the fan shroud for air leaks, cracks, or other damage.

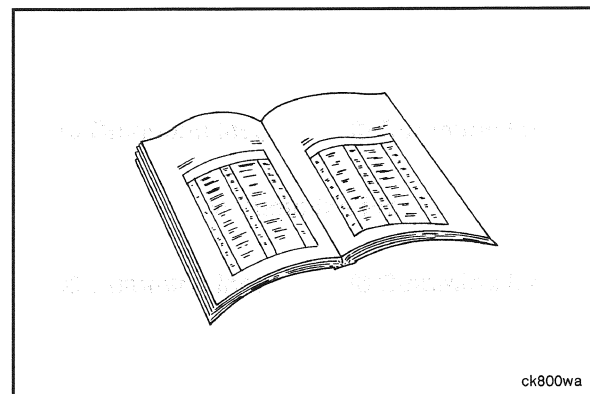
### Install

Install the fan shroud. See equipment manufacturer service information.



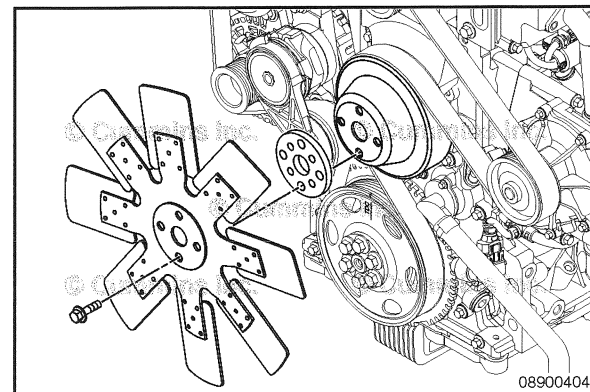
### Fan Spacer and Pulley (008-039) Preparatory Steps

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



### Remove

Remove the four fan capscrews, fan, and spacer.  
Remove the fan pulley.

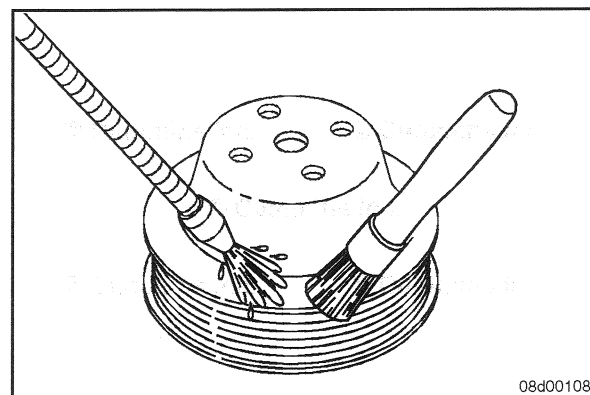


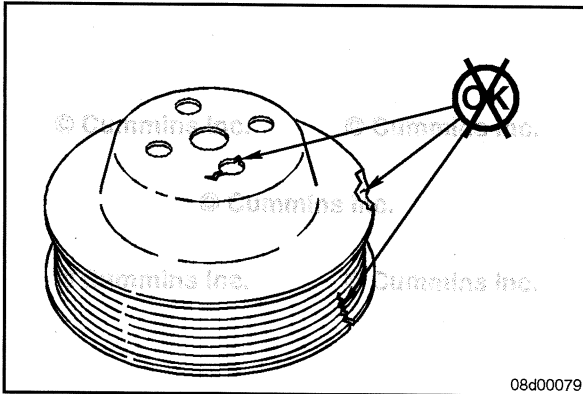
### Clean and Inspect for Reuse

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

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

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

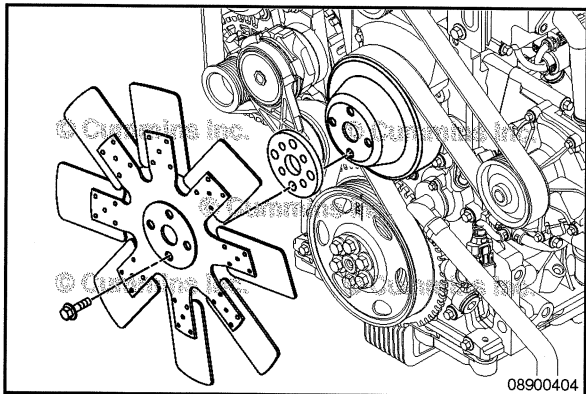




Inspect the fan pulley for cracks near the bolt holes and for damage at the drive belt contact surface.



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



### Install

Install the fan pulley.



Install the cooling fan and drive belt. Refer to Procedure 008-002 in Section 8.

Install the spacer, fan, and fan capscrews.

#### Torque Value:

M6

Step 1                      10 N•m                      [ 89 in-lb ]

#### Torque Value:

M10

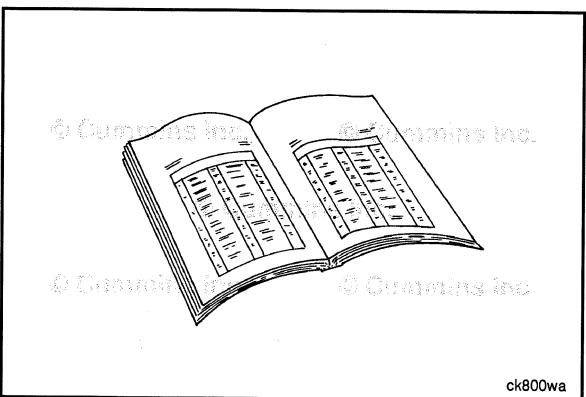
Step 1                      43 N•m                      [ 32 ft-lb ]

#### Torque Value:

M12

Step 1                      77 N•m                      [ 57 ft-lb ]

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



### Finishing Steps

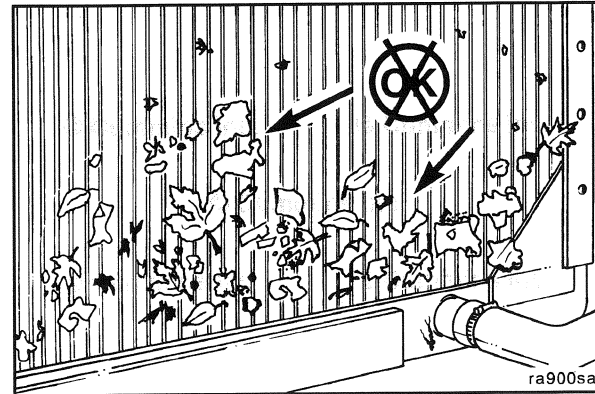
- Install the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.
- Operate the engine and check for proper operation.

## 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.

**NOTE:** For removal or installation of the radiator, see equipment manufacturer service information.



### Initial Check

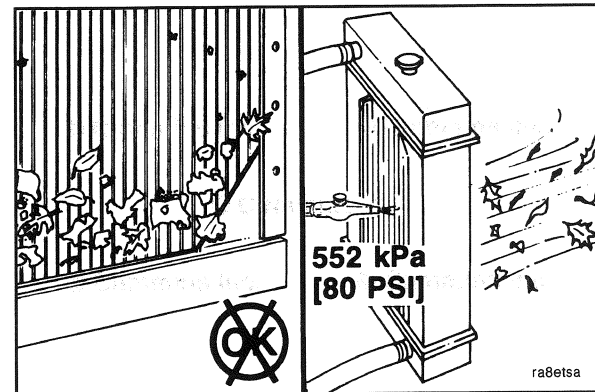
#### ⚠ CAUTION ⚠

Wear appropriate eye and face protection when using compressed air. Improper use can cause bodily injury from flying debris and dirt.

Inspect for plugged radiator fins.

Use compressed air to blow out the dirt and debris.

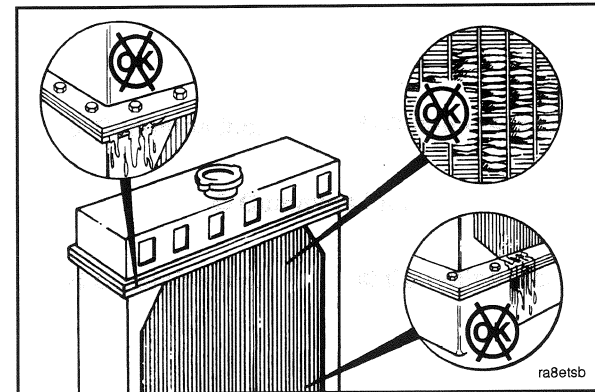
**Air Pressure:** 552 kPa [ 80 psi ]



Inspect for bent or broken fins.

Inspect for radiator core and gasket leaks.

If the radiator **must** be replaced, see equipment manufacturer service information for replacement procedures.

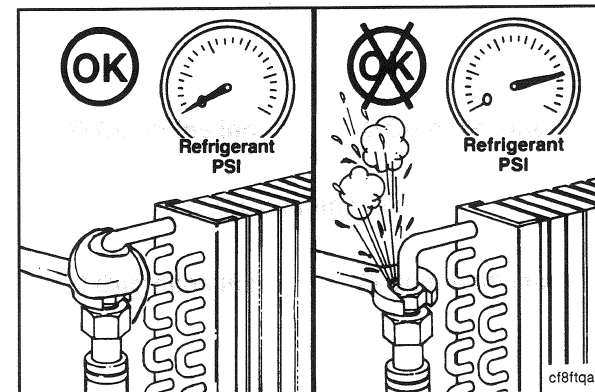


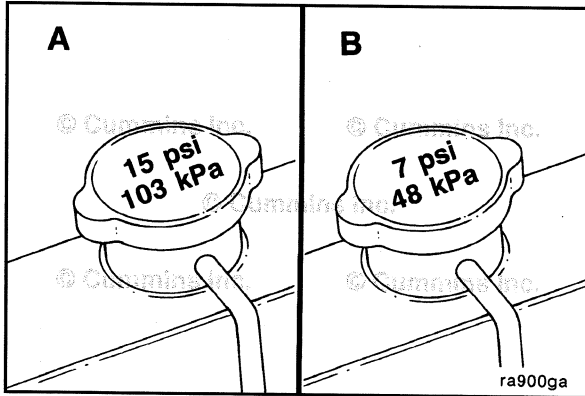
#### ⚠ WARNING ⚠

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

#### ⚠ WARNING ⚠

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



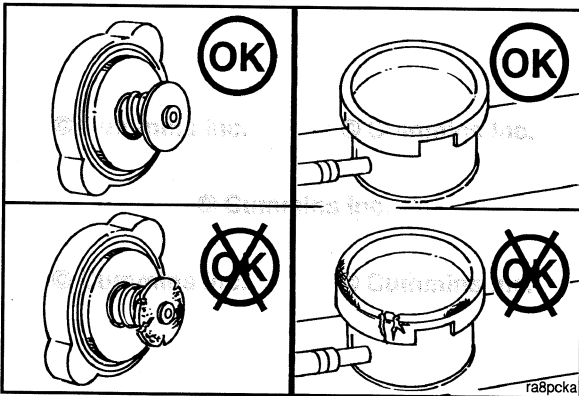


## Radiator Pressure Cap (008-047)

### General Information

The cooling system is designed to use a pressure cap to prevent boiling of the coolant. See equipment manufacturer service information 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

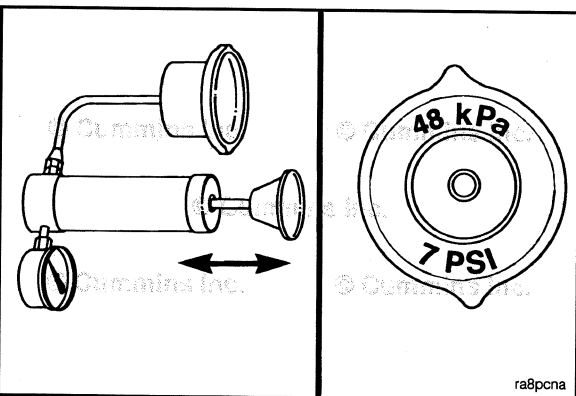
Make sure the correct radiator pressure cap is being used.



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.

## Water Pump (008-062)

### Preparatory Steps

#### ▲ WARNING ▲

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

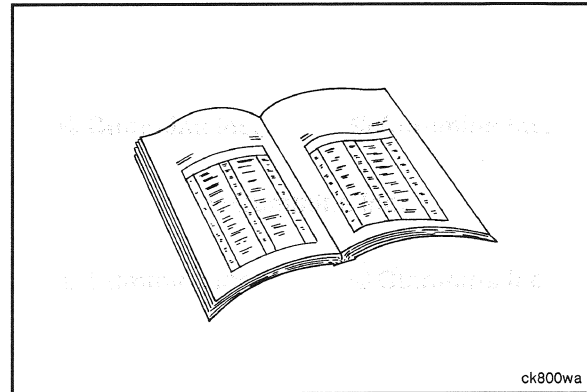
#### ▲ WARNING ▲

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.

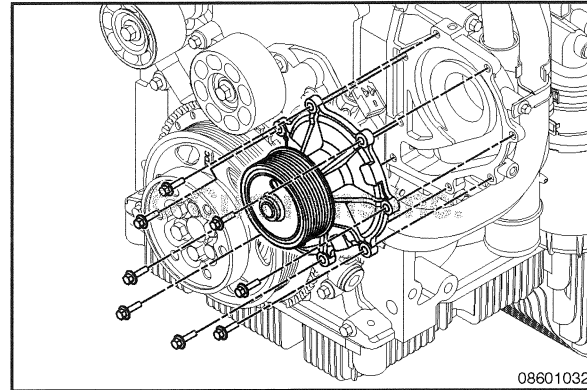
- Drain the coolant. Refer to Procedure 008-018 in Section 8.
- Remove the cooling fan drive belt. Refer to Procedure 008-002 in Section 8.

### Remove

Remove the eight mounting capscrews and the water pump from the front of the lubricating oil cooler module.

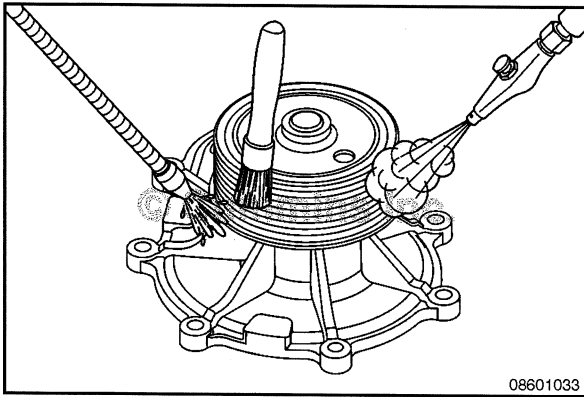


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## Clean and Inspect for Reuse

### ⚠️ 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 ⚠️

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 water pump with solvent.

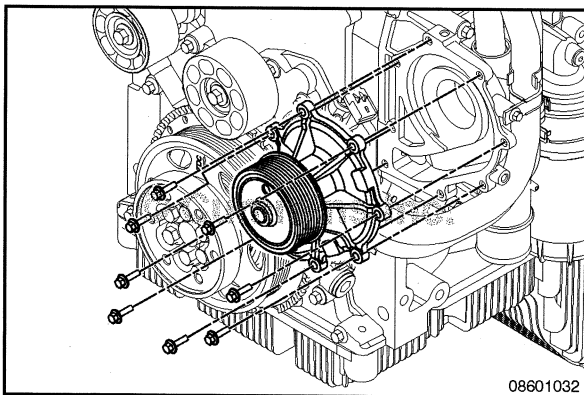
Dry with compressed air.

Inspect the water pump impeller for nicks or broken fins.

Inspect the water pump seal for cuts or other damage that could cause a water pump leak.

If the water pump or seal is damaged, it **must** be replaced.

**NOTE:** The water pump is serviced/replaced as an assembly. No internal parts are available for rebuild/replacement.



## Install

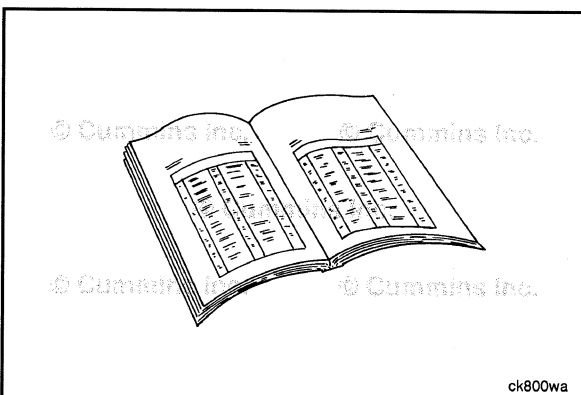
**NOTE:** If the water pump is to be replaced, make sure that the replacement pump has the same part number as the one removed.

Make sure the water pump mounting surfaces are clean.

Install the water pump and the mounting capscrews.

Tighten the capscrews evenly.

**Torque Value:** 8 N•m [ 71 in-lb ]



## 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. 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.

## Water Inlet Connection (008-082)

### 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. See equipment manufacturer service information.
- Drain the coolant. Refer to Procedure 008-018 in Section 8.
- Remove the lower radiator hose. See equipment manufacturer service information.

### Remove

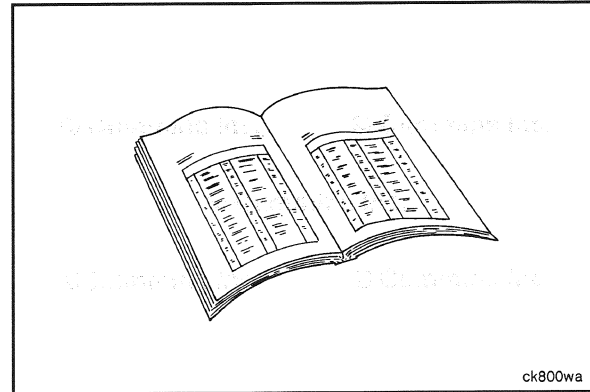
Remove the coolant hose(s).

Remove the capscrews, water inlet connection, and o-rings.

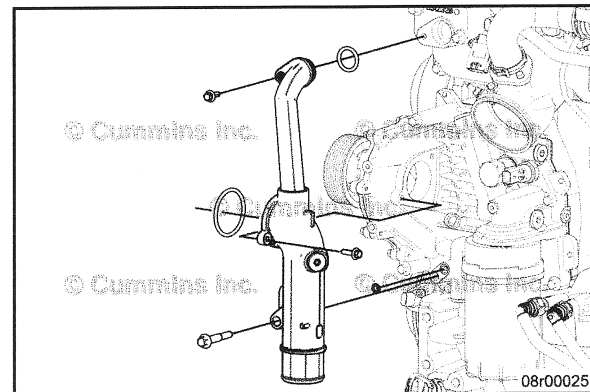
### Clean and Inspect for Reuse

Inspect the rectangular sealing ring for cracks.

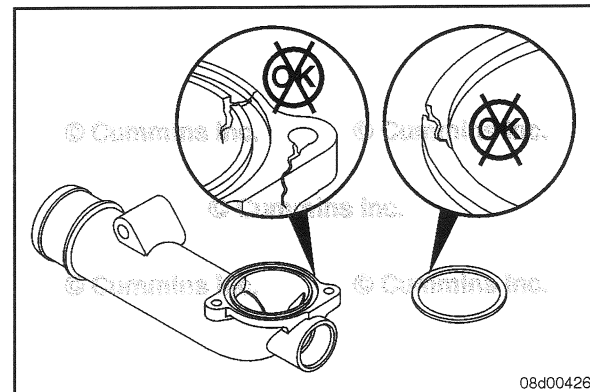
If evidence of leaking exists, replace the rectangular sealing ring.



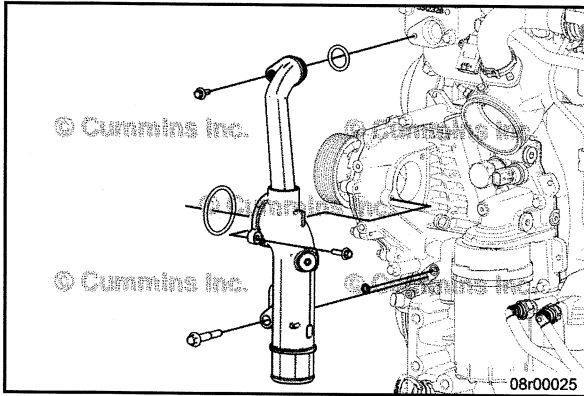
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### Install

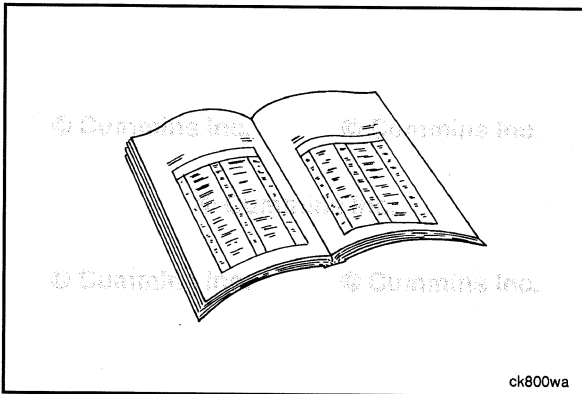
Install the capscrews, water inlet connection, and o-rings.



**Torque Value:**  
M6 9 N•m [ 80 in-lb ]

**Torque Value:**  
M8 13 N•m [ 115 in-lb ]

Install the coolant hose(s).



### Finishing Steps



#### ⚠ WARNING ⚠

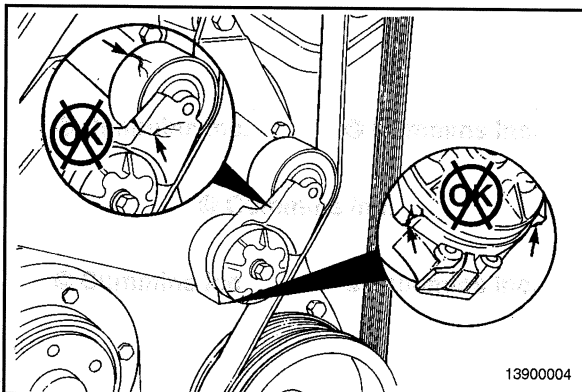
**Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.**



#### ⚠ WARNING ⚠

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

- Install the lower radiator hose. See equipment manufacturer service information.
- 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.



### Cooling Fan Belt Tensioner (008-087)

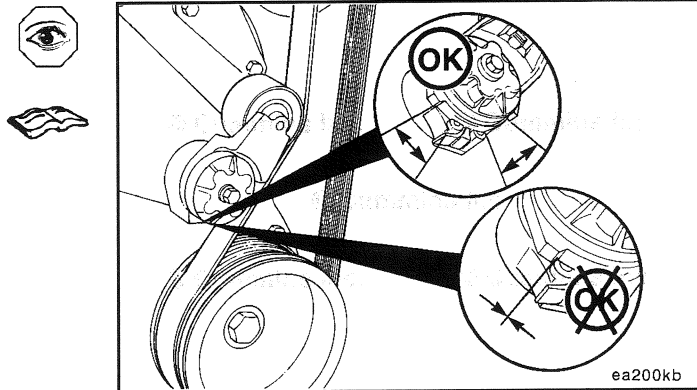
#### Initial Check

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

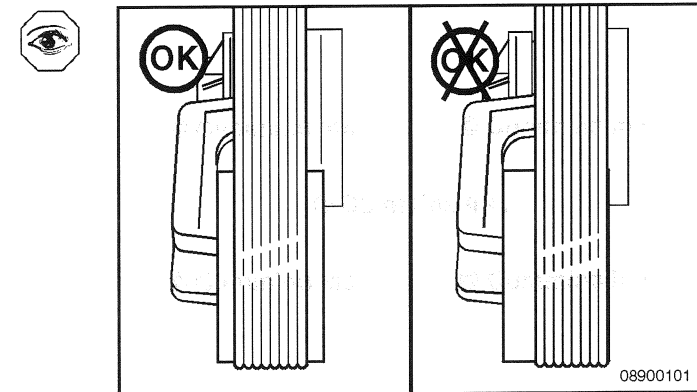
With the belt installed, verify that neither tensioner arm stop is in contact with the spring casing stop. If either of the stops is touching:

- Verify the correct belt part number is installed.
- If the correct belt is installed, replace the belt. Refer to Procedure 008-002 in Section A.
- If the correct belt is installed, replace the belt. Refer to Procedure 008-002 in Section 8.

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

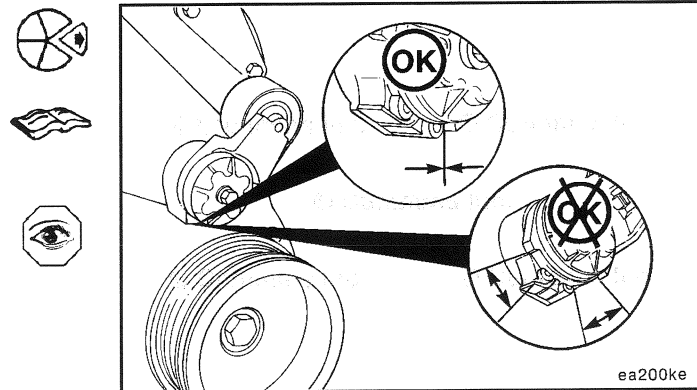


Check the location of the drive belt on the belt tensioner pulley. The belt should be centered on, or close to the middle of, the pulley. Misaligned belts, either too far forward or backward, can cause belt wear, belt roll-off malfunctions, or increase uneven tensioner bushing wear.



Remove the drive belt. Refer to Procedure 008-002 in Section 8.

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

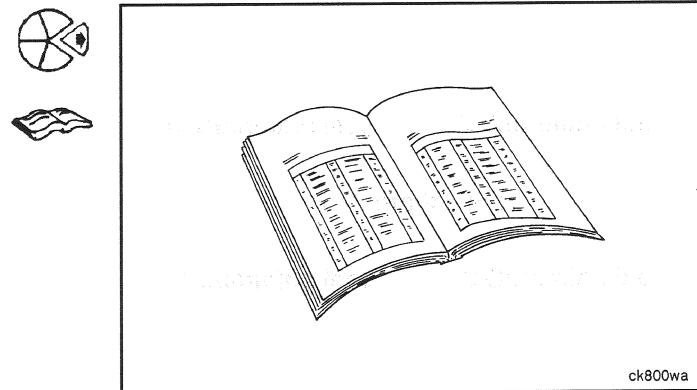


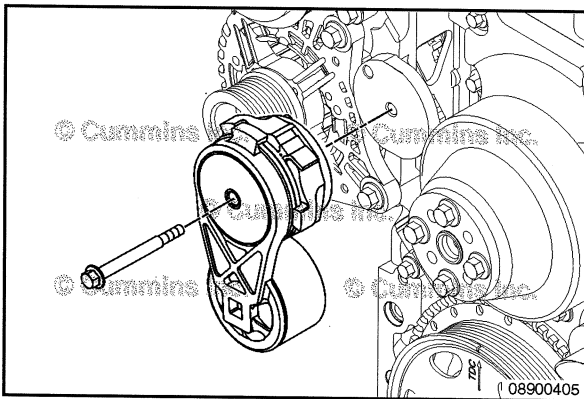
### Preparatory Steps

#### ⚠ WARNING ⚠

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

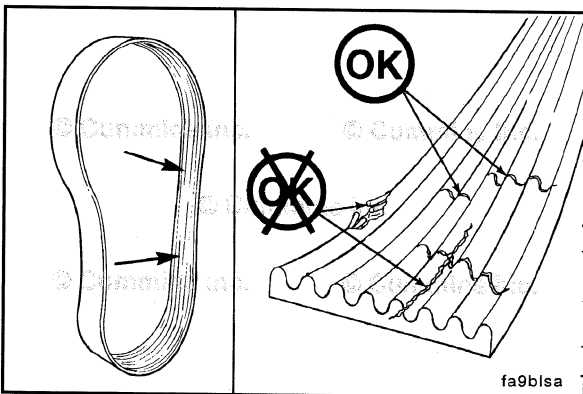
- Disconnect the batteries. See equipment manufacturer service information.
- Remove the drive belt. Refer to Procedure 008-002 in Section 8.





### Remove

Remove the cap screw and belt tensioner from the bracket.



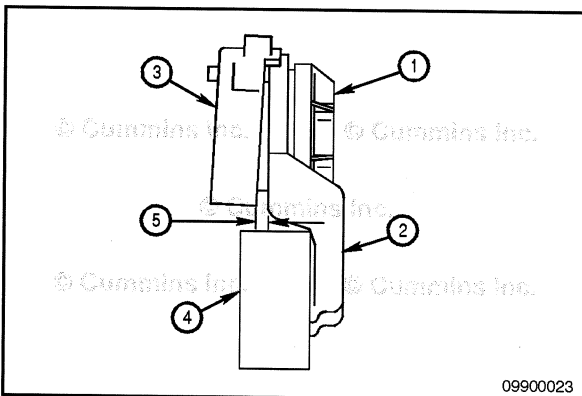
### Clean and Inspect for Reuse

Check the belt for damage.

Transverse (across the belt) cracks are acceptable.

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

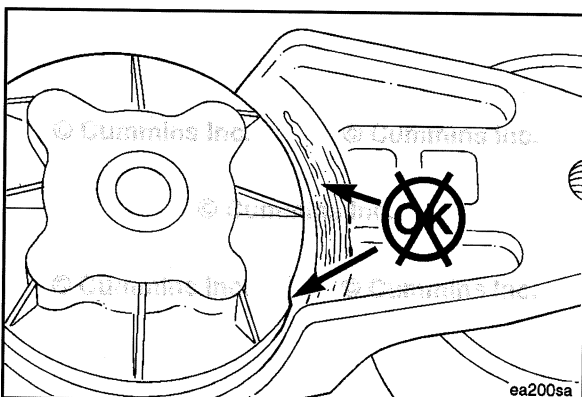
If the belt is frayed or has any piece of material missing, the belt is unacceptable and needs to be replaced.



Measure the clearance between the tensioner spring and the tensioner arm to verify tensioner wear-out and uneven bearing wear. If the clearance exceeds 3 mm [0.12 in] at any point, the tensioner has failed and **must** be replaced as a complete assembly.

Tensioners generally show a larger clearance gap near the lower portion of the spring case, resulting in the upper portion rubbing against the tensioner arm. **Always** replace the belt when a tensioner is replaced.

- 1 Tensioner cap
- 2 Tensioner arm
- 3 Spring case
- 4 Pulley
- 5 Clearance gap.



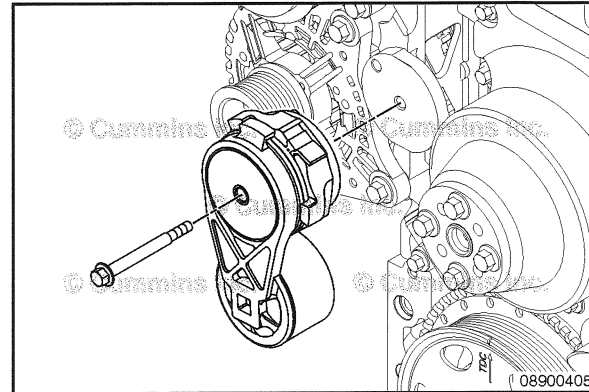
Inspect the tensioner for evidence of the tensioner arm contacting the tensioner cap. If there is evidence of the two areas making contact, the pivot tube bushing has failed and the tensioner **must** be replaced.

## Install

Install the belt tensioner and capscrew.

Tighten the capscrew.

**Torque Value:** 43 N•m [ 32 ft-lb ]

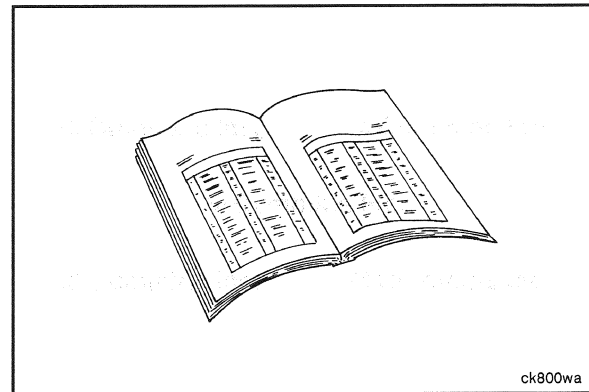


## Finishing Steps

### ⚠ 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.

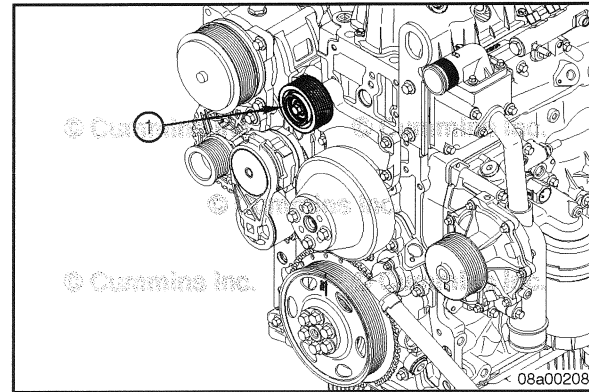
- Install the drive belt. Refer to Procedure 008-002 in Section 8.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine to check for proper operation.

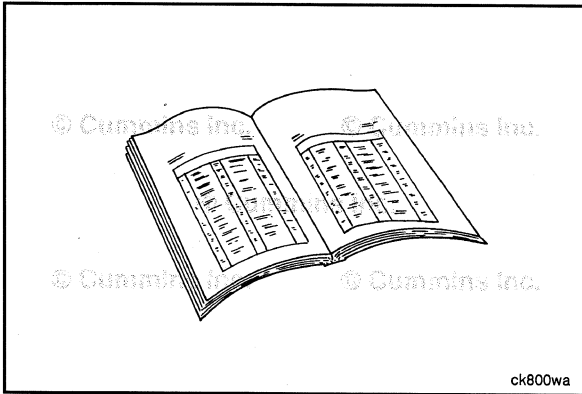


## Pulley, Fan Idler (008-111)

### General Information

Some front accessory drive configurations require an idler pulley (1) to support the drive belt. The location of the idler pulley varies, depending on the application and front accessory drive configuration.





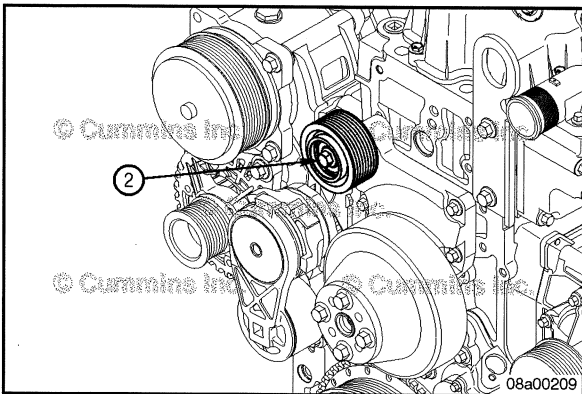
## Preparatory Steps



### ⚠ WARNING ⚠

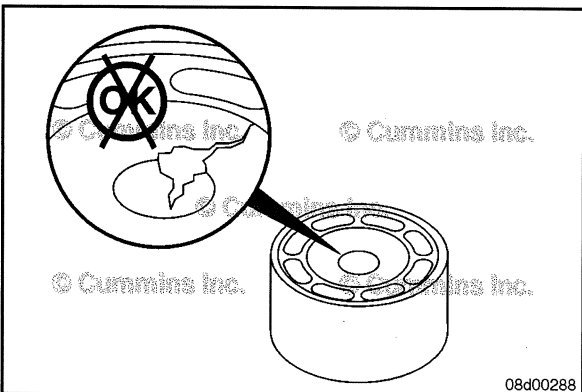
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries. See equipment manufacturer service information.
- If required, remove the fan shroud assembly. Refer to Procedure 008-038 in Section 8.



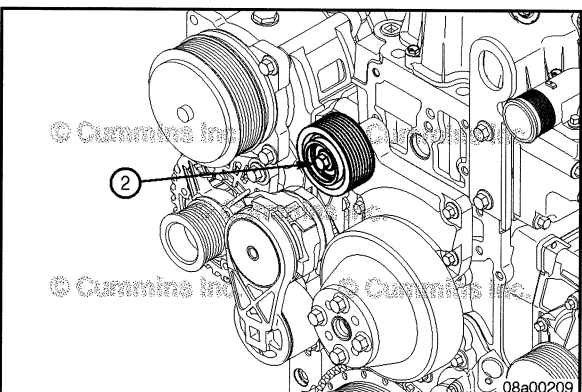
## Remove

- Remove the idler pulley mounting capscrew (2).
- Remove the idler pulley.



## Clean and Inspect for Reuse

- Inspect the idler pulley for nicks, cracks, or other damage.
- Spin the idler pulley to check for rough or noisy operation.
- Replace the idler pulley if any damage is found.



## Install



- Install the idler pulley and idler pulley mounting capscrew.

- Tighten the idler pulley mounting capscrew (2).

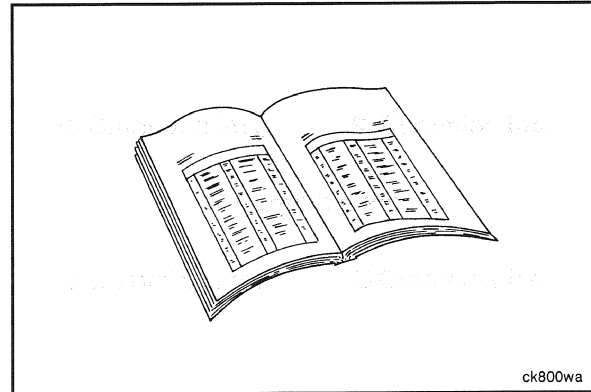
**Torque Value:** 43 N•m [ 32 in-lb ]

## 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 fan drive belt.
- If removed, install the fan shroud assembly. Refer to Procedure 008-038 in Section 8.
- Connect the batteries. See equipment manufacturer service information.



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## Section 9 - Drive Units - Group 09

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## Accessory Drive (009-001)

### 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.

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the drive accessory. See equipment manufacturer service information.

Typically the driven accessory is a hydraulic pump. Use the following procedure for general removal instructions. Refer to Procedure 009-016 in Section 9.

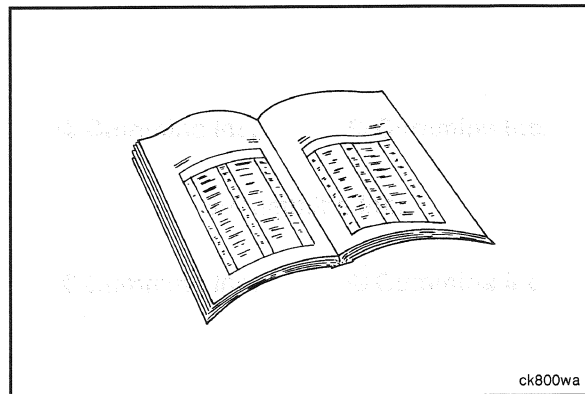
### Remove

Remove the two nuts from the studded screws securing the accessory drive to the rear gear housing.

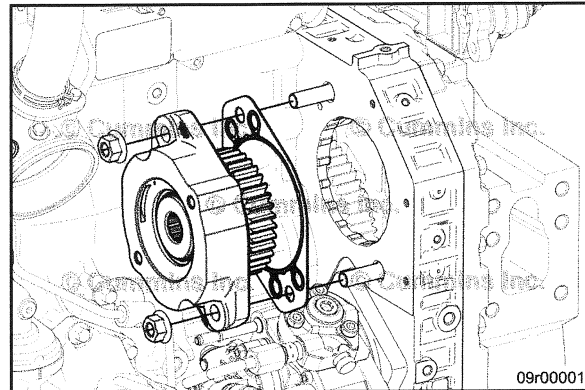
Remove the accessory drive and gasket.

### Clean and Inspect for Reuse

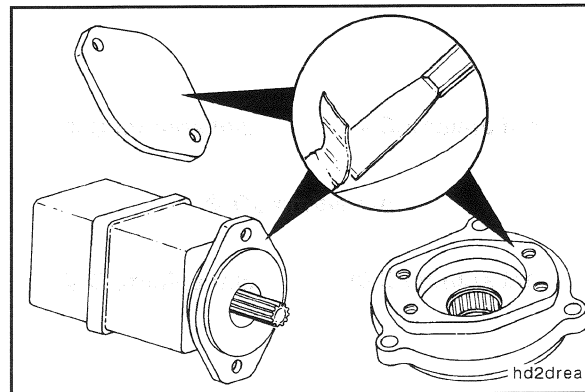
Remove any residual gasket material from the mounting surfaces of the accessory drive, drive accessory/hydraulic pump, and, if equipped, the cover plate surface.



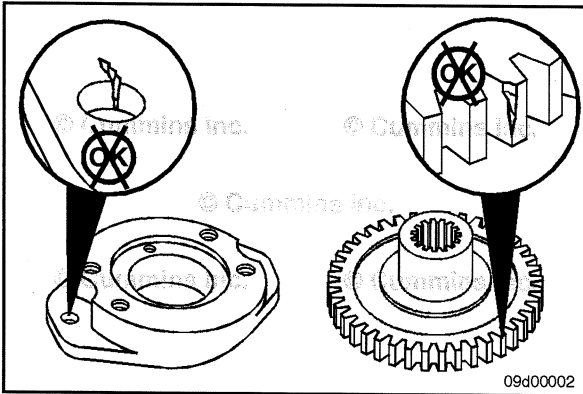
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09r00001



hd2drea



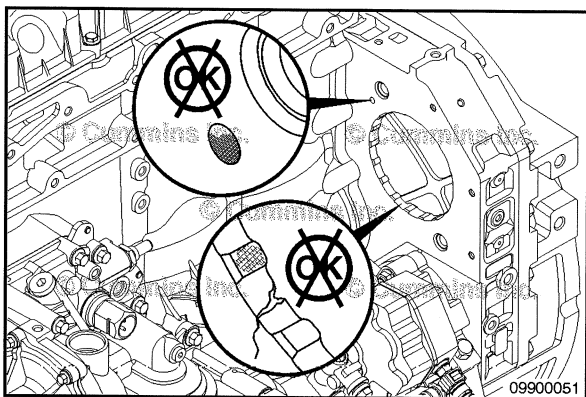
Make sure the oil supply hole in the accessory drive housing is open and free of debris.

Inspect the accessory drive housing for cracks.

Inspect the accessory drive gear and shaft splines for cracks, broken teeth, and other damage.

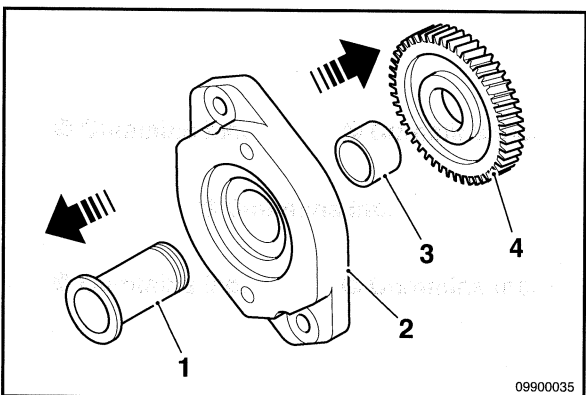
**NOTE:** If there is damage to the accessory drive gear teeth or there are signs of excessive heat, make sure to inspect the associated camshaft and fuel pump gears for damage. Measure camshaft gear backlash upon installation.

Replace any damaged components. See the Disassemble step of this procedure.



Make sure the oil supply hole in the gear housing is open and free of debris.

Inspect the inside diameter of the drive gear bore for excessive wear or damage; replace if necessary.



### Disassemble

If damage was found to a component of the accessory drive during the Clean and Inspect for Reuse step, the following components of the accessory drive, if damaged, may be replaced by disassembling the accessory drive.

- 1 Accessory Drive Shaft
- 2 Accessory Drive Housing
- 3 Accessory Drive Bearing
- 4 Accessory Drive Gear.

**NOTE:** Before disassembling the accessory drive, check to make sure the parts for the specific accessory drive being serviced are available. If **not**, replace the accessory drive as an assembly.

Use a hydraulic press and proper support to disassemble the accessory drive in the following order.

- 1 Press the drive shaft from the drive gear and housing
- 2 Press the bearing from the housing.

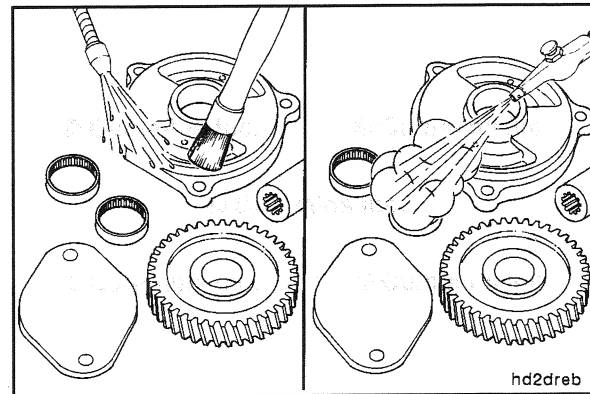
**▲ WARNING ▲**

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.

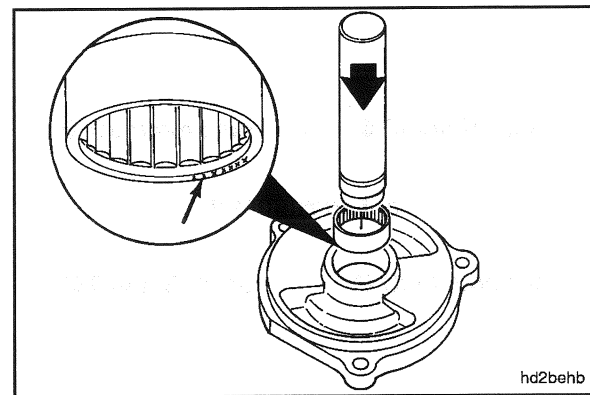
Clean the accessory drive components with solvent.  
Dry with compressed air.



hd2dreb

Inspect the bearing for binding, seizing, and excessive noise when spun.

Replace if any damage is found.



hd2behb

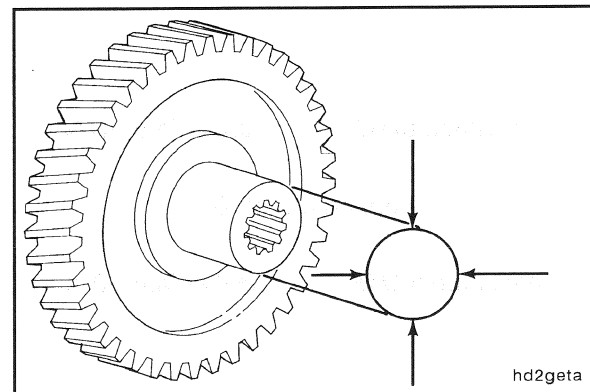
Measure the inside diameter of the accessory drive gear bore.



**Accessory Drive Gear Bore Inside Diameter (Accessory Drive Adapter)**

mm		in
38.920	MIN	1.5323
38.945	MAX	1.5333

If out of specification, replace the accessory drive gear.



hd2geta

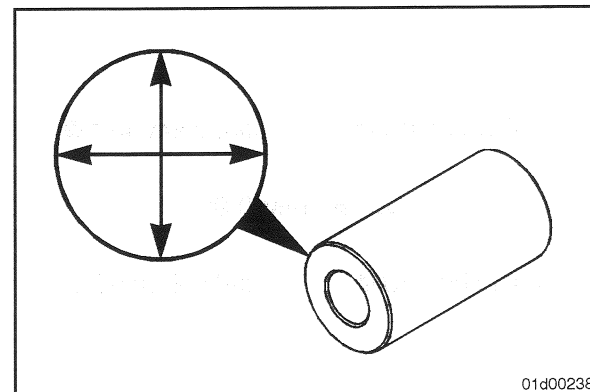
Measure the outside diameter of the accessory drive shaft at multiple locations along the shaft.



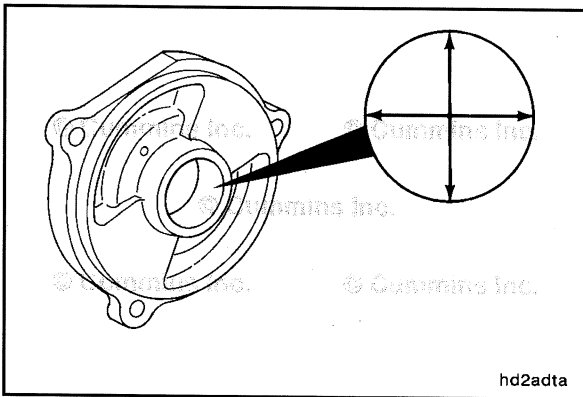
**Accessory Drive Shaft Outside Diameter (Accessory Drive Adapter)**

mm		in
39.008	MIN	1.5357
39.020	MAX	1.5362

If out of specification, replace the accessory drive shaft.



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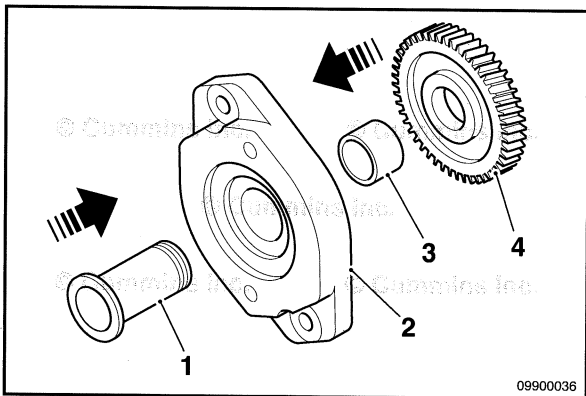


Measure the inside diameter of the bearing bore in the accessory drive adapter housing.

**Bearing Bore Inside Diameter (Accessory Drive Adapter)**

mm		in
67.759	MIN	2.6755
67.983	MAX	2.6765

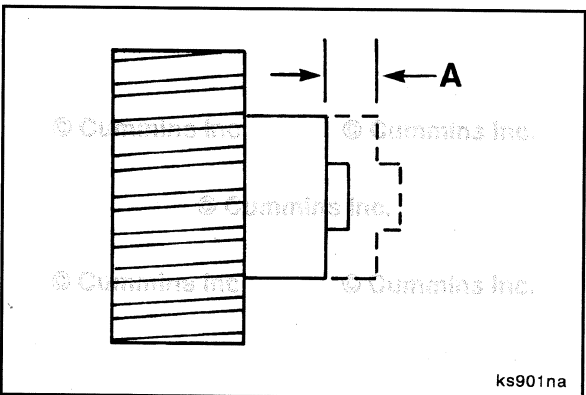
If out of specification, replace the housing.



**Assemble**

Use a hydraulic press and proper support to assemble the accessory drive in the following order:

- 1 Press the accessory drive shaft into the bearing, while supporting the bearing inner race, until the drive shaft bottoms on the inner race
- 2 Press the outer race of the bearing, with drive shaft, into the accessory drive housing, until the outer race bottoms in the housing
- 3 Press the accessory drive gear onto the shaft while supporting the bottom of the drive shaft. Press until gear bottoms against inner bearing race.



**Measure**

Use a gauge, Cummins® Part Number 3824564, and a magnetic base, Cummins 0174 Part Number 3377399, to check the accessory drive gear end play.

**Accessory Drive Gear End Play**

mm		in
0.5	MIN	0.020

If the end plays is out of specification:

- 1 If just assembled, check if the drive gear and bearing were completely pressed onto the drive shaft
- 2 If **not** previously disassembled, disassemble the accessory drive and inspect for damage. Replace as necessary
- 3 Replace the accessory drive assembly.

## Install

**NOTE:** If oil supply to the accessory drive is **not** required and the gasket does **not** have oil passages, this check is **not** required. If the accessory drive uses o-rings for seals, this check is **not** required.

Prior to installing the accessory drive, identify which gasket is going to be installed so that, if necessary, the gasket can be properly oriented.

There are two types of accessory drive gasket:

- 1 Three round oil supply passages and one elongated oil supply passage
- 2 Four round oil supply passages.

It is preferred that, when installing the accessory drive, the gasket with the four round oil supply passages be used. The gasket can be installed in any orientation.

If only the gasket with the one elongated oil supply passage is available, install the gasket so that the elongated oil supply passage is **not** over the oil supply hole in the gear housing.

### ⚠ CAUTION ⚠

**Failure to align the oil supply hole to the accessory drive properly will result in accessory drive damage.**

Install the accessory drive and new gasket.

If required, when installing the accessory drive and gasket, make sure the oil supply hole in the gear housing is lined up with the holes in the accessory drive and gasket. The accessory drive is marked for "Top" and "Bottom".

Install and tighten the two capscrews securing the accessory drive to the rear gear housing.

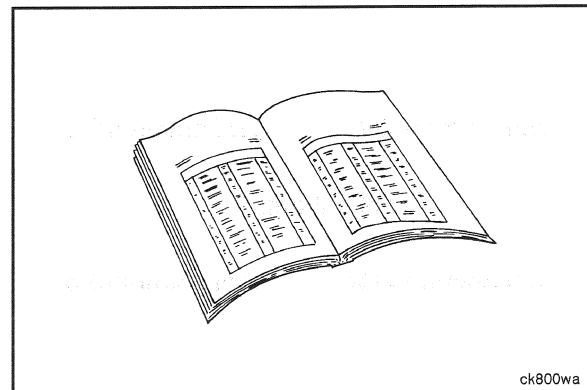
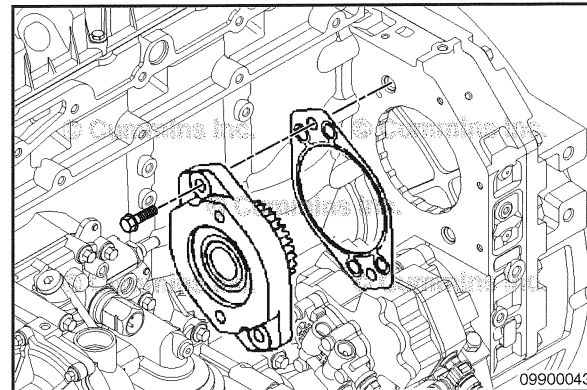
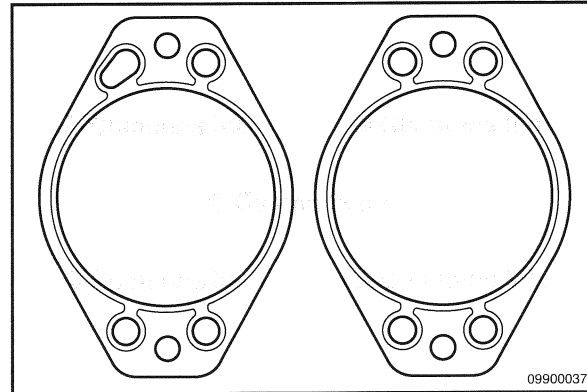
**Torque Value:** 77 N•m [ 57 ft-lb ]

## Finishing Steps

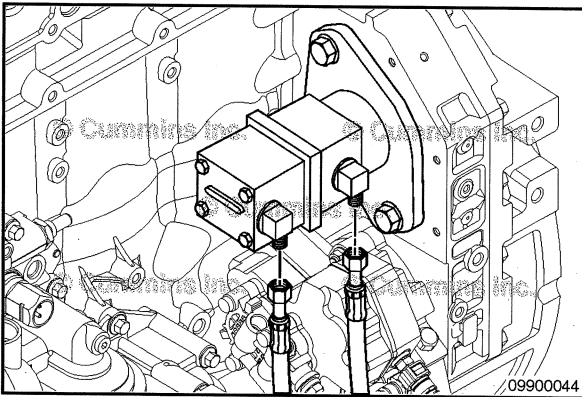
### ⚠ WARNING ⚠

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

- Install the drive accessory. See equipment manufacturer service information.
- Typically the drive accessory is a hydraulic pump. Use the following procedure for general installation instructions. Refer to Procedure 009-016 in Section 9.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.





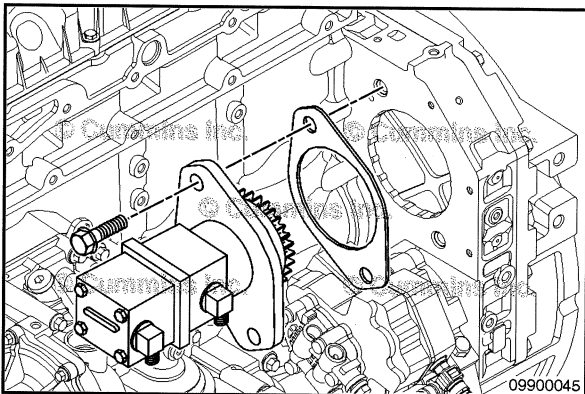


## Hydraulic Pump Drive (009-016)

### Remove

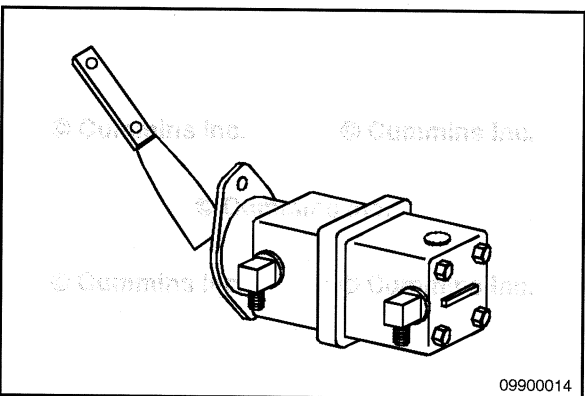
**NOTE:** The hydraulic pump is **not** installed on all applications.

Disconnect all hydraulic lines from the pump.



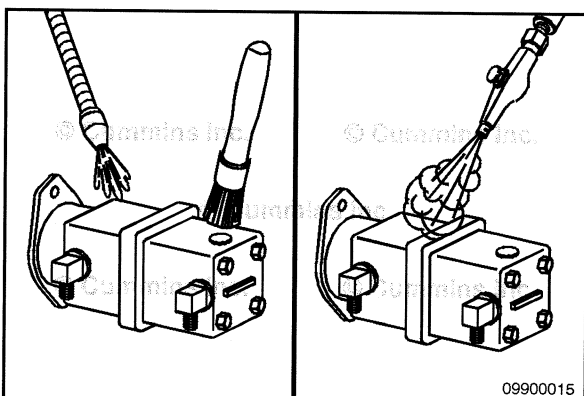
See equipment manufacturer service information for removal procedures.

Remove the hydraulic pump and gear assembly.



### Clean and Inspect for Reuse

Clean the gasket material from the hydraulic pump with a putty knife and a clean rag.



### ⚠ 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.

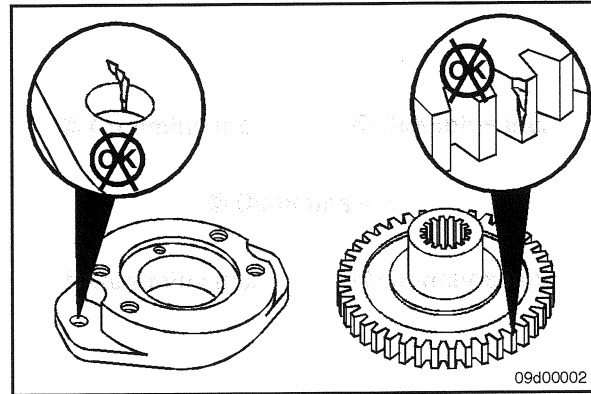
### ⚠ WARNING ⚠

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

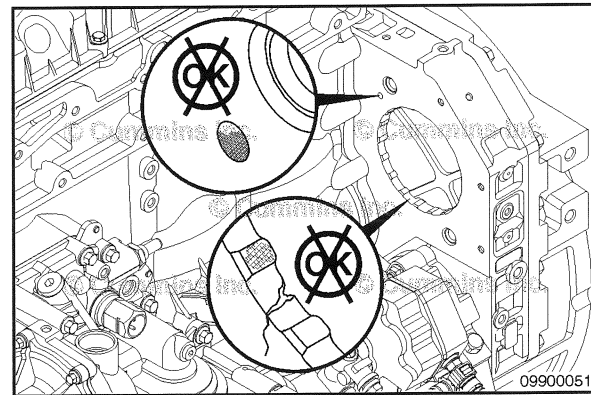
Clean the hydraulic pump gear with solvent.

Dry with compressed air.

Inspect the hydraulic pump drive gear for cracks, broken teeth, and other damage.

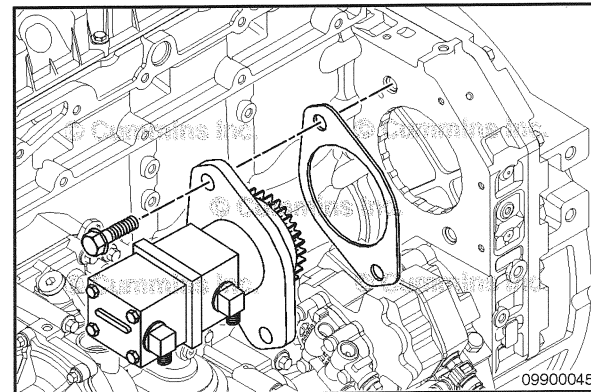


Inspect the inside diameter of the drive gear bore for excessive wear or damage; replace if necessary.

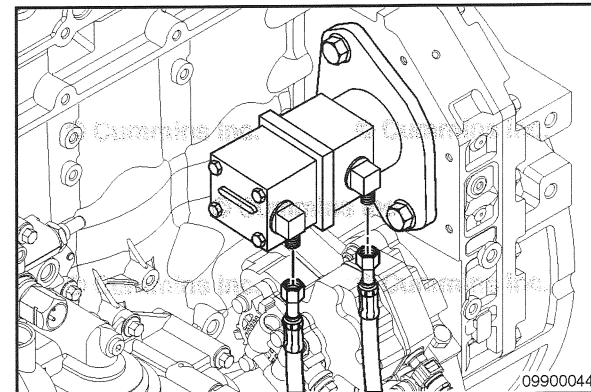


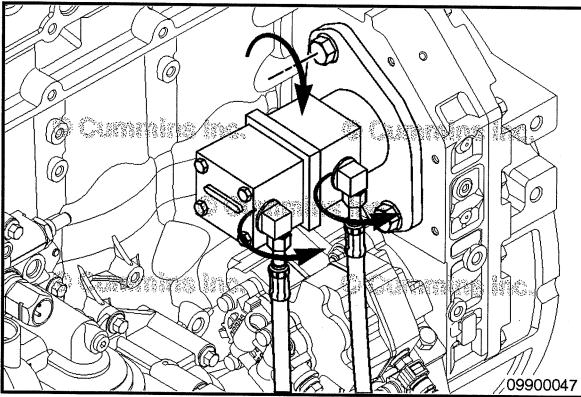
## Install

Use a new gasket and install the hydraulic pump.

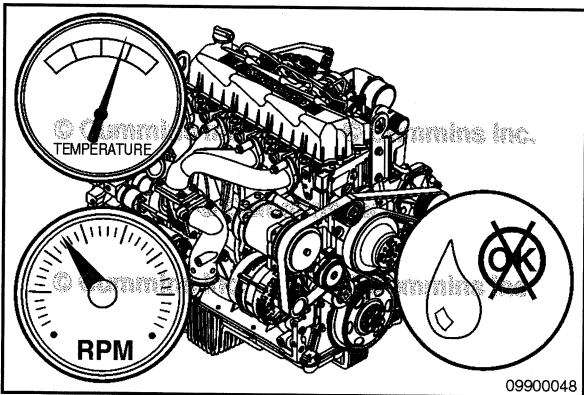


Connect all hydraulic lines to the pump.

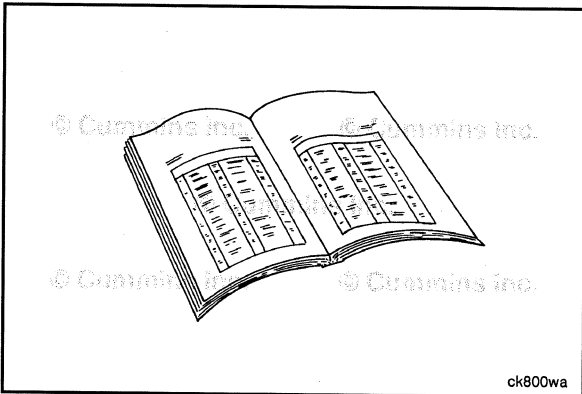




Tighten mounting capscrews.  
**Torque Value:** 62 N•m [ 46 ft-lb ]



Operate the engine and check for leaks.



## Refrigerant Compressor (009-051)

### Preparatory Steps



#### ▲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.

If complete removal of the refrigerant compressor is required, depressurize the refrigerant system. See equipment manufacturer service information for the proper procedure.

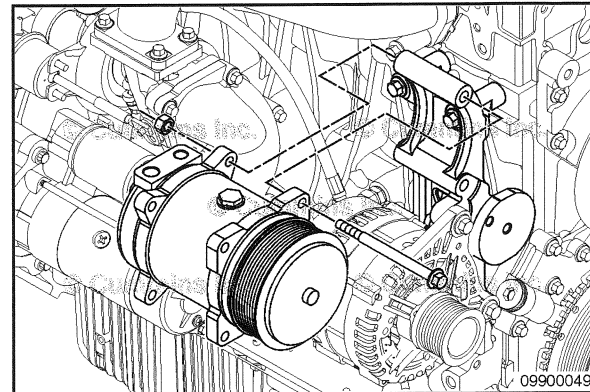
**NOTE:** If the refrigerant compressor is being removed to access other components, refrigerant system depressurization is **not** required. Leave hoses connected and properly support the refrigerant compressor to other vehicle components.

- Remove the fan drive belt, if necessary. Refer to Procedure 008-002 in Section 8.
- Remove the refrigerant compressor drive belt, if necessary. See equipment manufacturer service information.

## Remove

Remove the four refrigerant compressor mounting capscrews.

Remove the refrigerant compressor.



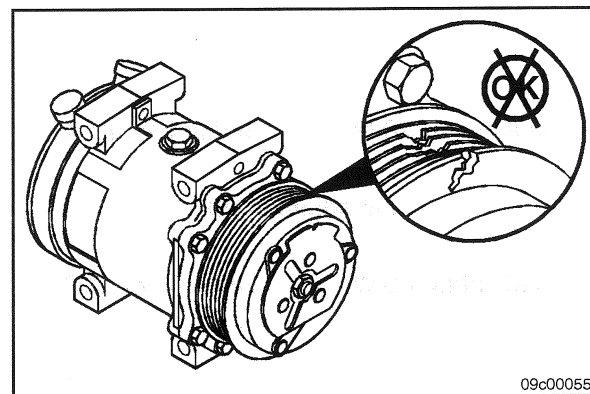
## Inspect for Reuse

Inspect the refrigerant compressor pulley for cracks or broken grooves.

Replace refrigerant compressor, if damaged.

See equipment manufacturer service information for proper compressor inspection.

Inspect the refrigerant compressor bracket for cracks. Replace bracket, if cracked.

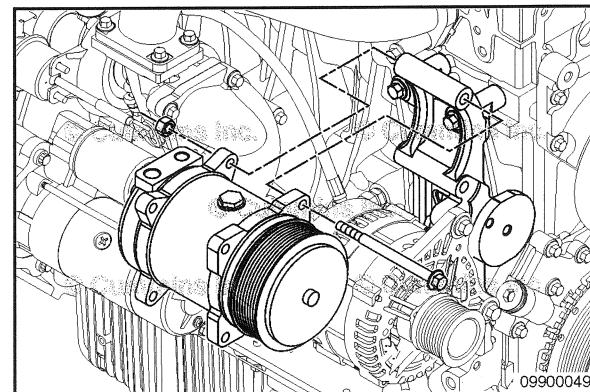


## Install

Install the four mounting capscrews through the refrigerant compressor and refrigerant compressor bracket.

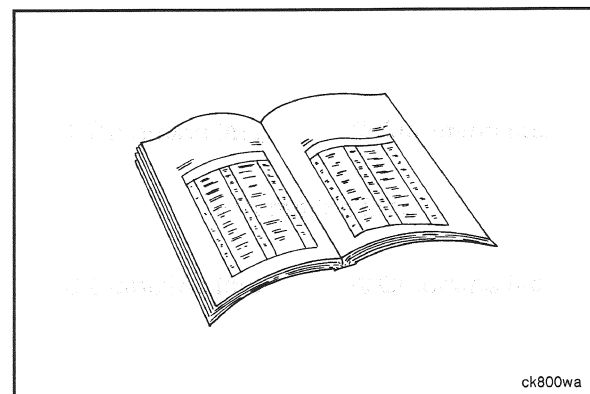
Tighten the capscrews.

**Torque Value:** 46 N•m [ 33 ft-lb ]



## Finishing Steps

- Install the refrigerant compressor belt, if necessary. See equipment manufacturer service information.
- Install the fan drive belt, if necessary. Refer to Procedure 008-002 in Section 8.
- Charge the refrigerant system if required. See equipment manufacturer service information.
- Operate the engine and check for leaks.





# Section 10 - Air Intake System - Group 10

## Section Contents

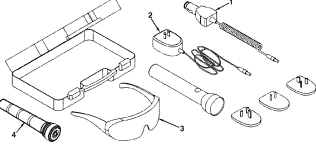
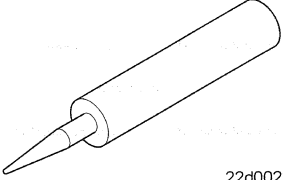
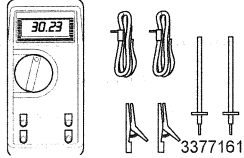
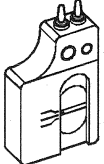
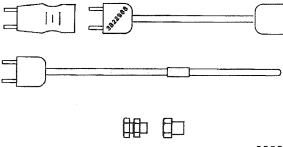
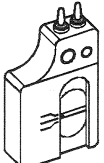
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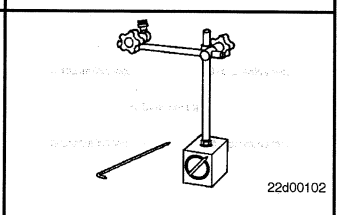
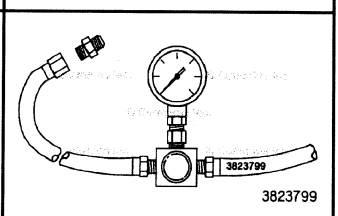
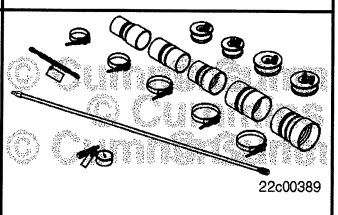
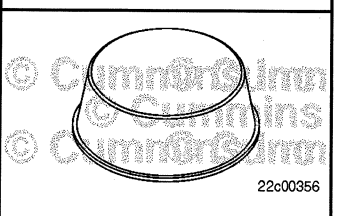
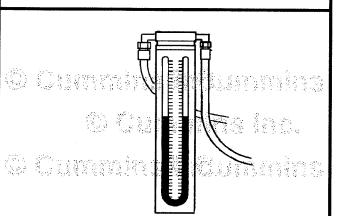
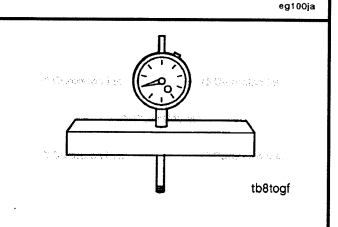
## Service Tools

### 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
2892320	<p align="center"><b>Leak Test Kit</b></p> <p>Used to detect leaks in all engine fluid systems (lubricating oil, coolant, and fuel) using a cordless "True UV" light that will detect the presence of fluorescent dye additive.</p>	
3164070	<p align="center"><b>RTV Sealant</b></p> <p>Used to seal rear gear housing to block, front cover to block, and intake manifold to cylinder head joints.</p>	 <p align="right">22d00220</p>
3164489	<p align="center"><b>Digital Multimeter</b></p> <p>Used to measure electrical circuits: Voltage (volts), resistance (ohms), and current (amps). 3164489 - with built in temperature adapter and tachometer.</p>	 <p align="right">3377161</p>
3164492	<p align="center"><b>Immersion Probe Thermocouple</b></p> <p>Used for checking charge-air cooler and piping. Use with digital multimeter, Part Number 3164488.</p>	 <p align="right">22d00110</p>
3164498	<p align="center"><b>Bead Probe</b></p> <p>Used with digital thermometer, Part Number 3164499.</p>	 <p align="right">3822994</p>
3164499	<p align="center"><b>Digital Thermometer</b></p> <p>Used to measure ambient air temperature. Use with digital multimeter, Part Number 3164488.</p>	 <p align="right">22d00110</p>



Tool No.	Tool Description	Tool Illustration
3376891	<p align="center"><b>Fluorescent Tracer</b></p> <p>Used for check leaks through the turbocharger.</p>	 <p align="right">3376891</p>
3377399	<p align="center"><b>Magnetic Base Indicator Holder</b></p> <p>Used in conjunction with dial indicator, Metric - Part Number 3824564. SAE - Part Number 4918289.</p>	 <p align="right">22d00102</p>
3823799	<p align="center"><b>Turbocharger Wastegate Pressure-Setting Kit</b></p> <p>Used to apply regulated pressure to wastegate actuator during troubleshooting and calibrating procedures.</p>	 <p align="right">3823799</p>
4919095	<p align="center"><b>Charge-Air Cooler Tester</b></p> <p>Used to pressure test charge-air coolers.</p>	 <p align="right">22c00389</p>
5298878	<p align="center"><b>Air Handling Clean Air Kit</b></p> <p>Contains a variety of protective caps to prevent contamination of vehicle air handling plumbing during service procedures.</p>	 <p align="right">22c00356</p>
ST-1111-3	<p align="center"><b>Manometer</b></p> <p>Used to measure pressure and restriction 0 to 2.5 kPa [0 to 36 in H<sub>2</sub>O] pressure differential with more accuracy.</p>	 <p align="right">eg100ja</p>
ST-537	<p align="center"><b>Dial Depth Gauge</b></p> <p>Used to measure turbocharger axial motion.</p>	 <p align="right">tb8togf</p>

## Air Cleaner Element (010-014)

### General Information



**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.**

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

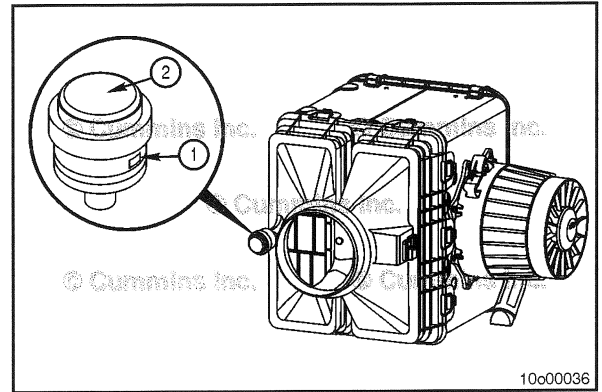
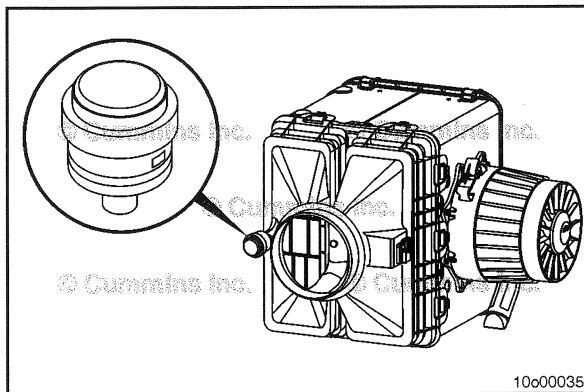
The direct flow air cleaner uses both a primary and secondary filter element for industrial applications. The direct flow air cleaner has been designed for a maximum restriction at 635 mm H<sub>2</sub>O [25 in H<sub>2</sub>O] of water, at which point the filter element(s) should be changed.

### Measure

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

#### Restriction Indicator Check

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

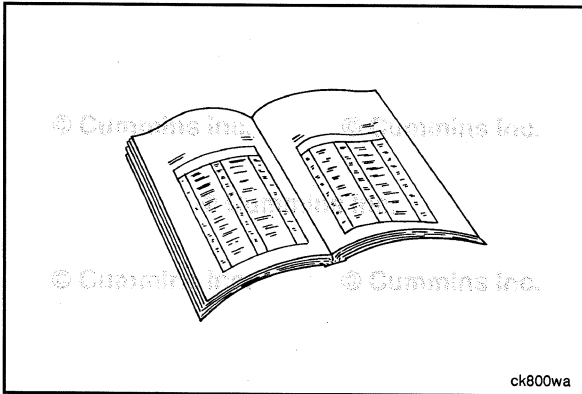


The red flag (1) in the window gradually rises as the air filter loads with dirt. When the maximum air filter restriction is indicated, the air filter **must** be replaced. After changing or replacing the air filter, reset the indicator by pushing the reset button (2).

Some restriction indicators are installed with an electronic switch that illuminates a lamp in the cab at full restriction of 635 mm H<sub>2</sub>O [25 in H<sub>2</sub>O] of water.

#### Pressure/Vacuum Gauge Measure

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



## Preparatory Steps



### ⚠️ WARNING ⚠️

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



### ⚠️ WARNING ⚠️

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

### ⚠️ WARNING ⚠️

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

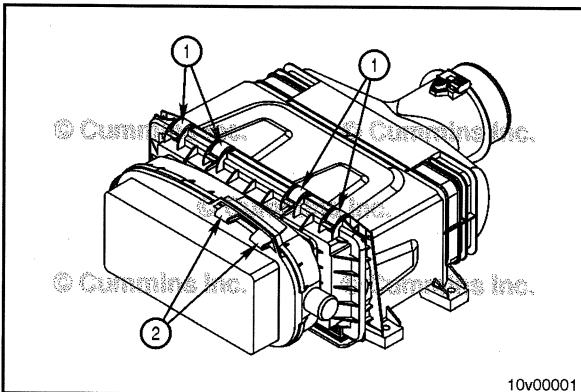
### ⚠️ CAUTION ⚠️

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

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

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

- Shut the engine OFF.
- Disconnect the battery cables. See equipment manufacturer service information.



## Remove

### Front Service Filter Housing

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

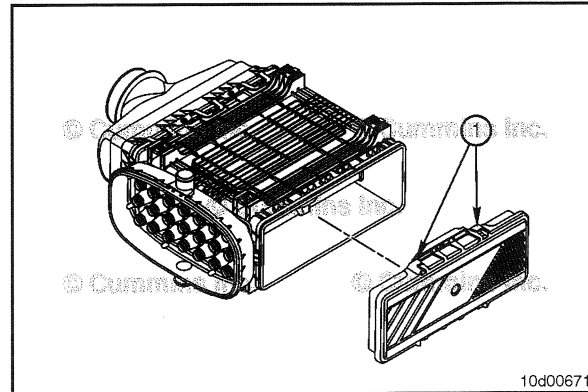
- 1 Clip locations.
- 2 Tab locations.

### Side Service Filter Housing

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

- 1 Service door clip (both sides).

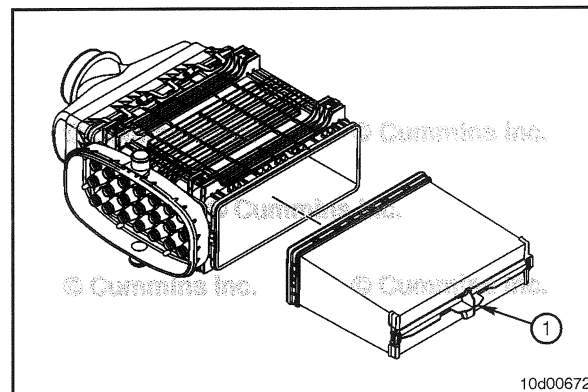
Make sure the gasket around the service door or pre-cleaner remains seated.



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

- 1 Primary element removal handle.

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



### ⚠ CAUTION ⚠

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

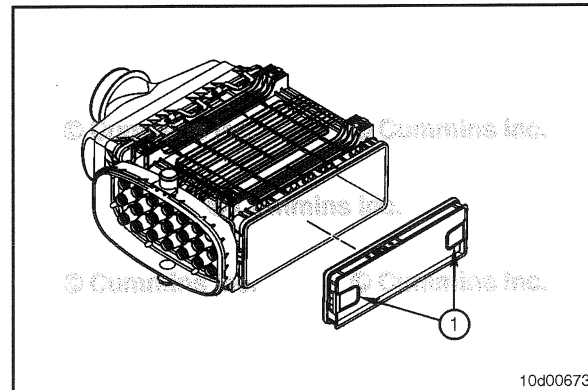
### ⚠ CAUTION ⚠

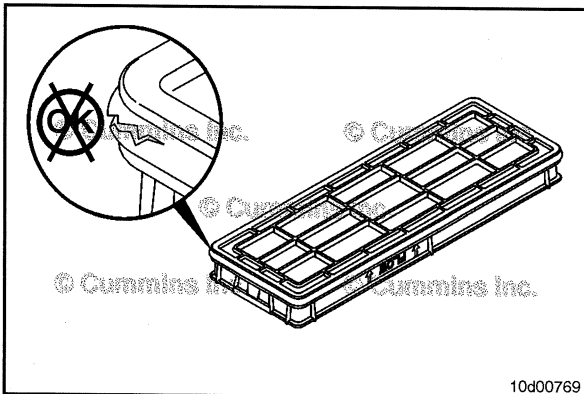
Do not attempt to clean the filter elements. Cleaning filter elements by impact or compressed air voids the warranty and can degrade or damage the filter media leading to malfunction.

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

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

- 1 Secondary element removal ring tab.

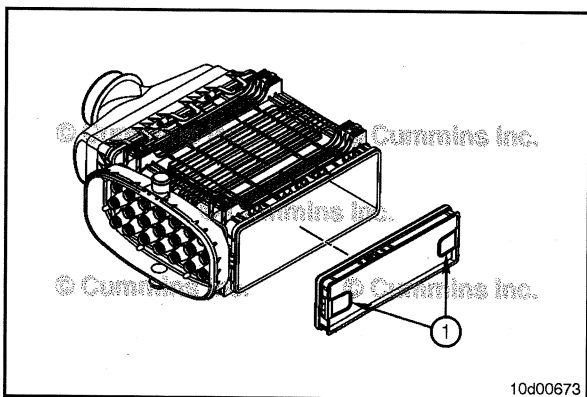




### Inspect for Reuse

If the used filter element is to be used again, the following precautions must be taken:

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



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

#### Secondary Element

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

- 1 Secondary element removal ring tab should be visible.

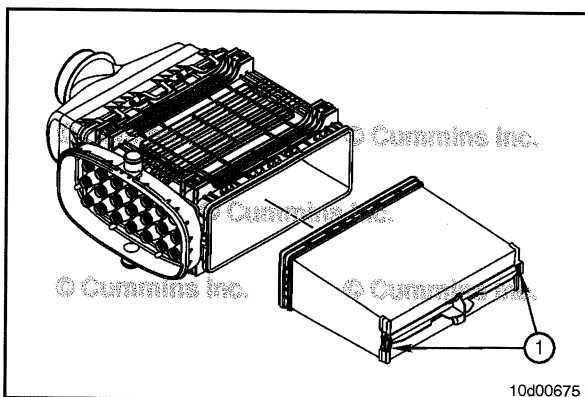
Push the secondary element into the back of the housing so all surfaces are seated inside the housing. Apply pressure to all four corners to make sure the element is secure within the housing. The secondary filter element includes an o-ring that is glued to the filter element to provide an airtight seal.

#### Primary Filter Element



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

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



## Finishing Steps

### ▲ WARNING ▲

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

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

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

**NOTE:** The Direct Flow filter elements are completely disposable.

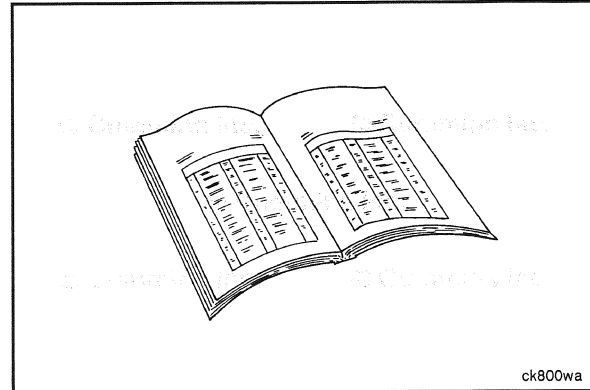
- Install the service door or pre-cleaner assembly by latching to the housing.
- Reset the restriction indicator by pushing the reset button.
- Connect the battery cables. See equipment manufacturer service information.
- Operate the engine and listen for a noise that could indicate an air leak. Use the following procedure to locate any air leaks in the air system. Refer to Procedure 010-024 in Section 10 in the QSF308 CM2350 F107 Service Manual, Bulletin 4367316.
- Operate the engine and listen for a noise that could indicate an air leak.

## Air Cleaner Precleaner (010-015)

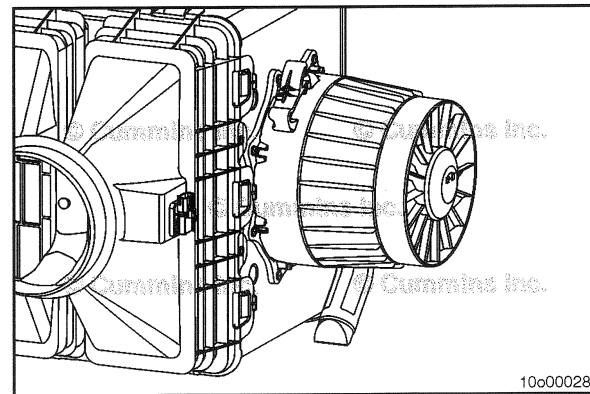
### General Information

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:

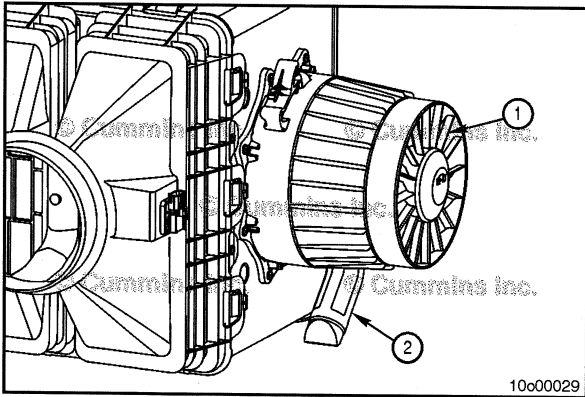
- Integrated precleaner with dust ejection valve
- Non-captive style precleaner
- Integrated precleaner with exhaust aspiration.



ck800wa



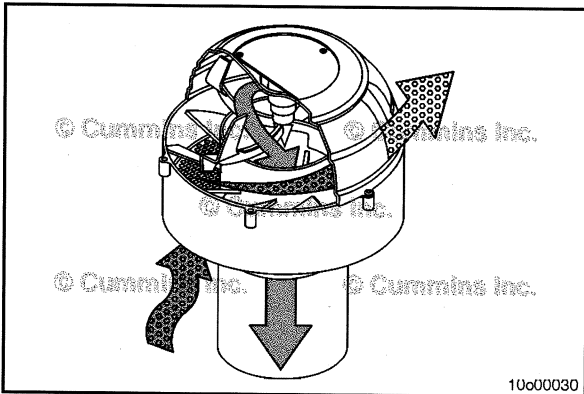
10o00028



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

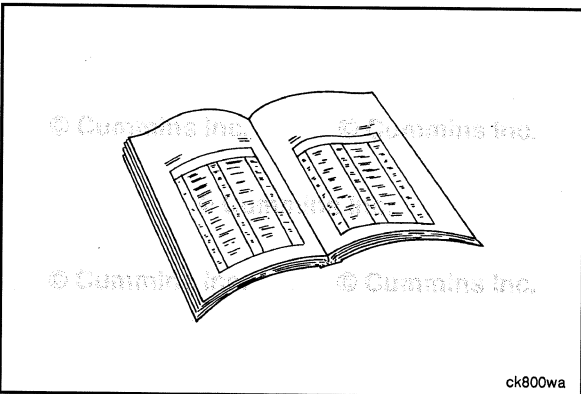
The centrifugal motion causes debris to be forced to the outside of the precleaner, where it is then collected in the dust ejection valve (2).

**NOTE:** If the dust ejection valve becomes full of debris, the precleaner will **not** function and the debris will remain in the air stream, which can lead to frequent air filter plugging or low air filter service life. Refer to Procedure 010-146 in Section 10.



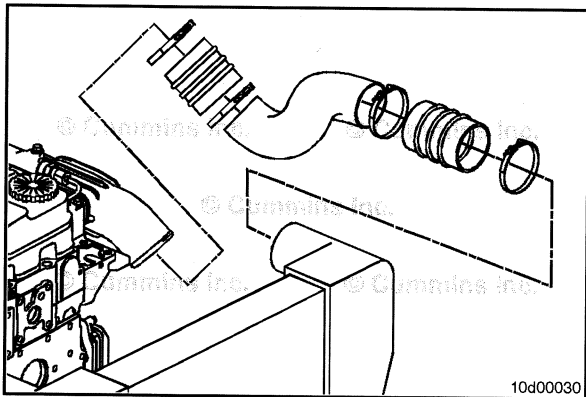
Non-captive style precleaners work similarly to integrated precleaners by using centrifugal motion to force debris to the outside of the precleaner. However, instead of being collected in the dust ejection valve, the debris is immediately expelled back into the outside air.

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



## Air Crossover (010-019) General Information

On automotive applications, the air crossover refers to the piping connecting to the charge-air cooler.



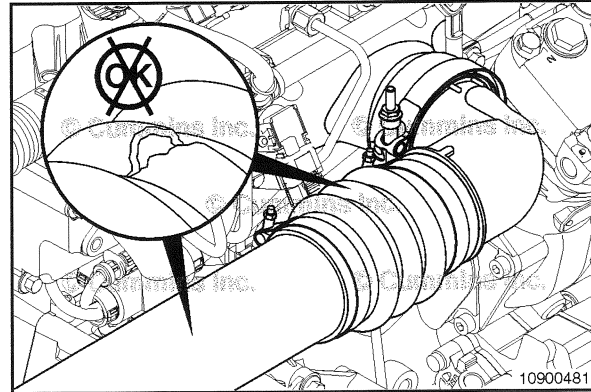
### Remove

- Loosen the air crossover hose clamps.
- Remove the air crossover tube.

### Clean and Inspect for Reuse

Check the crossover tube for cracks, holes, and worn sections.

If any damage is found, replace the air crossover and mounting components.

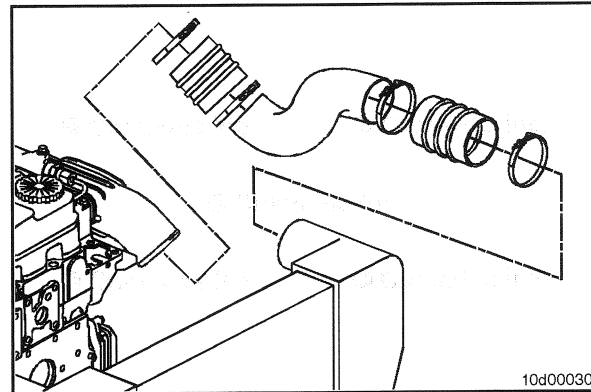


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### Install

Install the air crossover tube and clamps.

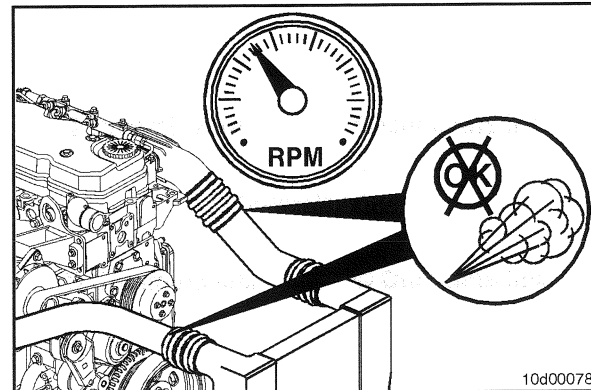
Tighten the clamps. See equipment manufacturer service information.



10d00030

### Finishing Steps

Operate the engine and check for leaks.

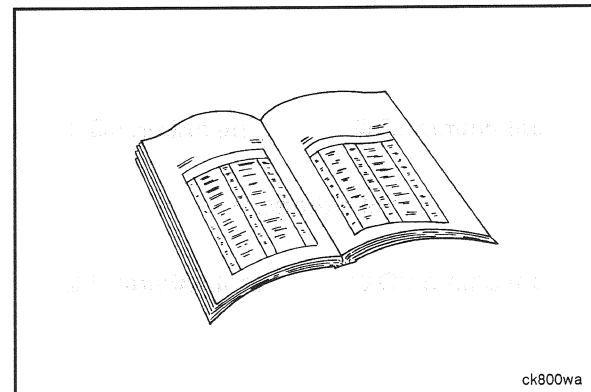


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## Air Inlet Connection (010-022)

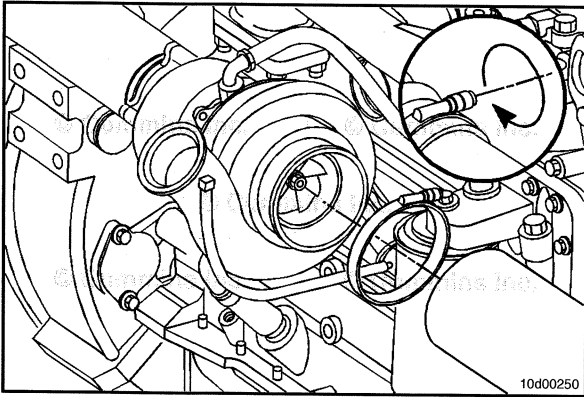
### General Information

The air inlet connection connects the turbocharger air inlet to the original equipment manufacturer (OEM) air inlet piping.



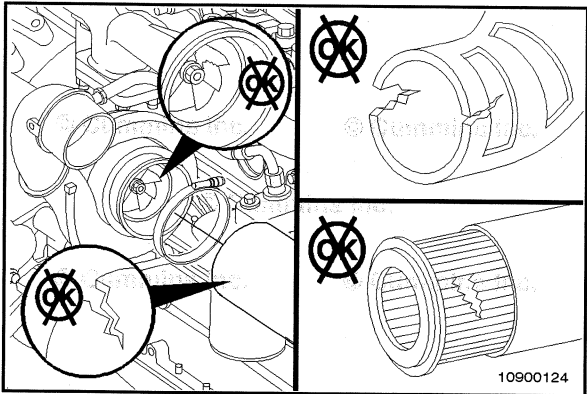
ck800wa





### Remove

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.



### 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.

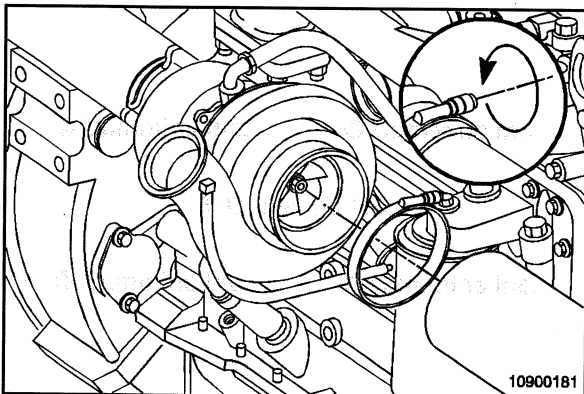
#### ⚠ WARNING ⚠

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 and dry with compressed air.

Check the piping and connections for cracks, holes, and worn sections.

If any damage found, replace the damaged components.



### Install

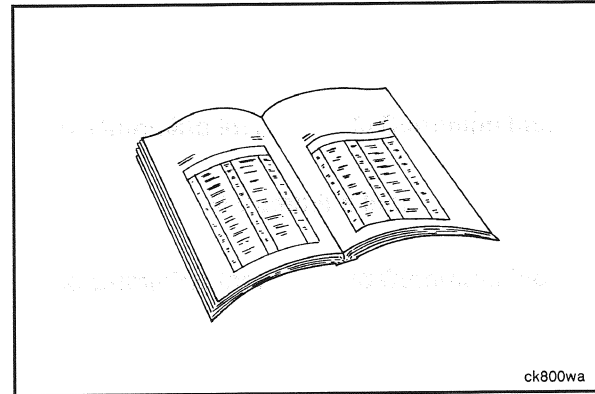
Install the air inlet piping and connections.



Tighten the attaching clamps. See equipment manufacturer service information.

## Finishing Steps

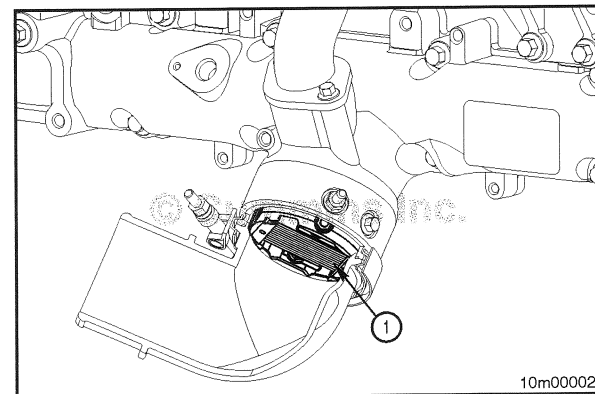
Operate the engine and check for leaks.

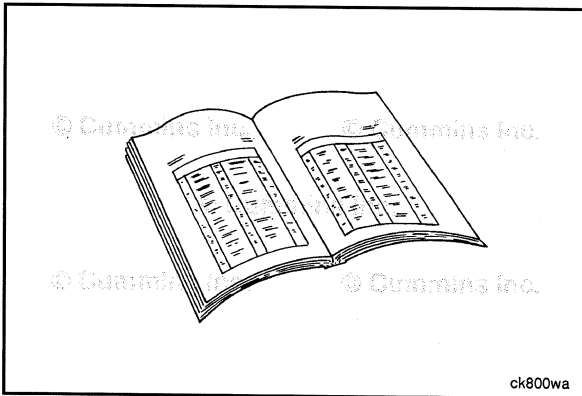


## Air Intake Manifold (010-023)

### Initial Check

Verify the cold starting aid (1) is functioning properly.  
Refer to Procedure 010-029 in Section 10.





## Preparatory Steps

### ⚠ WARNING ⚠

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

### ⚠ WARNING ⚠

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

### ⚠ WARNING ⚠

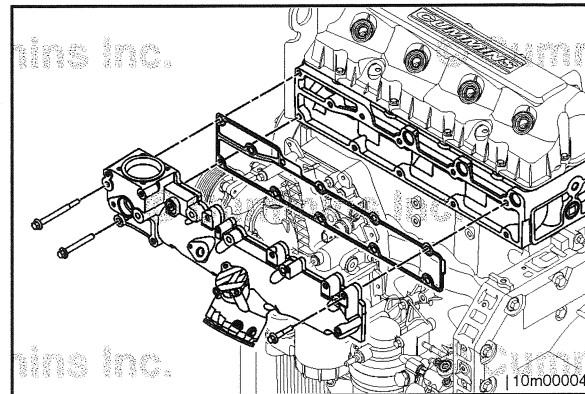
Coolant is toxic. Keep away from children and pets. If not reused, dispose of in accordance with local environmental regulations.

- Disconnect the batteries. See equipment manufacturer service information.
- Disconnect the electrical connection from the cold starting aid. See equipment manufacturer service information.
- Disconnect the coolant temperature sensor. Refer to Procedure 019-019 in Section 19.
- Remove the charge-air piping. Refer to Procedure 010-028 in Section 10.
- Remove the EGR valve. Refer to Procedure 011-022 in Section 10.
- Remove the EGR valve mounting bracket. Refer to Procedure 011-044 in Section 11.
- Remove the EGR differential pressure sensor adaptor. Refer to Procedure 011-028 in Section 11.
- Remove the EGR connection tubes. Refer to Procedure 011-025 in Section 11.
- Remove the fuel rail supply lines. Refer to Procedure 006-051 in Section 6.
- Remove the fuel drain lines. Refer to Procedure 006-013 in Section 6.
- Remove the air intake connection. Refer to Procedure 010-080 in Section 10.
- Remove the cold starting aid. Refer to Procedure 010-029 in Section 10.
- Remove the intake manifold temperature/pressure sensor, if required. Refer to Procedure 019-159 in Section 19.
- Drain the cooling system. Refer to Procedure 008-018 in Section 8.
- Remove the coolant bypass tube. Refer to Procedure 008-005 in Section 8.
- Remove the coolant thermostat, if required. Refer to Procedure 008-013 in Section 8.
- Remove the water outlet connection, if required. Refer to Procedure 008-082 in Section 8.
- Disconnect the oil dipstick tube, if required. Refer to Procedure 007-011 in Section 7.

### Remove

Cover the intake opening with tape to keep foreign material out of the manifold and intake system.

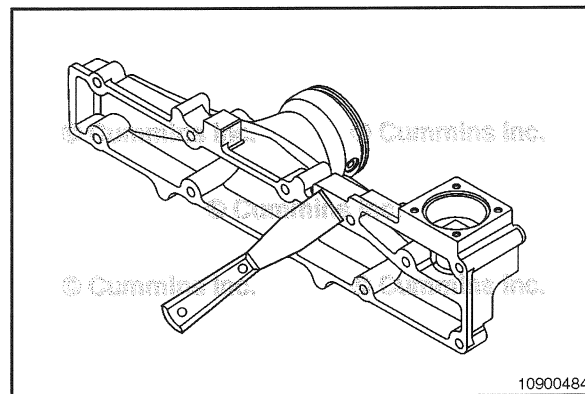
Remove the air intake manifold capscrews and remove the air intake manifold.



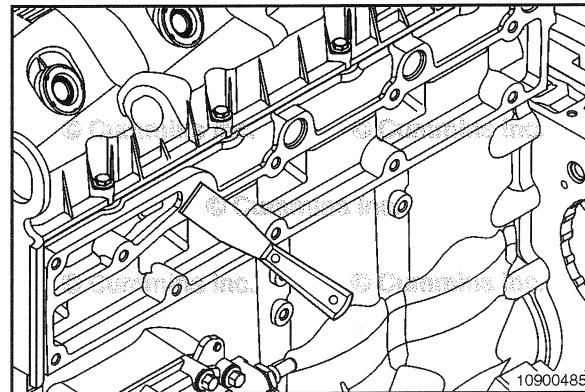
### Clean and Inspect for Reuse

Keep the gasket material and any other material out of the air intake.

Clean all air intake manifold sealing surfaces with a gasket scraper and a clean rag.

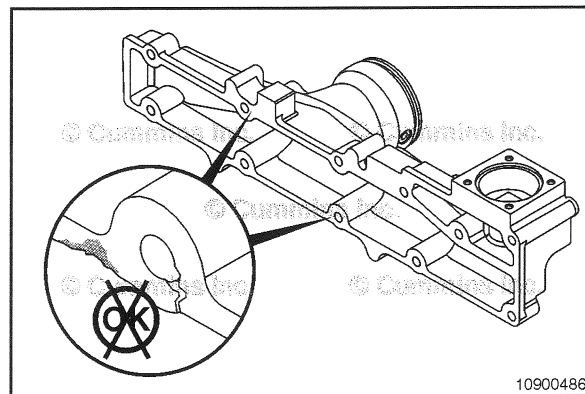


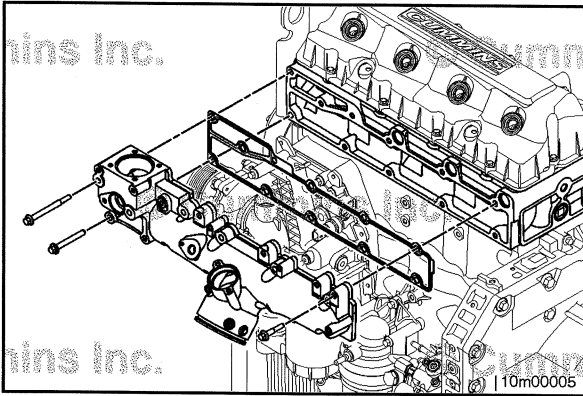
Clean the cylinder head sealing surfaces where the intake manifold seals.



Inspect the intake manifold for cracks or other damage.

**NOTE:** When inspecting the intake manifold for oil or debris from an air system malfunction, also inspect the cylinder head for oil and debris.





### Install

Remove the tape from the intake manifold opening before continuing with the installation process.

Install the air intake manifold and capscrews. Apply a light coating of thread sealant, Cummins® Part Number 3824041, to the capscrews before installation.

If the air intake manifold was originally equipped with a gasket, replace the gasket. If the air intake manifold was originally equipped with sealant, seal the intake with RTV sealant, Cummins® Part Number 3164070 or equivalent.

**Torque Value:** 24 N•m [ 212 in-lb ]

## Finishing Steps

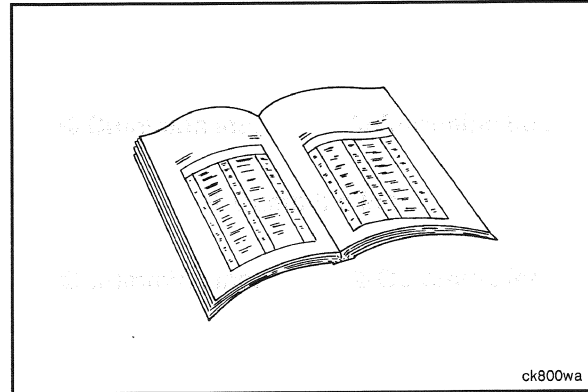
### ⚠ WARNING ⚠

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

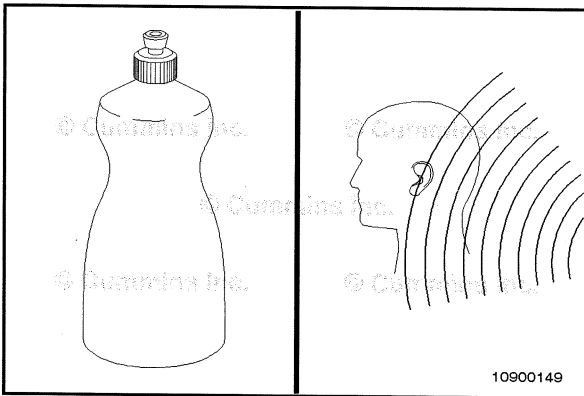
### ⚠ WARNING ⚠

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

- Install the intake manifold temperature/pressure sensor, if removed. Refer to Procedure 019-159 in Section 19.
- Install the cold starting aid on engines equipped with a cold starting aid. Refer to Procedure 010-029 in Section 10.
- Install the air intake connection. Refer to Procedure 010-080 in Section 10.
- Install the EGR valve mounting bracket. Refer to Procedure 011-044 in Section 11.
- Install the EGR valve. Refer to Procedure 011-022 in Section 11.
- Install the EGR differential pressure sensor adaptor. Refer to Procedure 011-028 in Section 11.
- Install the EGR connection tubes. Refer to Procedure 011-025 in Section 11.
- Install the coolant bypass tube. Refer to Procedure 008-005 in Section 8.
- Install the fuel drain lines. Refer to Procedure 006-013 in Section 6.
- Install the rail supply lines. Refer to Procedure 006-051 in Section 6.
- Install the electrical connection from the cold starting aid. See equipment manufacturer service information.
- Install the coolant temperature sensor. Refer to Procedure 019-019 in Section 19.
- Install the charge-air piping. Refer to Procedure 010-028 in Section 10.
- Install the water outlet connection, if removed. Refer to Procedure 008-082 in Section 8.
- Install the coolant thermostat, if required. Refer to Procedure 008-013 in Section 8.
- Install the oil dipstick tube, if required. Refer to Procedure 007-011 in Section 7.
- 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.



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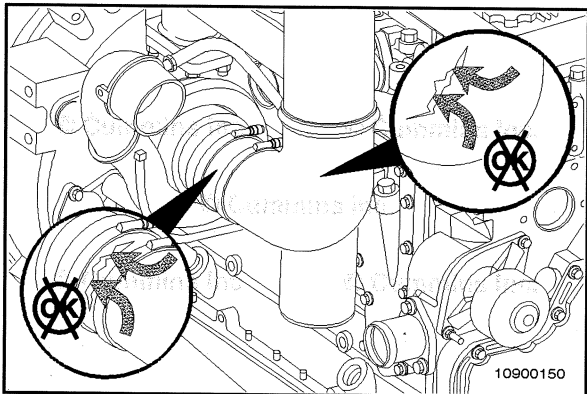


## Air Leaks, Air Intake and Exhaust Systems (010-024)

### Initial Check

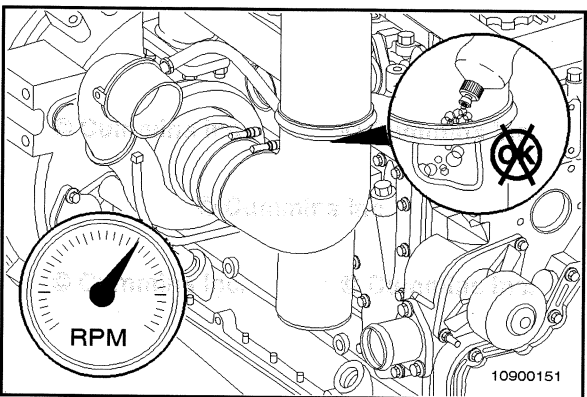
Leaks in the intake air system are most commonly identified by:

- 1 Inspection of piping for cracked or loose clamps.
- 2 Applying a solution of soapy water in the suspected area and inspecting for bubbles.
- 3 Listening for a high-pitched whining or sucking noise in the suspected area.



### ⚠ CAUTION ⚠

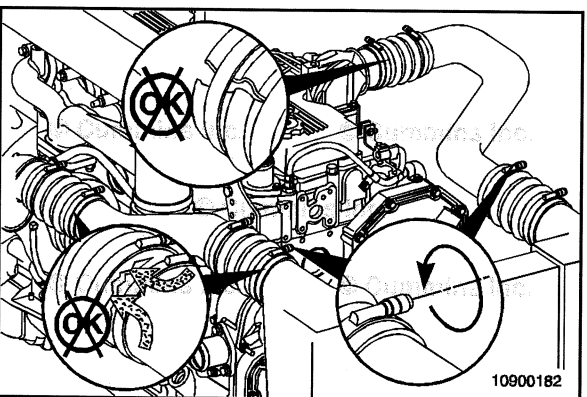
Engine intake air must be filtered to keep dirt and debris from entering the engine. If intake air piping is damaged or loose, unfiltered air will enter the engine and cause premature wear.



Inspect the inlet air piping for cracked hoses and damaged or loose clamps.

Operate the engine at high idle and use a solution of soapy water to spot inlet air leaks.

If an air leak exists at the turbocharger fresh air inlet, the soap bubbles will be drawn in with the air.



Replace damaged pipes and tighten loose clamps, if necessary, to make sure the air inlet system does **not** leak.



**Torque Value:** 10 N•m [ 89 in-lb ]



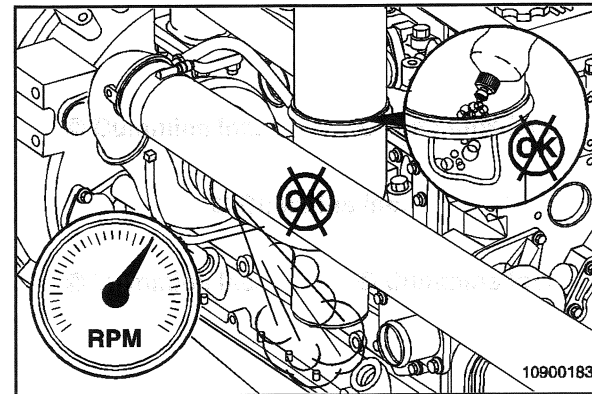
Check for corrosion of the inlet system piping under the clamps and hoses. Corrosion can allow corrosive products and dirt to enter the intake system.

Disassemble and clean as required.

**QSF3.8 CM2350 F107**  
**Section 10 - Air Intake System - Group 10**

**Pressure-Side Intake System**

Leaks in the intake system will reduce the amount of air to the cylinders during engine operation and decrease engine performance.

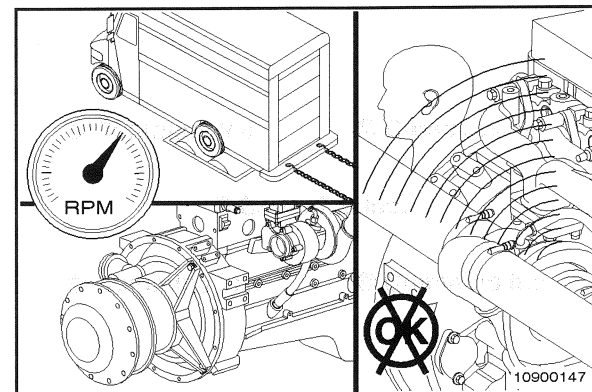


Operate the engine at full throttle and rated rpm with maximum load.



Listen for a high-pitched whistling noise from the turbocharger, nearby piping, and connections.

Apply a soapy water solution to sealing surfaces and inspect for bubbles.



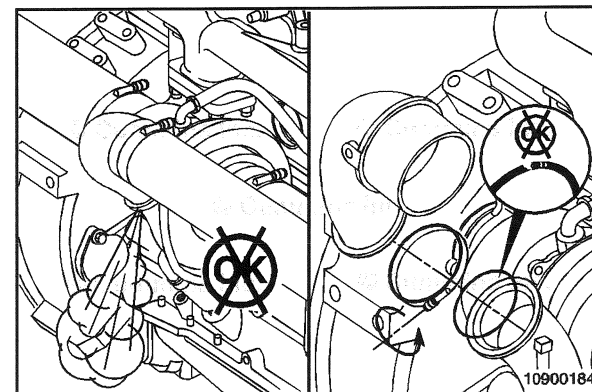
Leaks can also be found at the turbocharger outlet connection.



Inspect for damage, replace sealing o-ring, and tighten loose clamps.



**Torque Value:** 10 N•m [ 89 in-lb ]



**Charge-Air Cooler Tubing or Connection Hoses**

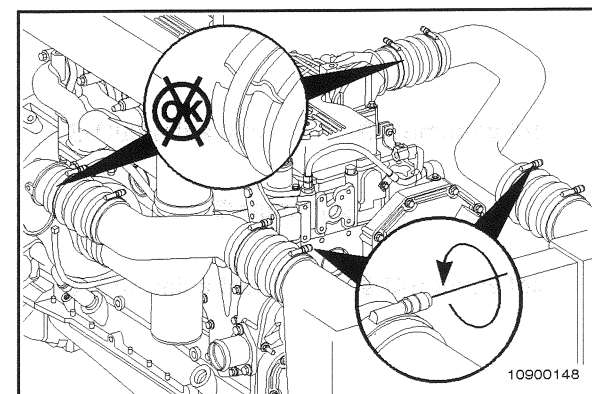
Inspect the hose and tubing for damage. Refer to Procedure 010-019 in Section 10.



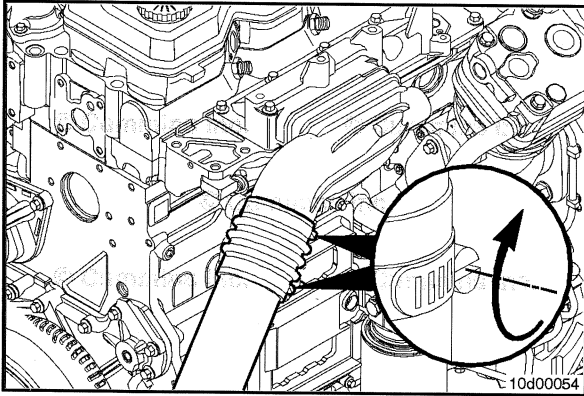
Tighten loose clamps.



Refer to the equipment manufacturer's specifications for the correct torque value.





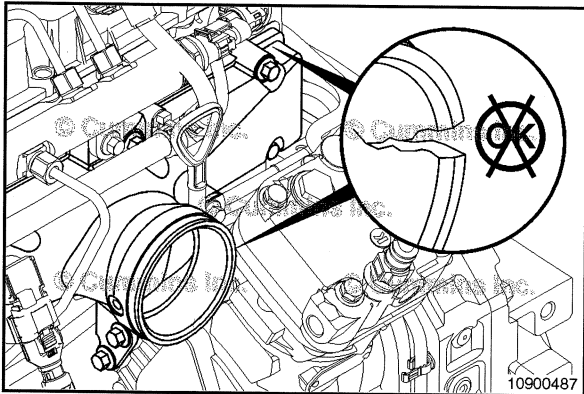


Intake Manifold Connection

Tighten loose clamps.



Replace the connection clamp, if necessary. Refer to Procedure 010-023 in Section 10.



Intake Manifold

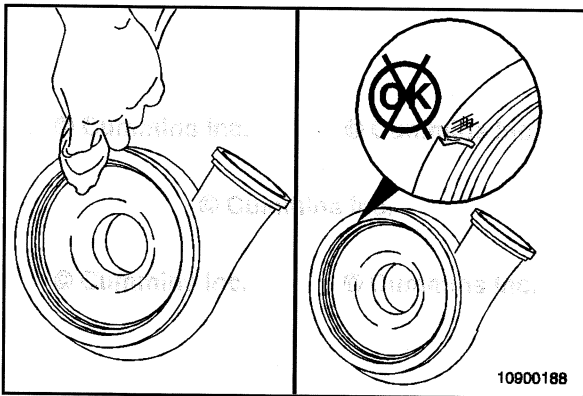
Inspect for damage.



If damage is found, replace the gasket if the engine was originally equipped with a gasket.



If the engine was originally equipped with sealant, replace with RTV sealant, Cummins® Part Number 3164070, or equivalent. Refer to Procedure 010-023 in Section 10.

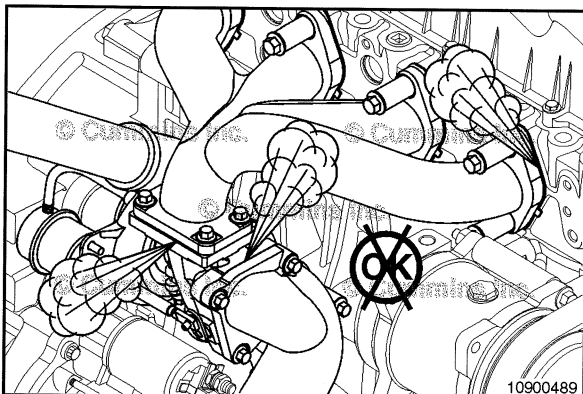


Compressor Housing Sealing Surface

Inspect for damage.



Clean surface with a clean cloth.



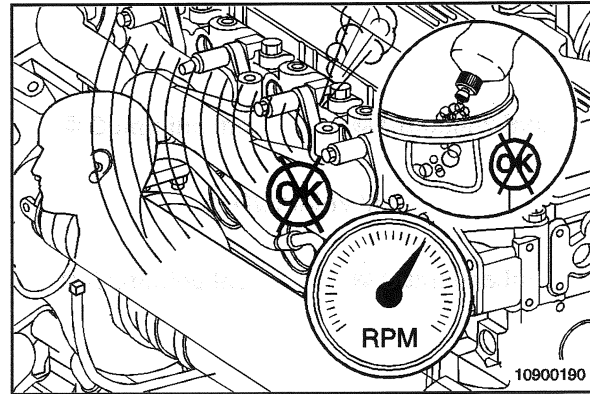
Exhaust System

Leaks in the exhaust system will cause the turbocharger to operate at a lower speed, reducing the amount of air going to the cylinders during engine operation.

**QSF3.8 CM2350 F107**  
**Section 10 - Air Intake System - Group 10**

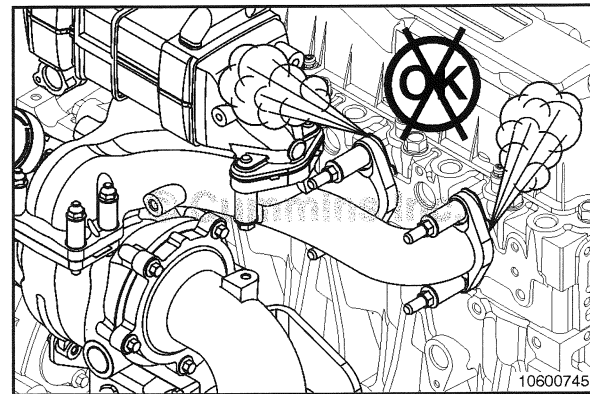
Operate the engine at full throttle and rated rpm with maximum load.

Leaks can be identified by noise, soapy water, or discoloration caused by the escaping hot gases.

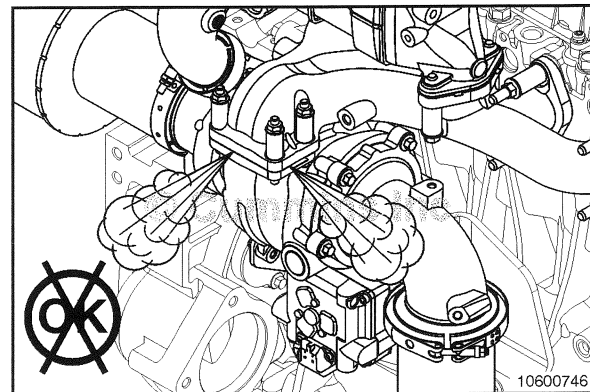


Leaks can be found at:

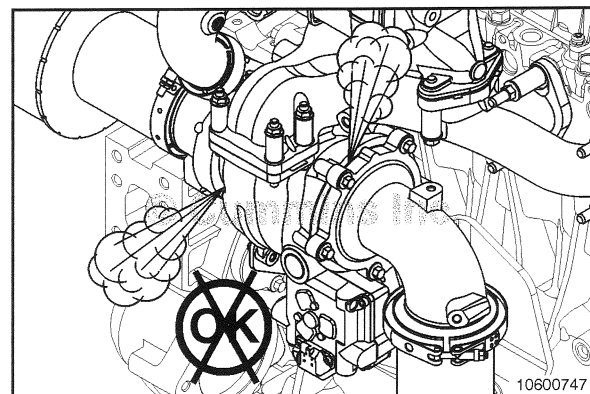
- Exhaust manifold gaskets

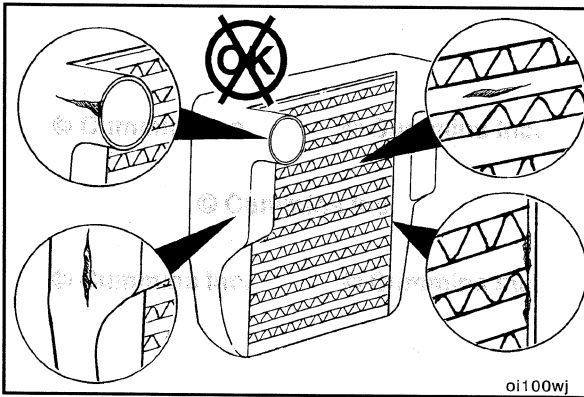


- Turbocharger mounting gaskets



- Turbine housing sealing surface.





## Charge-Air Cooler (010-027)

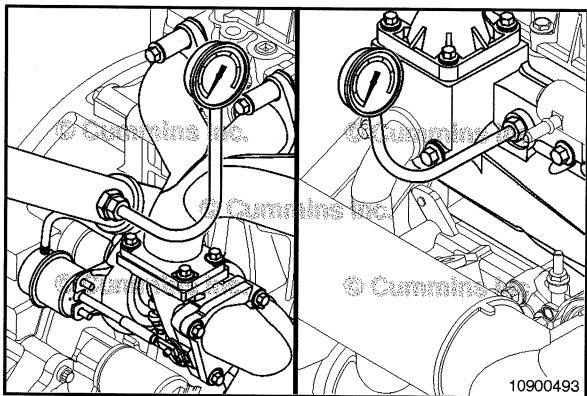
### Initial Check

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

Inspect the tubes, fins, and welds for tears, breaks, or other damage.

If any damage causes the charge-air cooler to **not** pass the air leak check, the charge-air cooler **must** be replaced.

Inspect the charge-air cooler plumbing for cracks and damage.



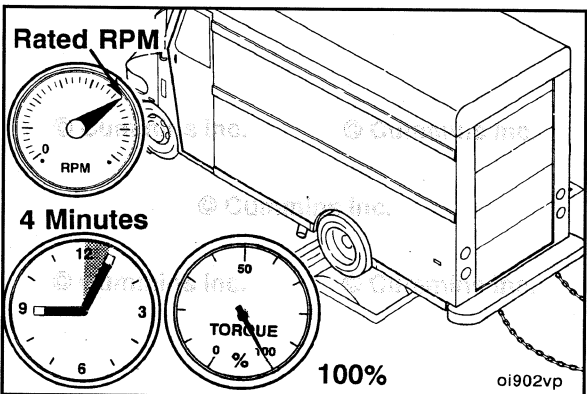
### Pressure Test

Obtain two pressure gauges, Cummins® Part Number 3823205. Check both gauges on the same pressure source at 206 kPa [30 psi] to verify consistency.



Install one pressure gauge in the 1/8-inch fitting in the turbocharger compressor outlet elbow. Install the other pressure gauge in the intake manifold.

Another alternative to measure the intake manifold pressure would be to use the monitor mode on the INSITE™ electronic service tool.



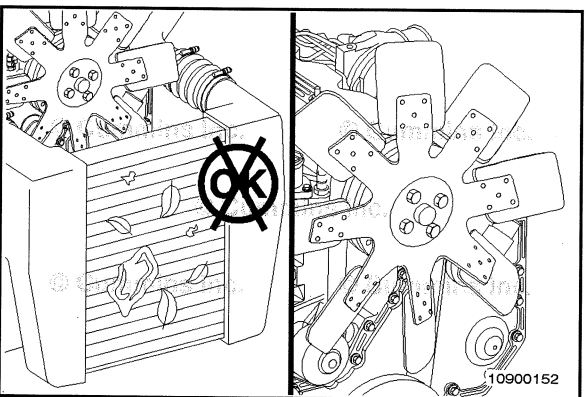
Operate the engine at rated rpm and load. Record the readings on the two gauges.



If the differential pressure is greater than 20.6 kPa [3 psi], check the charge-air cooler and associated piping for plugging, restrictions, or damage.



Clean or replace, if necessary.



### Temperature Differential Test

Inspect the charge-air cooler fins for obstructions to airflow. Remove obstructions such as a winterfront or debris. Manually lock shutters in the open position, if equipped.

Lock the fan drive in the ON mode to prevent erratic results. This can be done by installing a jumper wire across the temperature switch.

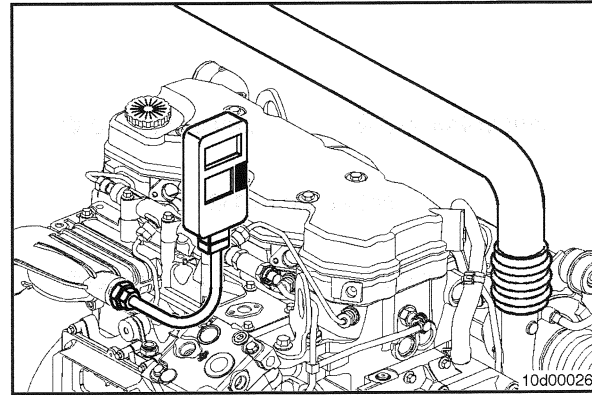
Install the thermocouple bead probe, Cummins® Part Number 3154498.



Connect the digital multimeter, Cummins® Part Number 3164488, and the temperature adaptor, Part Number 3164499, to the thermocouple bead probe to read intake air temperature.

Another alternative would be to use the monitor mode on the INSITE™ electronic service tool.

Install another thermocouple at the air cleaner inlet to measure ambient air temperature.



Perform a road test with the engine at peak power and a vehicle speed of 48 km/h [30 mph] or greater.

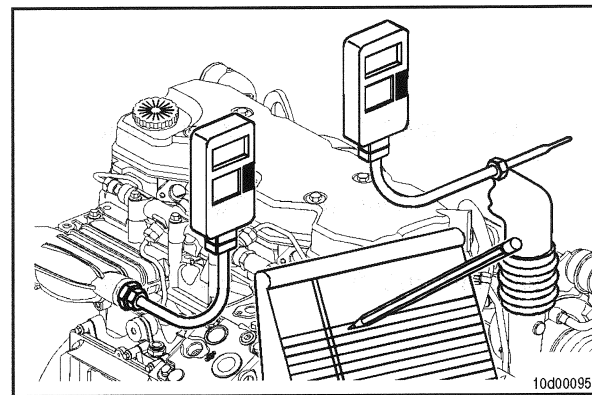


Record the intake manifold temperature and the ambient air temperature.

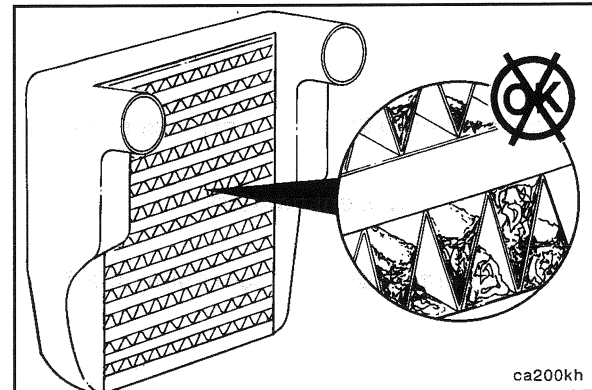
Calculate the differential temperature:

Intake manifold temperature - ambient air temperature = differential temperature.

- Differential temperature, delta T = 21°C [38°F].



If the temperature differential is greater than the specifications, check the charge-air cooler for dirt and debris on the fins and clean as necessary. If the problem still exists, check the charge-air cooler for debris in the fins or between the charge-air cooler and radiator. Confirm full fan engagement.

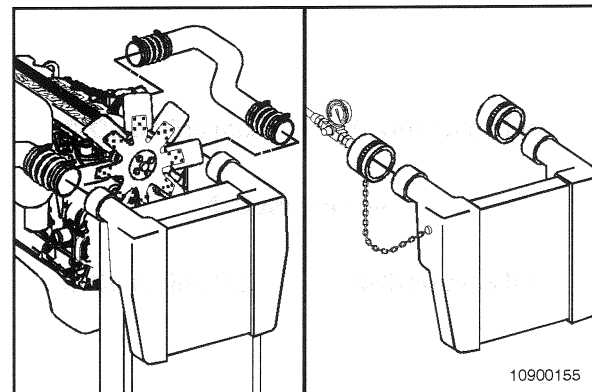


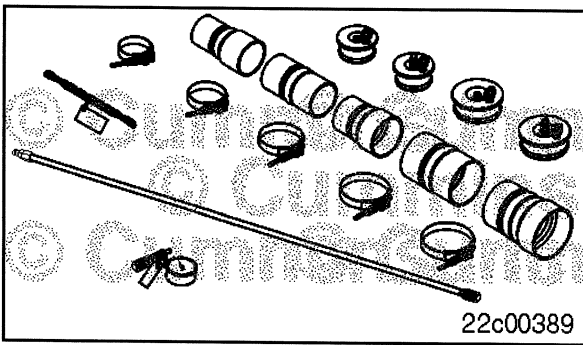
## Leak Test

### ⚠ WARNING ⚠

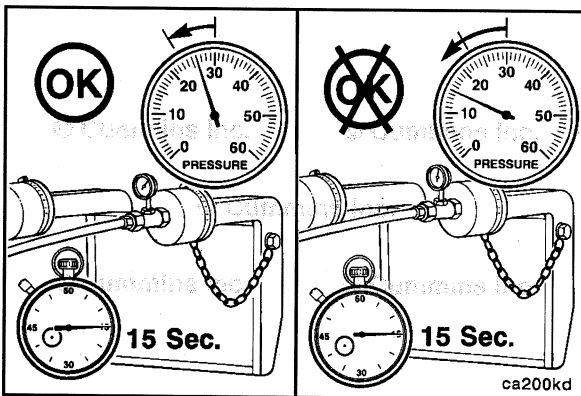
To reduce the possibility of injury if either plug blows off during the test, secure safety chains on the test plugs to any convenient capscrew on the radiator assembly. This test must not be performed without securely fastened safety chains.

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





To perform the leak test, use tool Cummins® Part Number 4919085. Install the cap over the outlet side of the cooler. Install the gauge end of the tool with a regulated shop air supply line and a shutoff valve to the inlet side of the cooler.

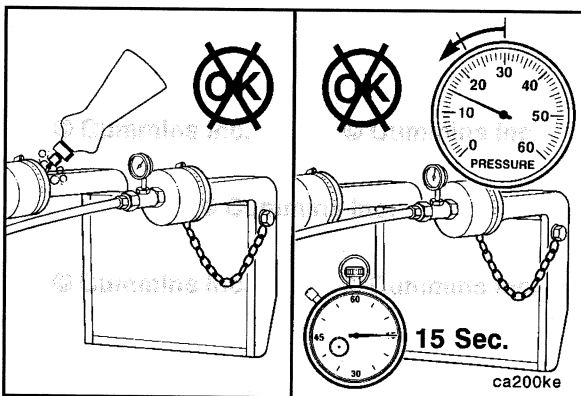


Apply air pressure to the cooler until the pressure gauge reads a steady 207 kPa [30 psi] of air pressure.

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

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

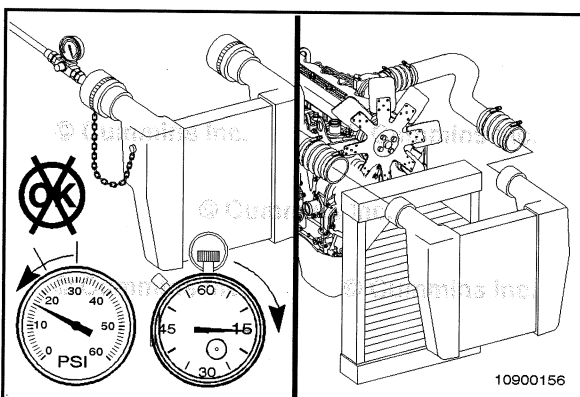
If the pressure drop is greater than 48 kPa [7 psi] in 15 seconds, check all connections again.



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

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

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



If the pressure drop is greater than 48 kPa [7 psi] in 15 seconds, the charge-air cooler **must** be replaced.

See equipment manufacturer service information for replacement instructions.

**NOTE:** Charge-air coolers are **not** designed to be 100-percent leak free. If the pressure drop is less than 48 kPa [7 psi] in 15 seconds, then the charge-air cooler does **not** need to be replaced.

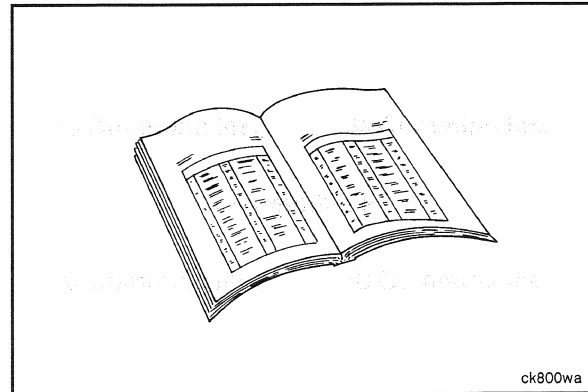
## Preparatory Steps

### ⚠ WARNING ⚠

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

Use compressed air to clean debris from the outside of the charge-air cooler.

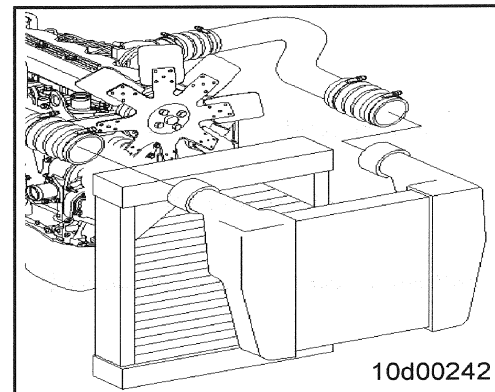
Remove the charge-air cooler piping. Refer to Procedure 010-019 in Section 10.



ck800wa

## Remove

Remove the charge-air cooler. See equipment manufacturer service information.



10d00242

## Clean

**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.

### ⚠ 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.

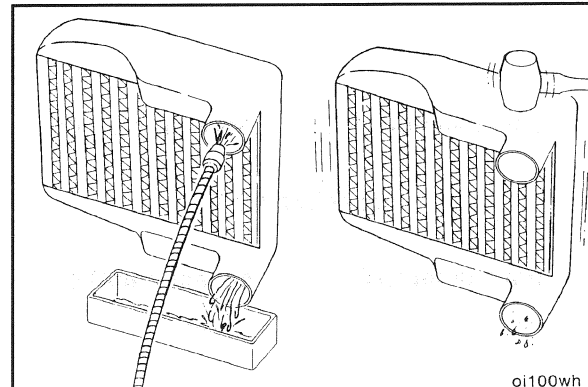
### ⚠ CAUTION ⚠

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

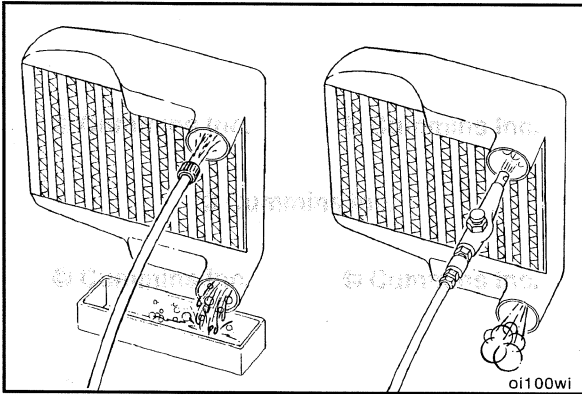
Flush the charge-air cooler internally with solvent in the opposite direction of normal airflow. Shake the charge-air cooler and lightly tap on the end tanks with a rubber mallet to dislodge trapped debris. Continue flushing until all debris or oil is removed (i.e., the water runs clear).

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

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



oi100wh



**▲ WARNING ▲**

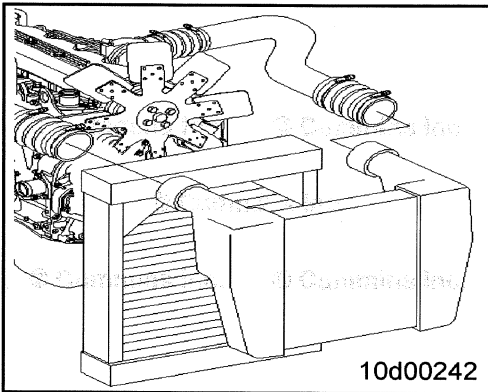
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

**▲ CAUTION ▲**

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

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

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

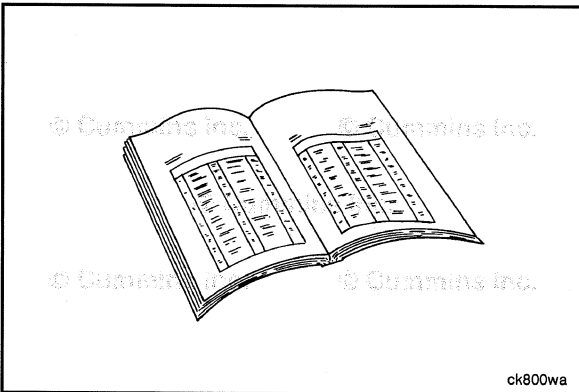


**Install**

Install the charge-air cooler.



See equipment manufacturer service information for instructions.



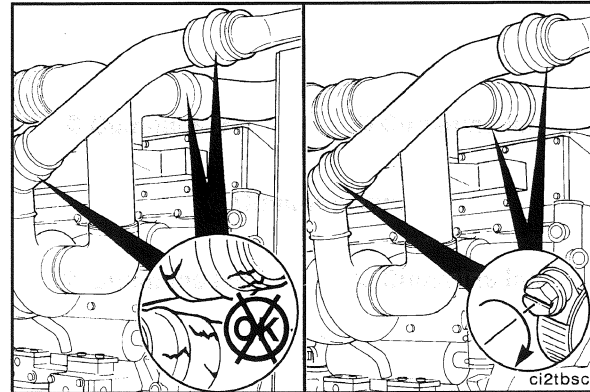
**Finishing Steps**

- Install the charge-air cooler piping. Refer to Procedure 010-019 in Section 10.



## 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.

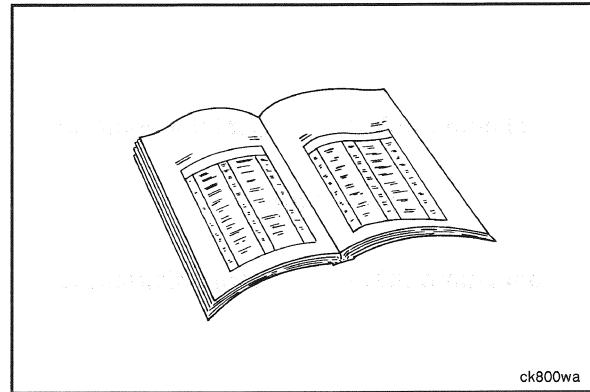


## Cold Starting Aid (010-029) Preparatory Steps

### ⚠ 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.

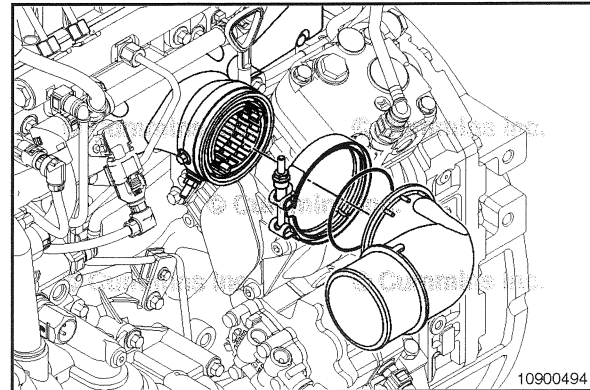
- Disconnect the batteries. See equipment manufacturer service information.
- Remove the charge-air piping. Refer to Procedure 010-019 in Section 10.



## Remove

Remove the air intake connection V-band clamp and air intake connection.

- Refer to Procedure 010-080 in Section 10.



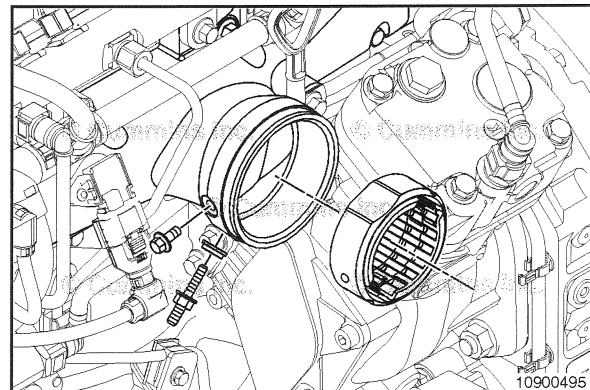
Remove the electrical supply terminal.

Remove the nylon isolating spacer from the electrical supply terminal.

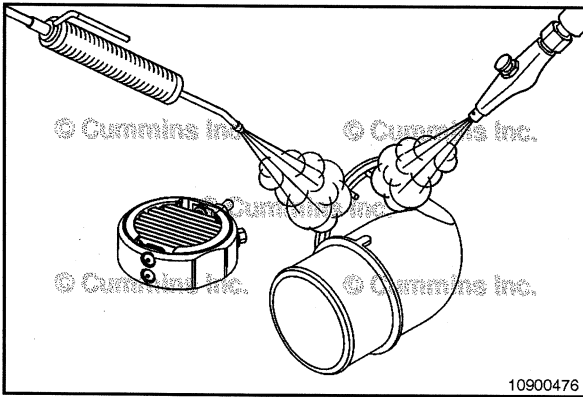
Disconnect the cold starting aid wiring.

Remove the ground strap capscrew from the air intake manifold and remove the ground strap.

Remove the cylindrical cold starting aid assembly from the air intake manifold.







### 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 ▲

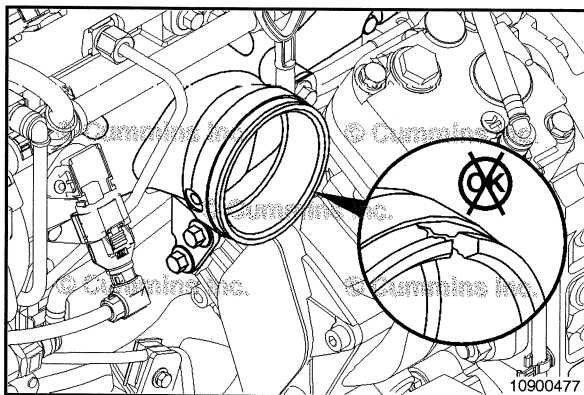
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Keep the gasket material and any other materials out of the air intake manifold.

Check the air filter and connections for evidence of dust buildup in the cold starting aid. Dirt or leaking may be found.

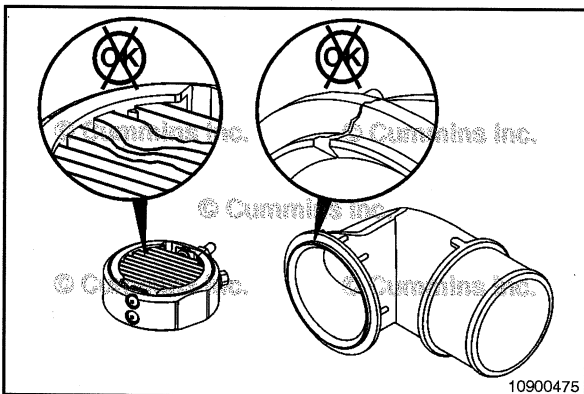
Clean the air intake, cold starting aid, and intake connection sealing surfaces with a gasket scraper and a clean rag.

Steam clean the intake manifold and dry with compressed air.



Remove the tape or rag from the intake manifold.

Inspect the intake manifold cover.



Inspect the cold starting aid and air intake connection sealing surfaces for cracks or other damage.

## Install

Fit the cold starting aid into the intake manifold.

Rotate the cold starting aid to align the electrical supply terminal with the machined hole in the top of the air intake manifold.

Insert the electrical supply terminal through the air intake manifold hole.

Install the nylon isolating spacer onto the electrical supply terminal.

Thread the terminal into the cold starting aid and tighten to specification.

**Torque Value:** 8 N•m [ 71 in-lb ]

Connect the cold starting aid wiring.

Install the ground strap and ground strap attaching capscrew to the intake manifold.

Tighten to specification.

**Torque Value:** 8 N•m [ 71 in-lb ]

Install the air intake connection V-band clamp and air intake connection.

- Refer to Procedure 010-080 in Section 10.

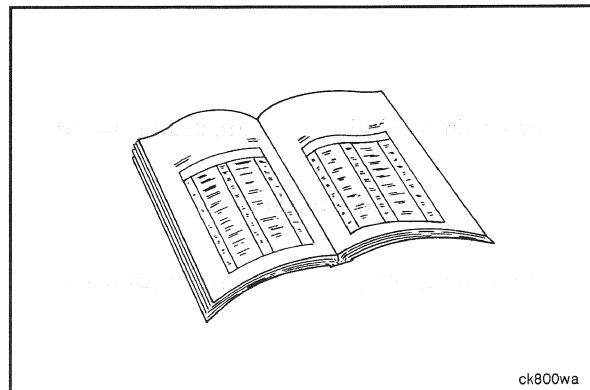
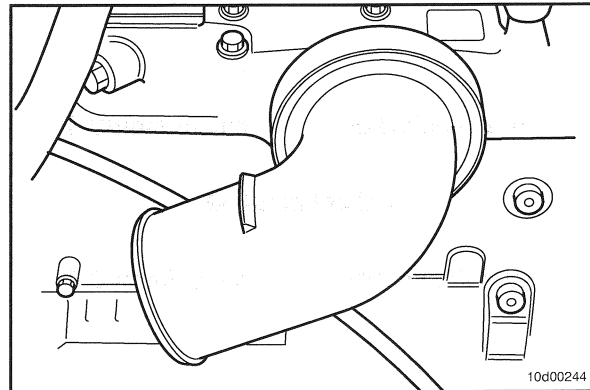
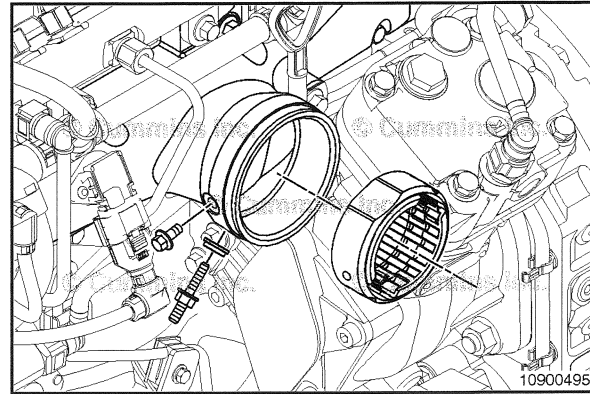
Tighten the clamp to specification.

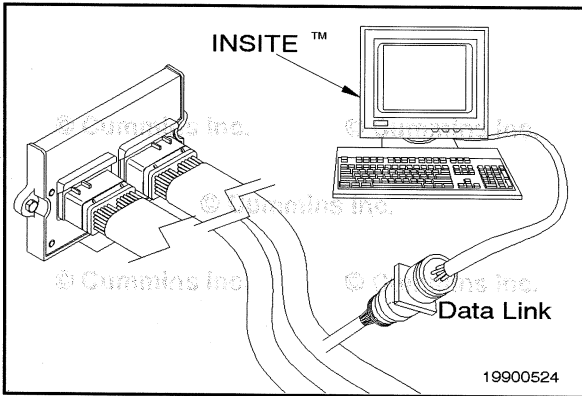
**Torque Value:** 10 N•m [ 89 in-lb ]

## Finishing Steps

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

- Install the charge-air piping. Refer to Procedure 010-019 in Section 10.
- Connect the batteries. See equipment manufacturer service information.
- Operate engine and check for leaks. Refer to Procedure 010-024 in Section 10.





### Test

#### ▲ WARNING ▲

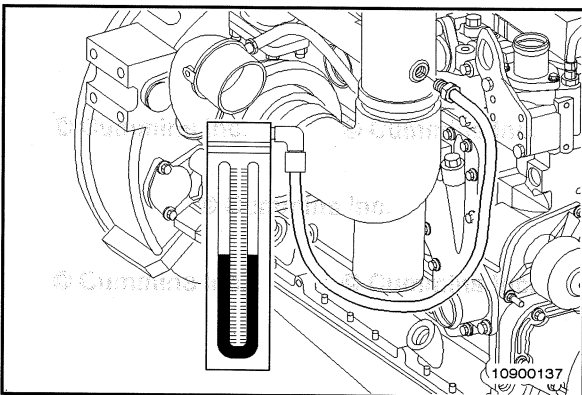
Avoid touching the cold starting aid with your hands while the cold starting aid is operating. The heated surfaces can cause personal injury.

Connect INSITE™ electronic service tool.

From the list of engine control module (ECM) diagnostic tests, select "Intake Air Heater Override".

Follow the on-screen instructions to determine if the cold starting aid and cold starting aid circuitry are functioning properly.

To check if the cold starting aid is heating, use an infrared non-contact thermometer, Cummins® Part Number 3164487.



### Air Intake Restriction (010-031)

#### Measure

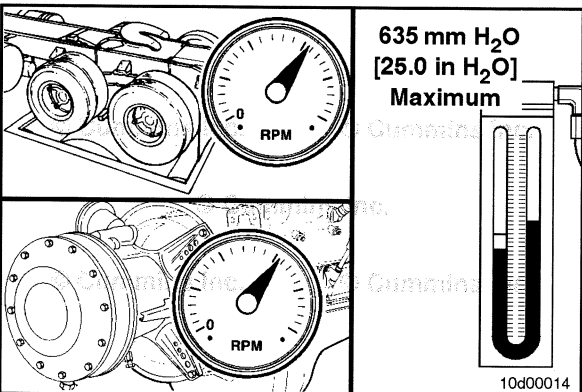


Manometer, Cummins® Part Number ST-1111-3

Install a vacuum gauge or water manometer, Cummins® Part Number ST-1111-3, in the inlet air piping.

The gauge adapter **must** be installed at a 90-degree angle to the airflow in a straight section of pipe, one pipe diameter before the turbocharger.

**NOTE:** The air intake restriction can be measured by removing the pop-up flag restriction gauge and installing a vacuum gauge or water manometer.



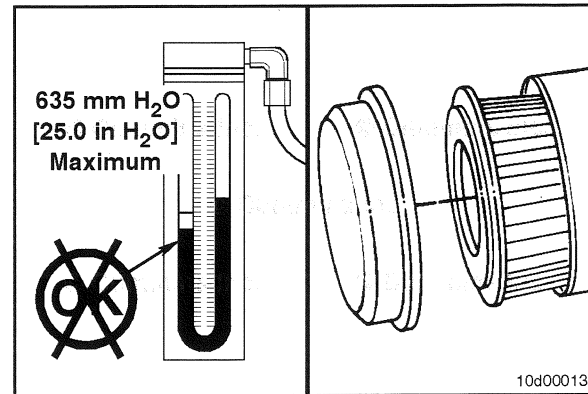
Operate the engine at full throttle and rated rpm with maximum load.

Record the data on the gauge or manometer.

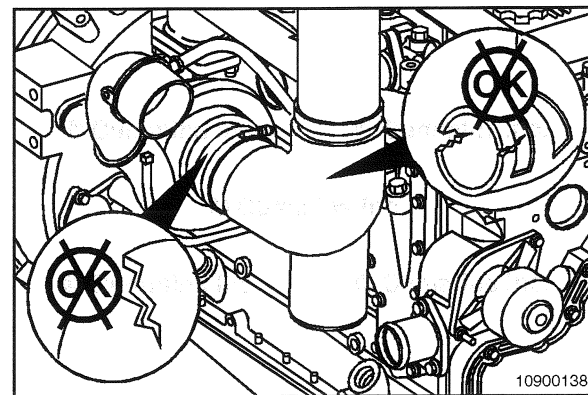
Air Intake Restriction		
mm H <sub>2</sub> O		in H <sub>2</sub> O
635	MAX	25

If restriction exceeds specifications:

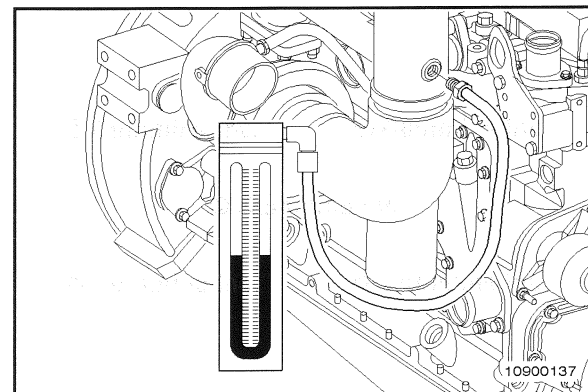
- Replace the air filter element. See equipment manufacturer service information.



- Inspect the air inlet piping for damage. See equipment manufacturer service information.

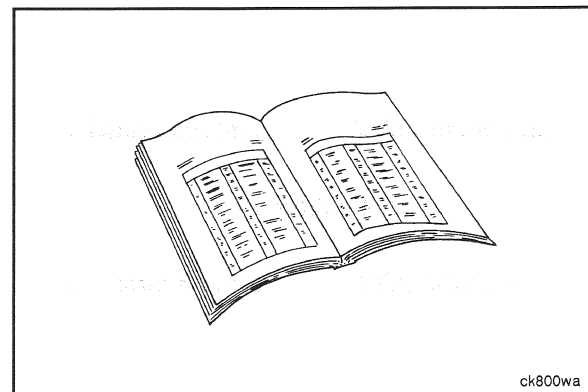


Remove the test equipment.

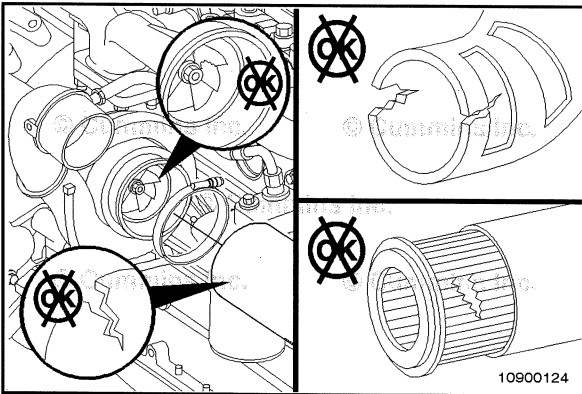


## Turbocharger (010-033) General Information

This engine uses Cummins® HE200WG turbocharger.



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### Initial Check

Remove the inlet pipe and air inlet connection from the turbocharger. Refer to Procedure 010-022 in Section 10.



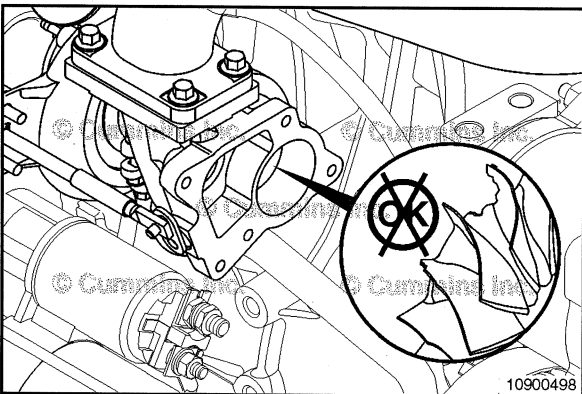
Inspect the turbocharger compressor impeller blades for damage.



Replace the turbocharger if damage is found. See the Remove and Install steps in this procedure.

If the compressor impeller is damaged, inspect the inlet piping and filter element for damage.

Repair any damage before operating the engine.

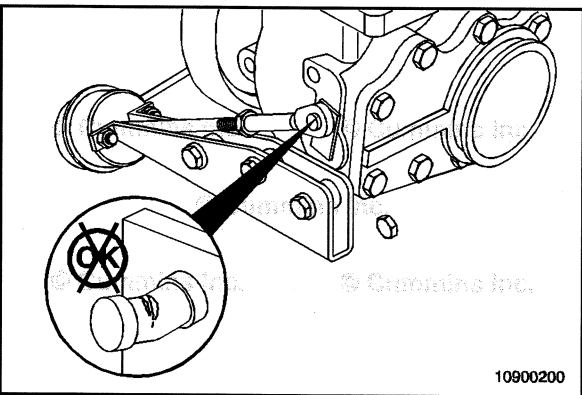


Remove the exhaust pipe from the turbocharger.

Inspect the turbine wheel for damage.



Replace the turbocharger if damage is found. See the Remove and Install sections in this procedure.

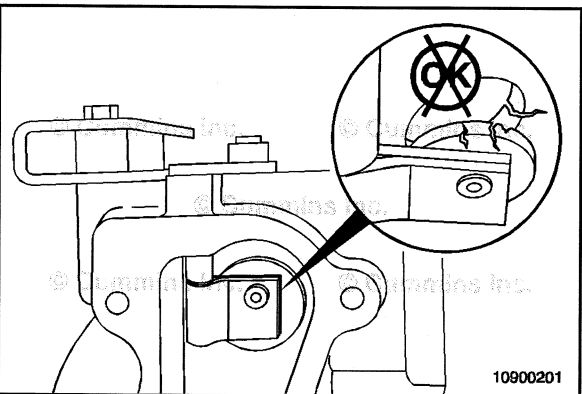


### Wastegate Check:

Inspect the lever pin.



Replace the turbocharger if the lever pin is bent or worn excessively. See the Remove and Install sections in this procedure.



Inspect the valve and valve seat for cracks or erosion.



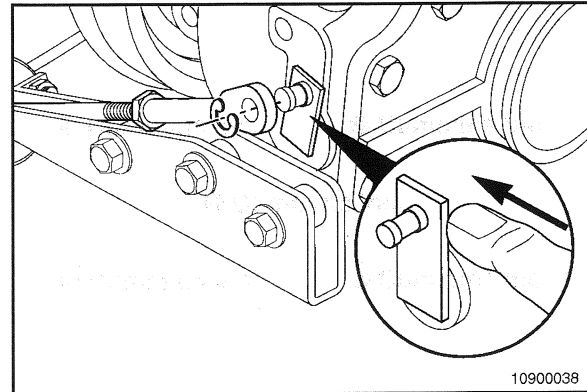
**NOTE:** On some turbochargers, removal of the turbine exhaust outlet cover may be necessary to inspect the valve and valve seat. If the turbine exhaust outlet cover is removed, replace the gasket before reinstalling the cover.

Replace the turbocharger if the valve or valve seat are excessively cracked or eroded. See the Remove and Install sections in this procedure.

Actuate the lever by hand to verify that the shaft rotates freely and is **not** seized.

Check for excessive movement between the shaft and bushing.

Replace the turbocharger if the shaft is seized or if there is excessive movement between the shaft and bushing. See the Remove and Install sections in this procedure.



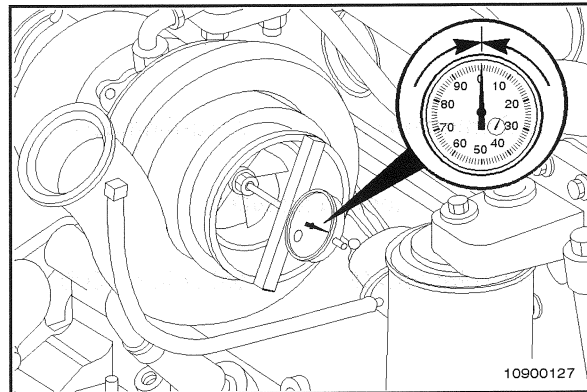
10900038

**Axial Clearance Check:**

Use dial depth gauge, Cummins® Part Number ST-537.

Push the rotor assembly away from the gauge.

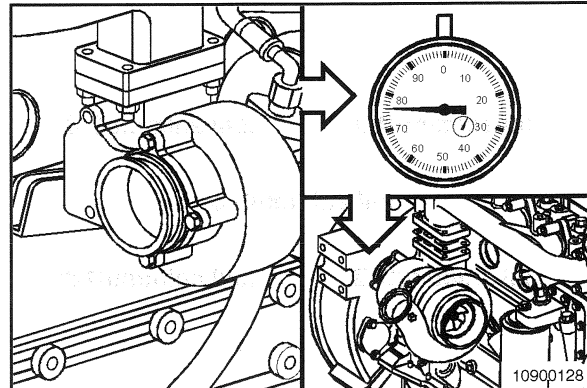
Set the gauge to zero.



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Push the rotor assembly toward the gauge and record the reading.

Replace the turbocharger if the clearance does **not** meet specifications. See the Remove and Install sections in this procedure.



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**Axial Specifications**

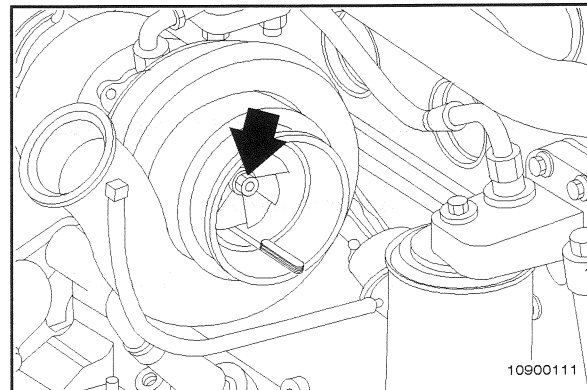
mm		in
0.01	MIN	0.0004
0.076	MAX	0.003

**Radial Clearance Check:**

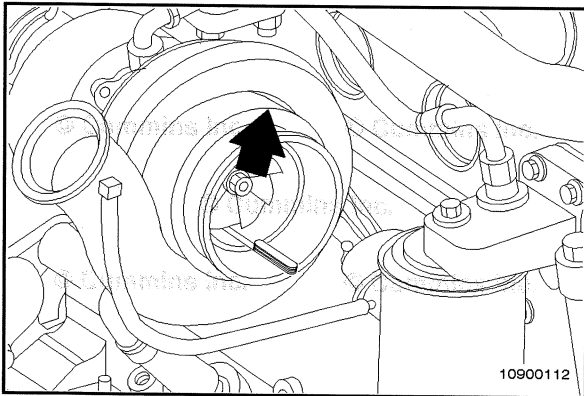
Use a wire-type feeler gauge to measure the clearance between the compressor wheel and housing.

Gently push the compressor wheel toward the compressor housing and gauge.

Record the clearance.



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With the feeler gauge in the same location, gently push the compressor wheel away from the compressor housing and measure the clearance between the compressor wheel and housing.



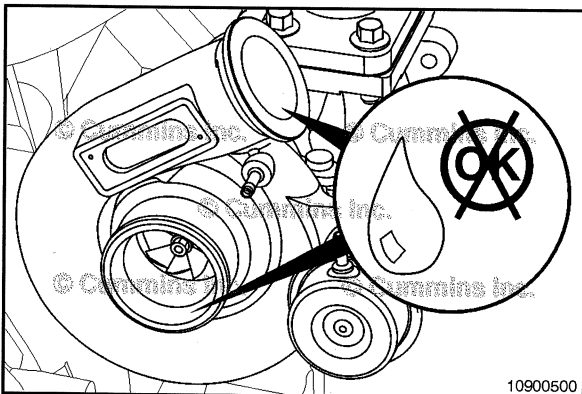
Subtract the smaller clearance from the larger clearance. This is the radial bearing clearance.

Repeat the procedure on the turbine wheel.

Replace the turbocharger if the radial bearing clearance does **not** meet specifications. See the Remove and Install sections in this procedure.

#### Radial Specifications

mm		in
0.394	MIN	0.016
0.602	MAX	0.024



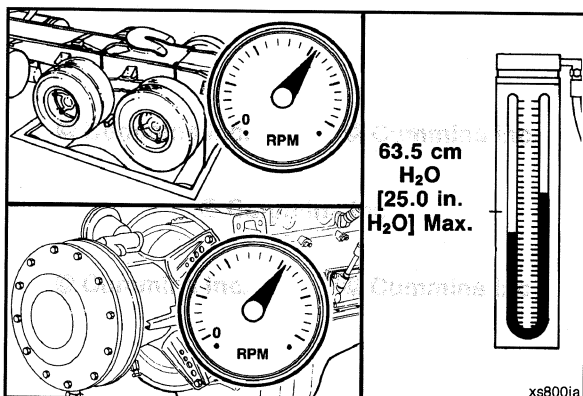
Inspect the turbocharger compressor intake and discharge for oil.

If oil is present in the compressor intake as well as in the discharge, check upstream of the turbocharger for the source of the oil.

If oil is pooling in the turbocharger cavities or the charge-air cooler cavities, go to the Crankcase Gases (Blowby) Excessive troubleshooting symptom tree in Section TS.

**NOTE:** If the engine experiences a turbocharger malfunction or any other occasion where oil is put into the charge-air system, the charge-air system **must** be inspected and cleaned. Refer to Procedure 010-027 in Section 10.

**NOTE:** If the engine experiences a turbocharger malfunction or any other occasion where oil is put into the exhaust, the aftertreatment components **must** be inspected. Inspect the aftertreatment diesel oxidation catalyst. Refer to Procedure 011-036 in Section 11.



If heavy deposits and/or streaks of oil are present **only** in the discharge side, install the air inlet and charge air cooler piping to check the air restriction indicator. See equipment manufacturer service information.



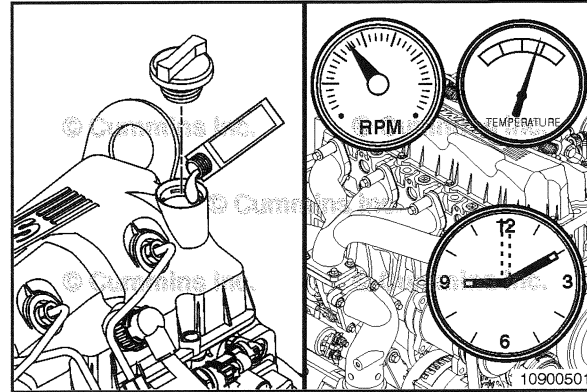
Check for air intake restriction. Refer to Procedure 010-031 in Section 10.

If no intake restriction is found, replace the turbocharger.

### Leak Test

Add one unit of fluorescent tracer, Cummins® Part Number 3376891, to each 38 liters [10 gal] of engine lubricating oil.

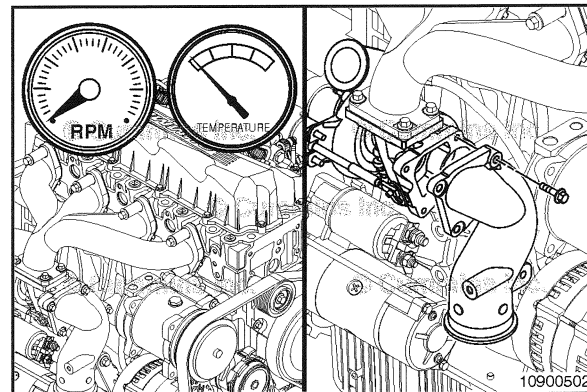
Operate the engine at low idle for 10 minutes.



Shut OFF the engine.

Allow the turbocharger to cool.

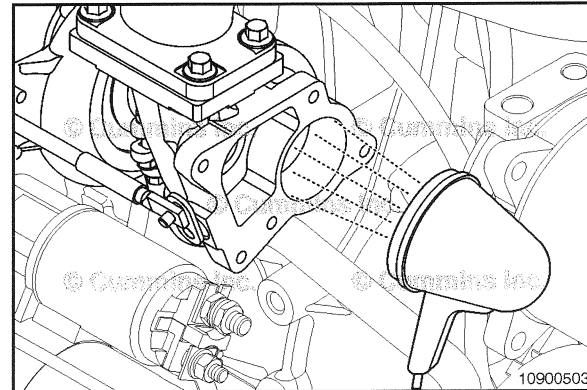
Remove the exhaust pipe from the turbine housing.



Use a high-intensity black light, Cummins® Part Number 3163338, to inspect the turbine outlet for leaks.

A yellow glow indicates an oil leak.

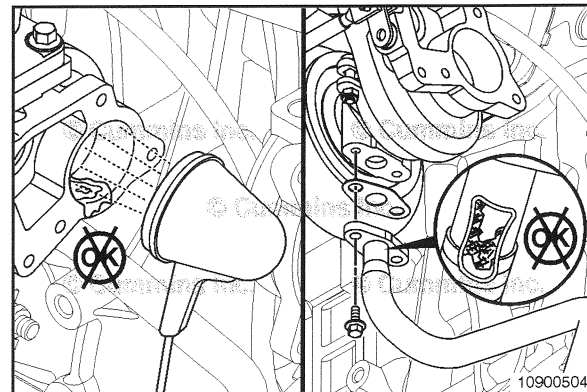
A dark blue glow indicates fuel in the oil.



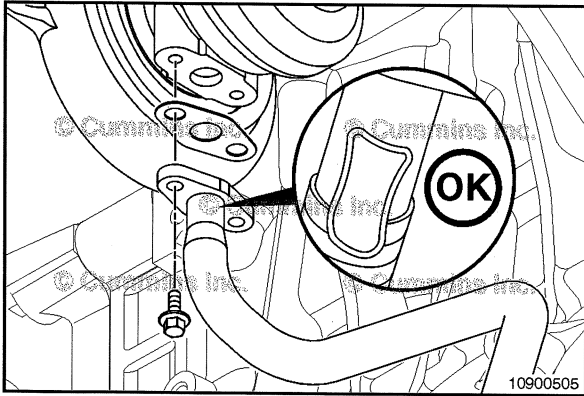
If oil is found on the turbine housing, remove the oil drain line, and check for restrictions. Refer to Procedure 010-045 in Section 10.

Clear any restrictions found.

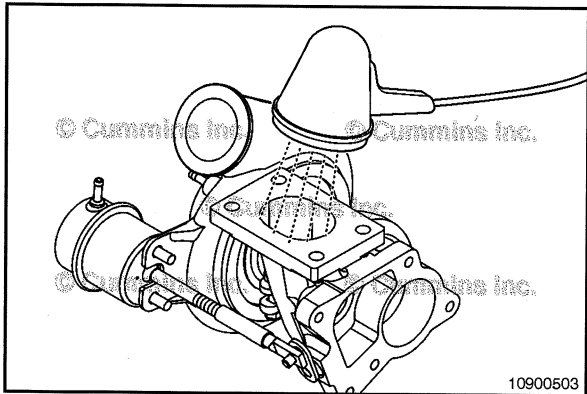
Install the drain line and new o-ring seals into the engine block. Refer to Procedure 010-045 in Section 10.







If the oil drain line was **not** restricted, remove the turbocharger.

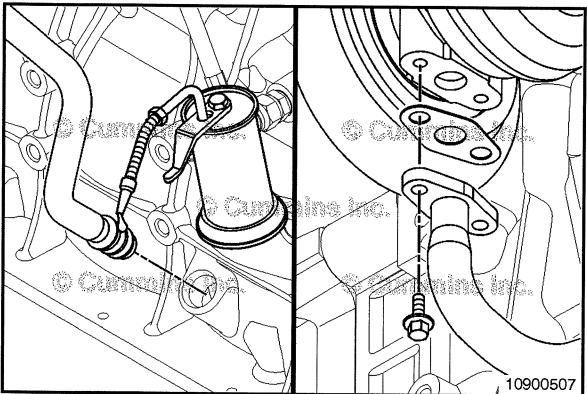


Use a high-intensity black light, Cummins® Part Number 3163338, to inspect the turbine inlet for leaks.

A yellow glow indicates an oil leak from the engine.

If a yellow glow is seen, the turbocharger can be reinstalled and returned to service. A light coating of oil in the turbine housing and on the turbine does **not** need to be cleaned as it will be burned off during engine operation. Any puddles of oil in the turbine housing **must** be removed with a clean rag prior to installation.

If a yellow glow is **not** seen in the turbine inlet, replace the turbocharger.



Install the exhaust pipe to the turbocharger turbine outlet.  
Install the intake pipe to the turbocharger compressor inlet.

## 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.
- Disconnect the charge-air cooler piping. Refer to Procedure 010-019 in Section 10.
- Remove the oil supply line from the turbocharger. Refer to Procedure 010-046 in Section 10.
- Remove the oil drain line from the turbocharger. Refer to Procedure 010-045 in Section 10.
- Remove the exhaust piping. See equipment manufacturer service information.
- Remove the turbocharger compressor air inlet connection. Refer to Procedure 010-022 in Section 10.

## 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.

### ⚠ CAUTION ⚠

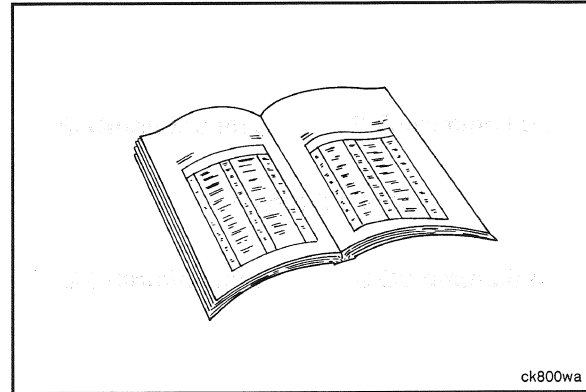
Before discarding the turbocharger mounting gasket, identify the type of gasket removed. Some turbocharger mounting gaskets have a divider down the middle of the gasket and some do not. Only replace the gasket with a like gasket. Use of the incorrect gasket will result in turbocharger damage.

Remove the turbocharger compressor outlet connection, V-band clamp, and o-ring from the turbocharger compressor outlet. Refer to Procedure 010-132 in Section 10.

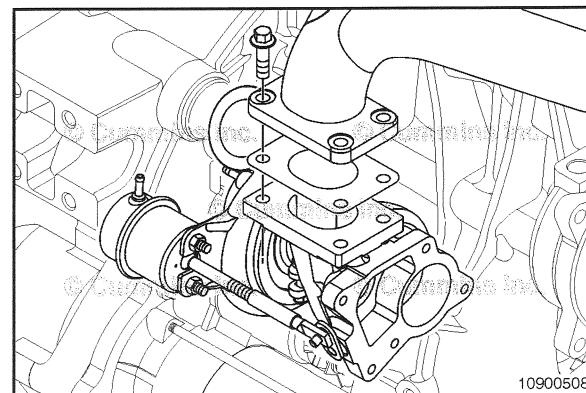
Remove the four turbocharger mounting nuts.

Remove the turbocharger and gasket.

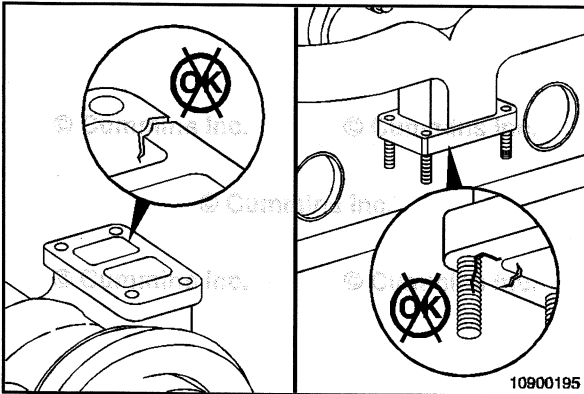
Discard the gasket.



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### Clean and Inspect for Reuse

Clean the turbocharger and exhaust manifold gasket surfaces.

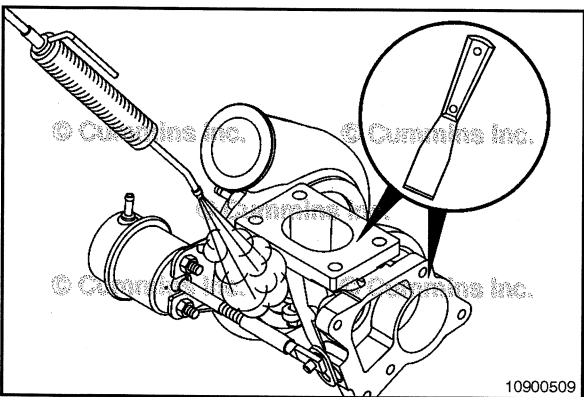


Inspect the turbocharger, exhaust manifold gasket surfaces, and mounting studs for cracks and other damage.



Replace the turbocharger if any cracks are found in the mounting flange surfaces.

Replace the exhaust manifold if any cracks are found in the mounting flange surfaces. Refer to Procedure 011-007 in Section 11.



### ⚠ 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.

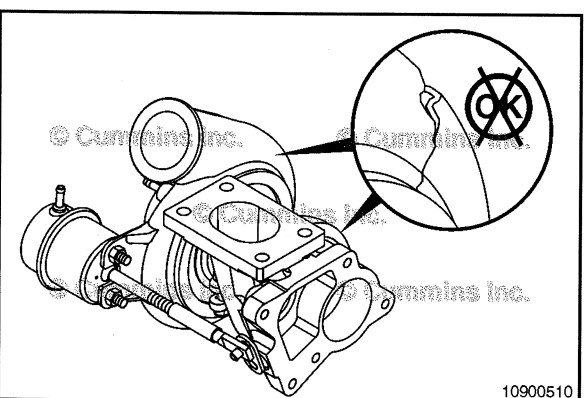
### ⚠ WARNING ⚠

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

Remove all carbon deposits and gasket material from surfaces.

Use solvent or steam to clean the exterior of the turbocharger.

Dry with compressed air.



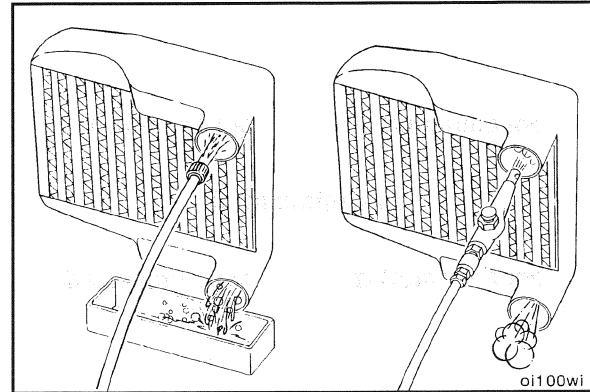
Inspect the turbine and compressor housings.

If cracks are found which go all the way through the outer walls, the turbocharger **must** be replaced.



**NOTE:** A charge-air cooler malfunction can cause progressive damage to the turbine housing. If the turbine housing is damaged, check the charge-air cooler. Refer to Procedure 010-027 in Section 10.

**NOTE:** If the engine experiences a turbocharger failure or any other occasion in which 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.



### 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 ⚠

The new gasket must match the one that was removed. Use of the incorrect gasket will result in turbocharger damage. Never reuse a turbocharger mounting gasket.

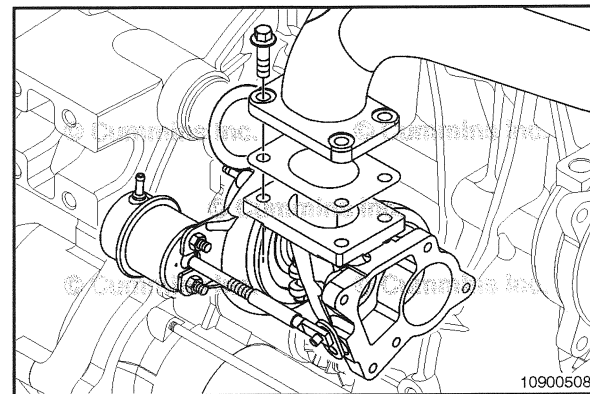
Apply a film of high-temperature anti-seize compound to the turbocharger mounting studs.

Use a new gasket and install the turbocharger.

Install and tighten the four mounting nuts.

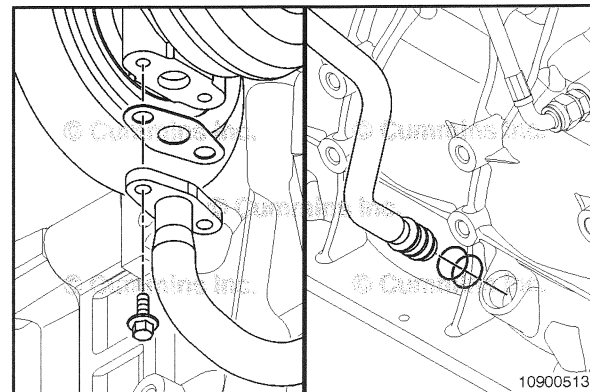
**NOTE:** The torque values given have been established with the use of anti-seize compound as a lubricant.

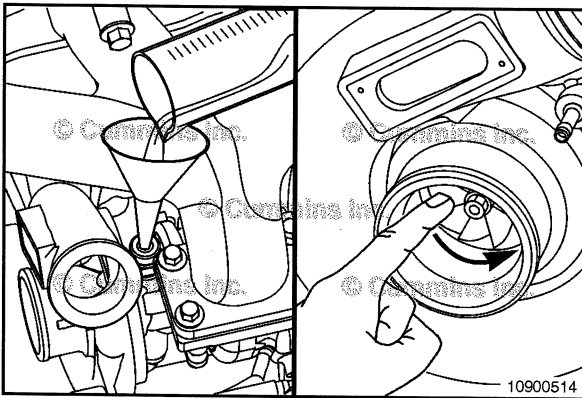
**Torque Value:** 24 N•m [ 212 in-lb ]



### Prime

Install and tighten the turbocharger oil drain line. Refer to Procedure 010-045 in Section 10.

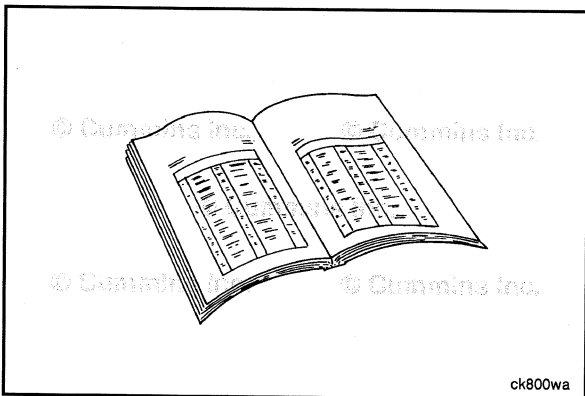




Lubricate the bearings by pouring 60 to 90 cc's [2 to 3 oz] of clean 15W-40 engine oil in the turbocharger oil supply line fitting.



Rotate the turbine wheel to allow oil to enter the bearing housing.



### Finishing Steps

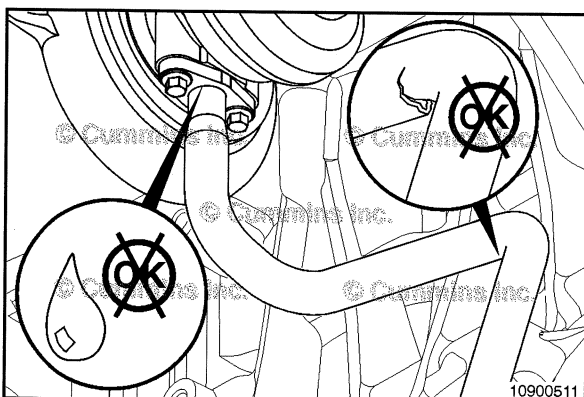


#### **▲ WARNING ▲**

**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 compressor outlet elbow, V-band clamp, and a new o-ring seal on the turbocharger compressor discharge outlet, if applicable. Refer to Procedure 010-132 in Section 10.
- Install the charge-air cooler piping. Refer to Procedure 010-019 in Section 10.
- Install and tighten the turbocharger oil supply line. Refer to Procedure 010-046 in Section 10.
- Install the exhaust piping. Refer to manufacturers' operating instructions.
- Install the turbocharger compressor air inlet connection. Refer to Procedure 010-022 in Section 10.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



### Turbocharger Oil Drain Line (010-045) Initial Check

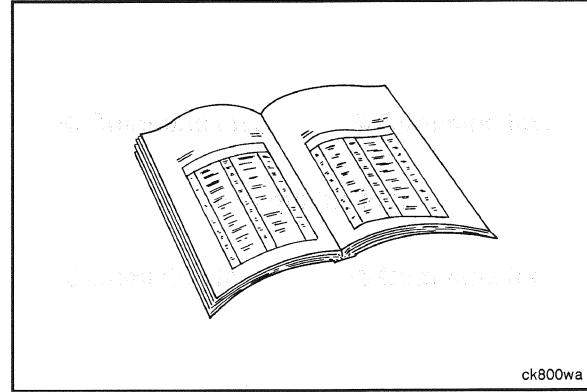
Inspect the line(s) for oil leaks or damage.  
Repair or replace as necessary.

## 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

## Remove

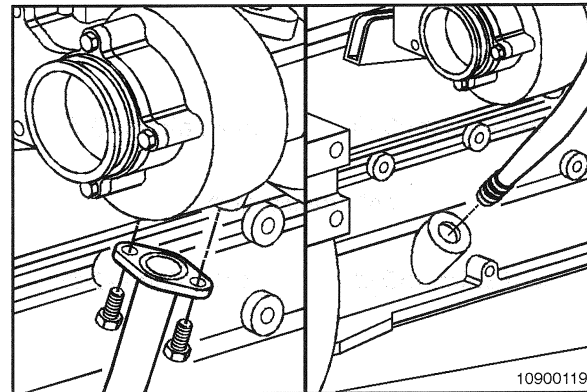
Remove the capscrews from the turbocharger oil drain line.

Remove the hose spring clamps from the oil drain hose connections, if applicable.

Pull the drain line out of the oil drain hose connections, if applicable.

Pull the oil drain line connection out of the cylinder block.

Remove and discard the o-rings.

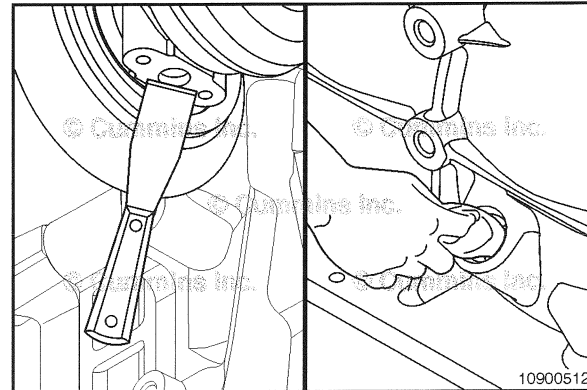


10900119

## Clean and Inspect for Reuse

Clean the gasket sealing surfaces.

Clean the o-ring seating bore and make sure it is free of dirt and debris.



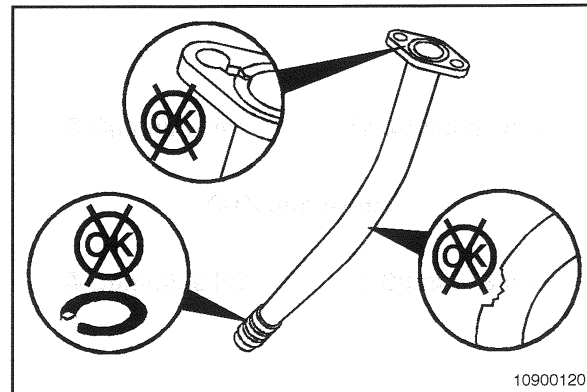
10900512

### ⚠ CAUTION ⚠

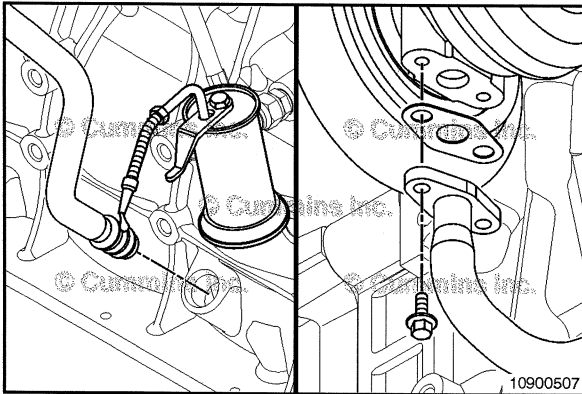
A restricted oil drain line can cause the turbocharger bearing housing to be pressurized, causing oil to leak past the seal rings, which can cause component damage.

Inspect the line for wear, cracks, and other damage.

Inspect the o-ring for fretting and cracking and replace, as necessary.



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### Install

Install new o-rings onto the turbocharger oil drain line.



Apply a thin film of oil to the drain line o-rings.

Push the drain line into the drain line boss. Be sure both o-rings are completely seated in the bore.

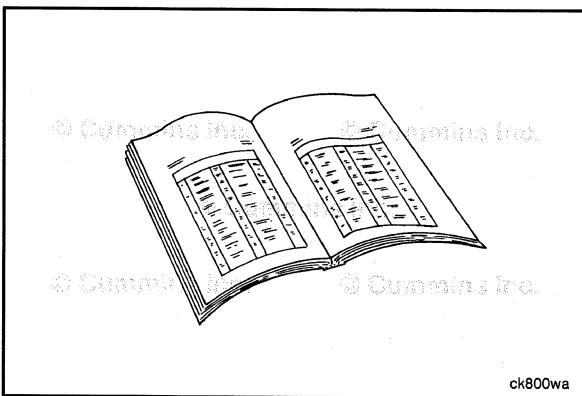


Install the hose and two spring clamps. Make sure spring clamps are oriented outward.



Install the drain line to the turbocharger bearing housing. Use a new gasket. Install and tighten the drain line capscrews at the bottom of the turbocharger.

**Torque Value:** 10 N·m [ 89 in-lb ]



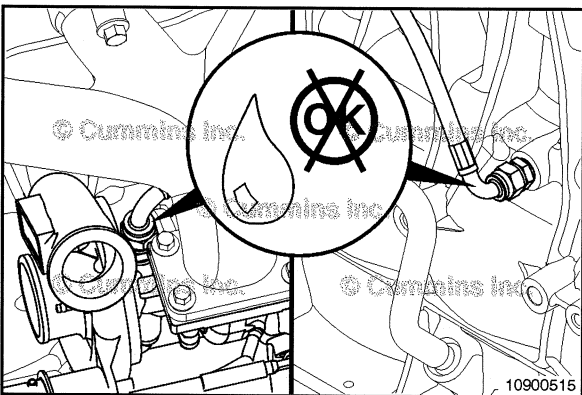
### Finishing Steps



#### ▲ 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.

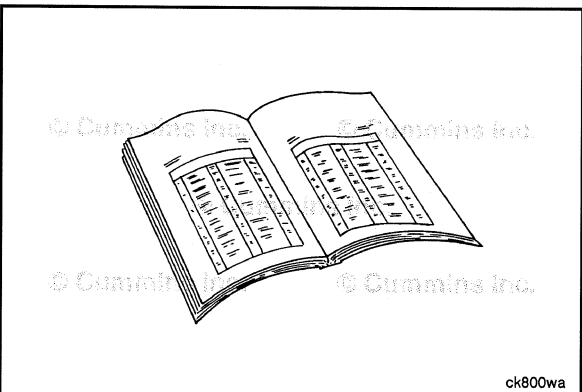
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



### Turbocharger Oil Supply Line (010-046)

#### Initial Check

Inspect the line(s) and engine block fittings for oil leaks or damage. Replace as necessary.



### 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.

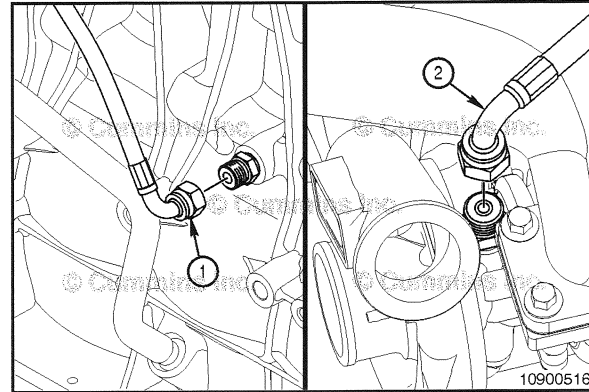
## Remove

**NOTE:** Use a wrench to hold the fitting at the oil rifle connection (1) while loosening the oil supply line fitting. This will help prevent accidental loosening of the fitting.

Remove the oil supply line from the engine block fitting in the oil rifle on the side of the cylinder block (1).

Remove the oil supply line from the turbocharger bearing housing (2).

Remove the banjo screw and two sealing washers from the turbocharger oil supply line at the bearing housing (2).

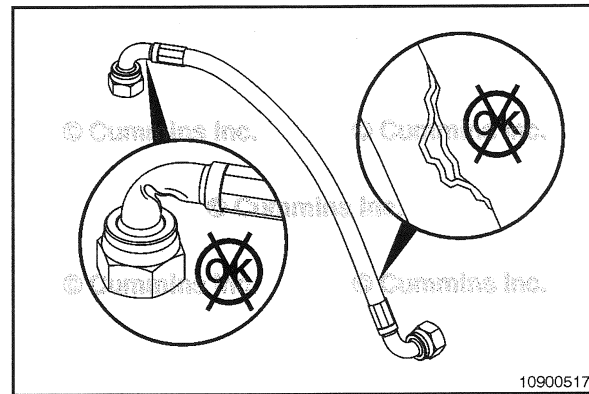


## Inspect for Reuse

**NOTE:** Some turbocharger oil supply line fittings may seal with a banjo screw and copper sealing washers, others may seal with o-ring seals.

Inspect the line for wear, cracks, and other damage.

Discard the old copper sealing washers or o-ring seals.



## Install

Use new copper sealing washers or o-ring seals.

Install the oil supply line onto the engine block fitting located at the oil rifle connection (1).

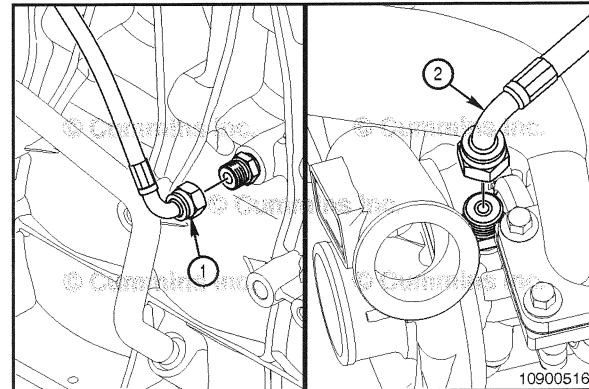
**NOTE:** A wrench will be required to prevent the fitting from rotating in the cylinder block.

Tighten the oil supply line (1)

**Torque Value:** 35 N•m [ 26 ft-lb ]

Install the turbocharger oil supply line at the bearing housing (2) using two sealing washers and banjo screw.

**Torque Value:** 16 N•m [ 142 in-lb ]

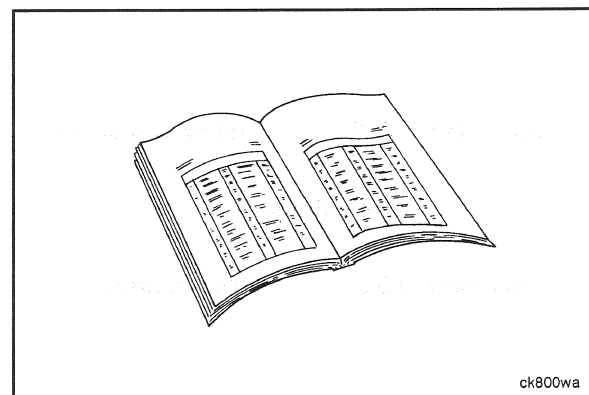


## Finishing Steps

### ⚠ 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 leaks.

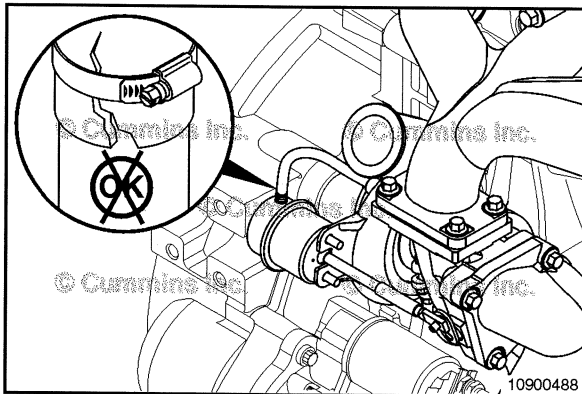
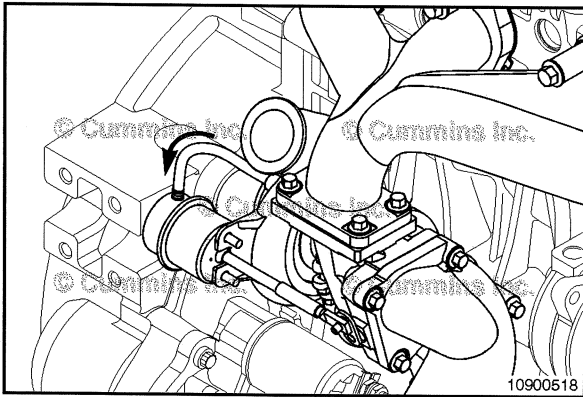




## Turbocharger Wastegate Actuator (010-050)

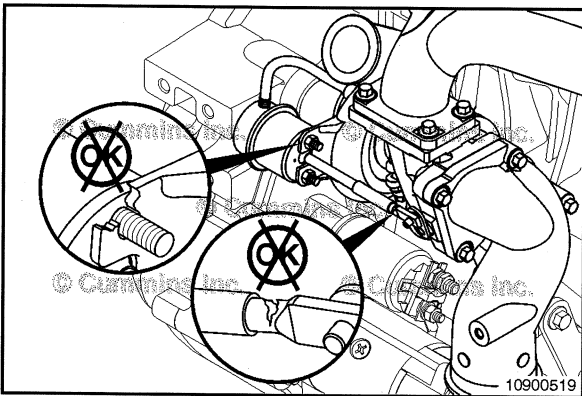
### Initial Check

The integral wastegate line transfers boost from the turbocharger compressor outlet to the wastegate capsule.



Inspect the integral wastegate actuator hose for cracks or holes.

Replace the hose, if damaged.

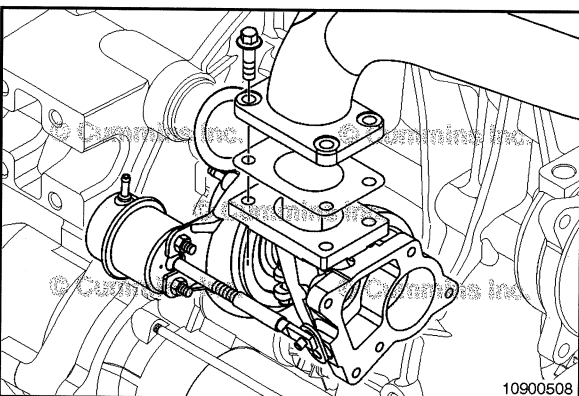


### ⚠CAUTION⚠

**A bent wastegate mounting bracket, actuator rod, or lever can cause improper operation.**

Inspect the wastegate mounting bracket, actuator rod, and lever for damage.

If the wastegate mounting bracket, actuator rod, or lever is bent or otherwise damaged, it **must** be replaced.

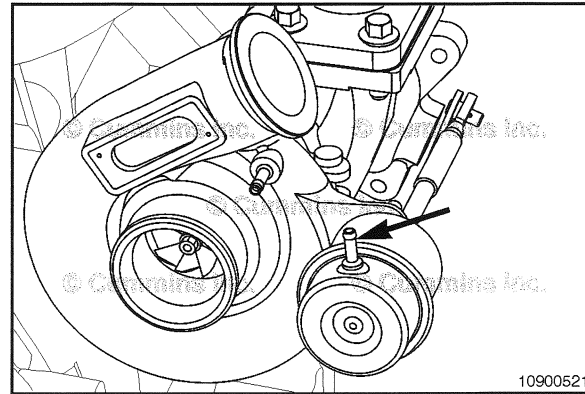


### Remove

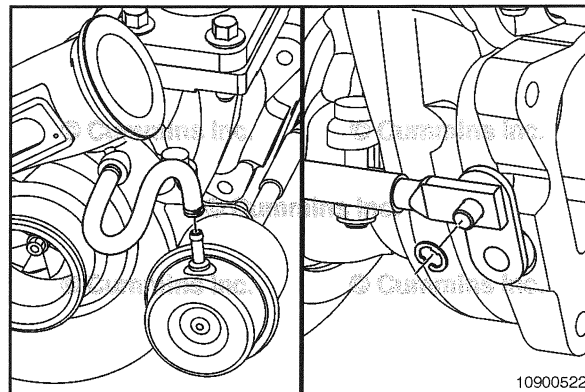
**NOTE:** In some applications, the turbocharger **must** be removed in order to remove the wastegate actuator. Refer to Procedure 010-033 in Section 10.

**NOTE:** If a wastegate actuator leak test is to be performed, do the leak test before removal of the wastegate actuator.

**NOTE:** Prior to removal, note the orientation of the boost capsule hose connector in relation to the mounting bracket.



Remove the retaining clip from the control lever.  
Disconnect the integral boost line from the wastegate capsule.

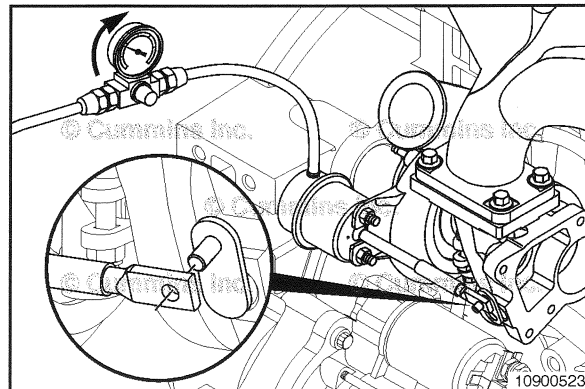


**CAUTION**  
Be careful not to bend the control lever. Damage to the wastegate actuator can occur.

Use an air regulator with pressure gauge service tool, Cummins® Part Number 3823799, or equivalent, to apply air pressure to the control rod.

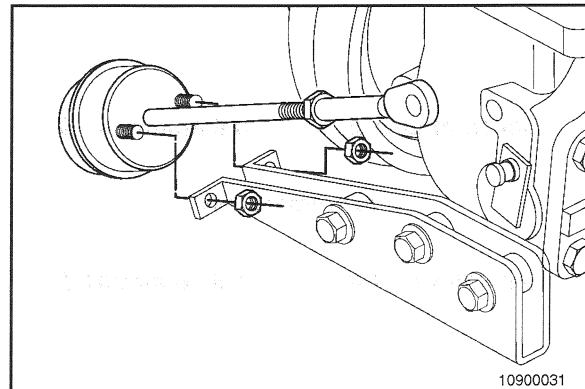
Disconnect the boost capsule actuator rod end from the turbocharger wastegate lever. This can be accomplished by slowly applying regulated air pressure to the boost capsule until the control rod is activated.

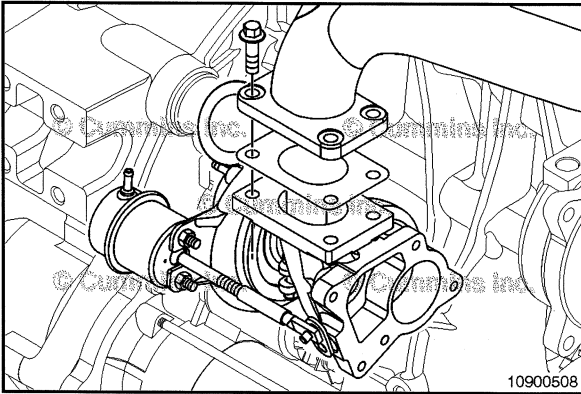
Disconnect the control rod from the turbocharger wastegate lever pin.



**NOTE:** If the boost capsule diaphragm material is ruptured and will **not** hold air pressure, manually pull the control rod outward in order to overcome boost capsule spring tension for removal of the control rod from the turbocharger wastegate lever pin.

Loosen the boost capsule mounting capscrews, disconnect the air supply hose, and remove the assembly from the mounting bracket.

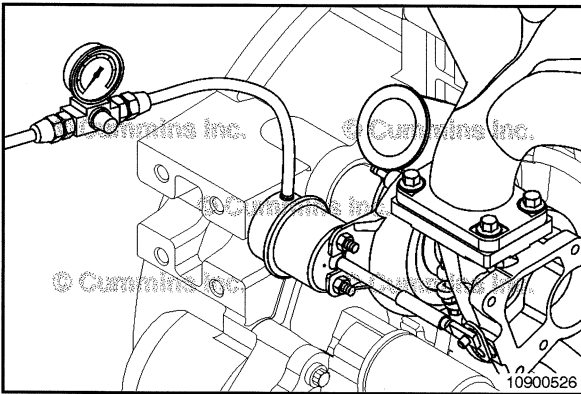




### Leak Test



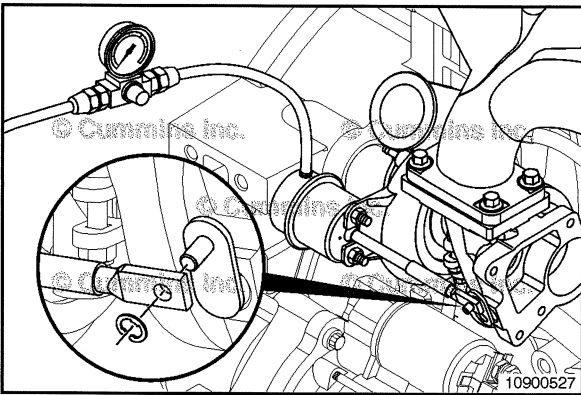
**NOTE:** In some applications, the turbocharger **must** be removed in order to test the wastegate actuator. Refer to Procedure 010-033 in Section 10.



**NOTE:** No air should be heard (i.e., leaking noise) through a functional wastegate capsule.

Disconnect the integral boost line from the wastegate capsule.

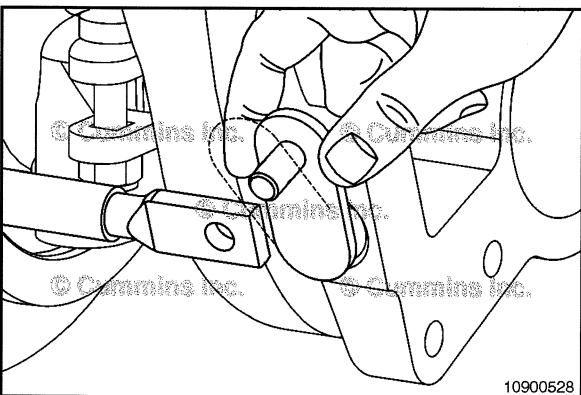
Connect clean, regulated air pressure and a pressure gauge to the capsule. Apply 300 kPa [43 psi] and check for actuator rod movement.



If the actuator rod shows no sign of movement, remove the actuator rod retaining clip and disconnect the actuator rod from the turbocharger wastegate pin.

Reapply air pressure to the wastegate capsule and check for actuator rod movement. If there is no movement, replace the wastegate actuator.

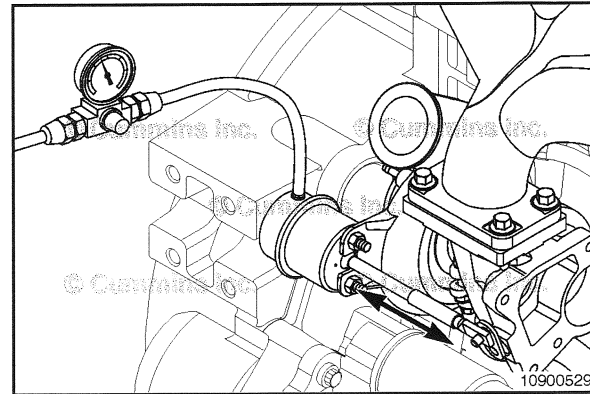
If the wastegate actuator does move, then move the wastegate lever back and forth and feel for smooth and proper operation.



If the wastegate lever does **not** move freely or binds, spray a penetrating oil on the wastegate lever joint and try to free the wastegate lever by working the lever back and forth. If the lever does **not** become free, replace the turbocharger.

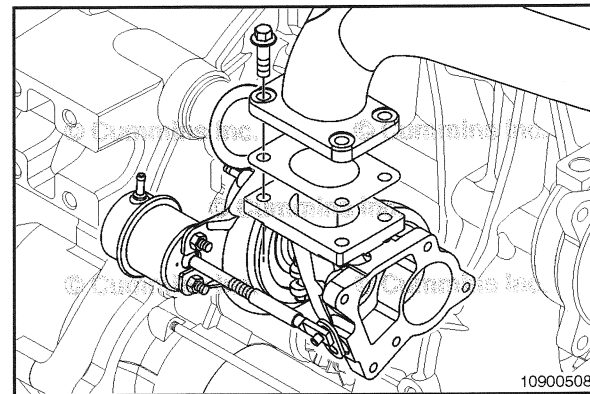
- Use the following procedure. Refer to Procedure 010-033 in Section 10.

If the lever does become free and operates smoothly, connect the actuator rod and recheck for movement with air pressure.



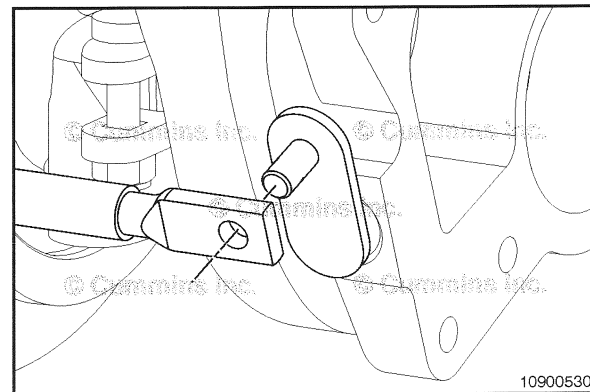
### Install

**NOTE:** In some applications, the turbocharger **must** be removed in order to install a new wastegate actuator. Refer to Procedure 010-033 in Section 10.

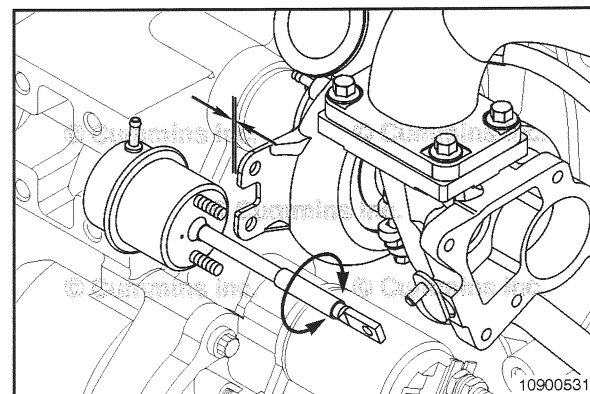


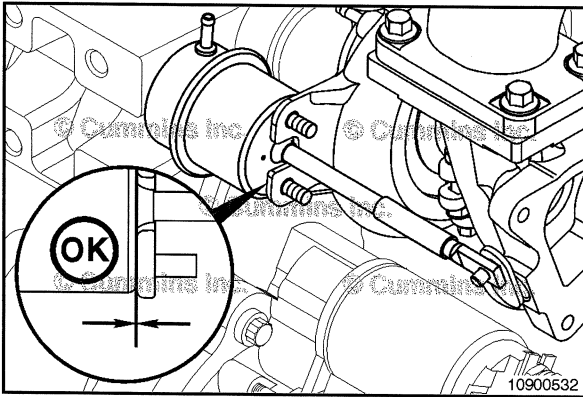
**NOTE:** Do **not** fit the two studs into the mounting holes at this time.

Fit the end-link over the turbocharger wastegate lever pin. With the spine of the spacer visible and the turbocharger wastegate lever pushed toward the rod, lay the actuator alongside the mounting bracket.

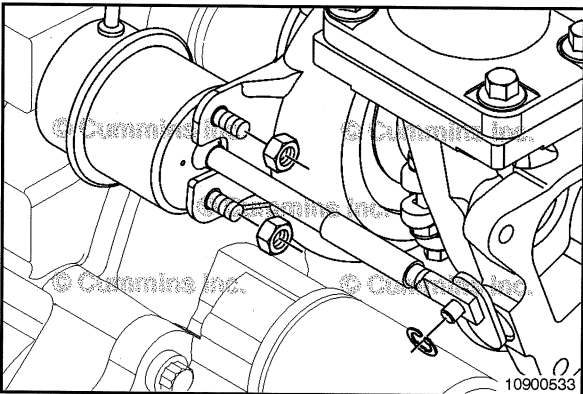


Adjust the length of the actuator assembly by removing it from the turbocharger, rotating the end-link, and refitting the actuator until the underside of the actuator will just fit over the bracket mounting studs.





The setting is correct when the underside of the actuator will just fit over the bracket mounting studs with less than 0.5-mm [0.020-in] gap.



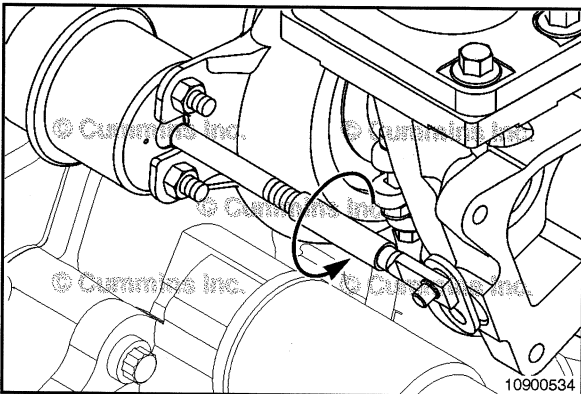
Fit the actuator mounting studs into the holes in the bracket.



Install the end-link onto the crank pin. Install the control rod retaining clip.

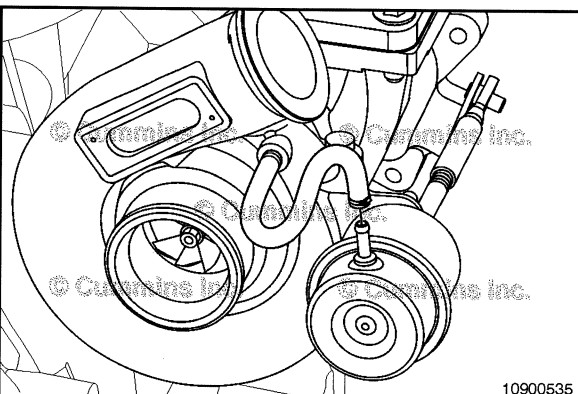
Tighten the mounting nuts.

**Torque Value:** 8 N•m [ 71 in-lb ]



Tighten the control rod jam nut against the end-link.

**Torque Value:** 8 N•m [ 71 in-lb ]



Use the new hose clamp provided to connect the air supply hose to the actuator.

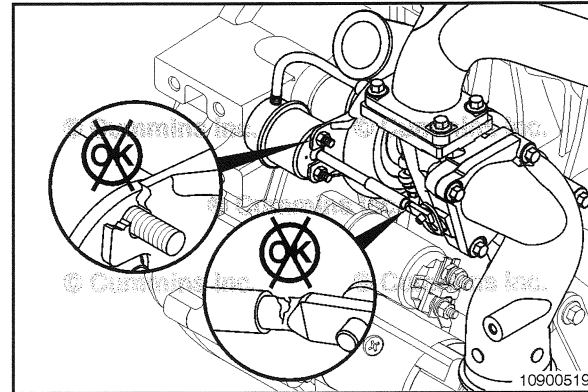
## Turbocharger Wastegate Valve Body (010-055)

### Maintenance Check

Inspect the lever pin.

Inspect the valve and valve seat for cracks or erosion.

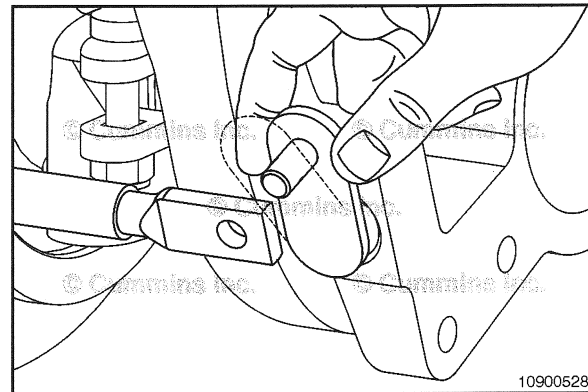
Replace the turbine housing assembly if it is worn excessively. Refer to Procedure 010-033 in Section 10.



Actuate the lever by hand to verify that the shaft rotates freely and is **not** seized.

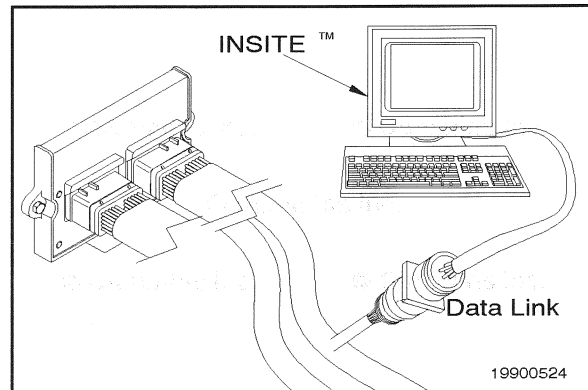
Check for excessive movement between the shaft and bushing.

Replace the turbine housing if the shaft and bushing are damaged or seized. Refer to Procedure 010-033 in Section 10.

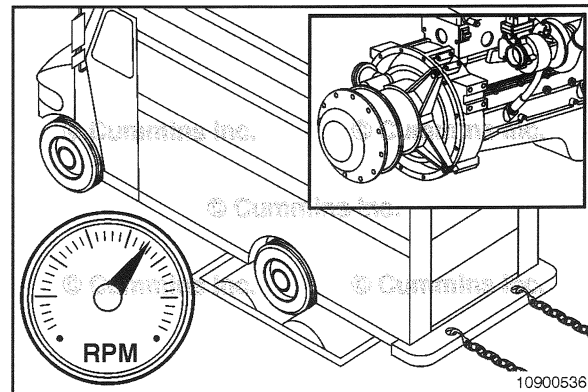


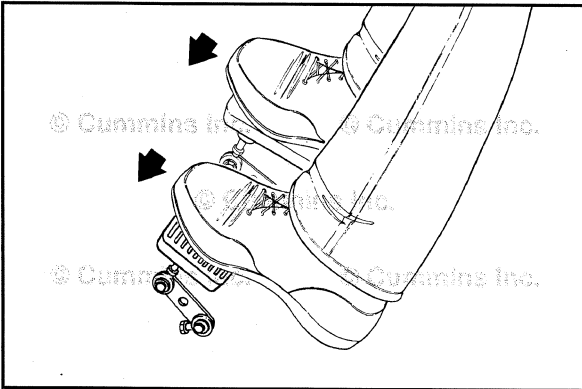
## Intake Manifold Pressure (010-057) Measure

Use INSITE™ electronic service tool to measure the boost pressure at the intake manifold.



Operate the engine at rated rpm and full load. Record the boost reading.



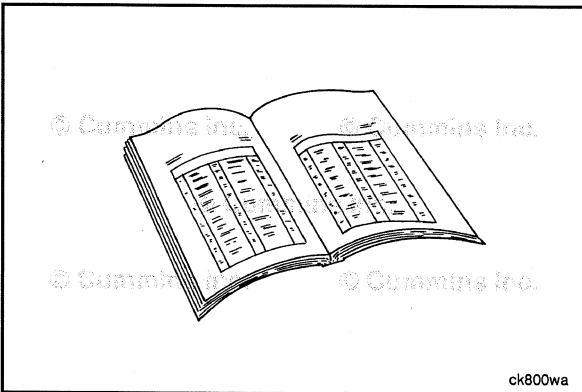


Alternate Loading Method, if equipped with an automatic transmission:

If a chassis dynamometer is **not** available, an alternate method of engine loading can be used. Stalling the engine, using the vehicle torque converter, can produce a full-load condition.

Stall the vehicle until the engine speed is steady at full-throttle condition.

Record the stall speed and boost reading.



## Air Intake Connection (010-080)

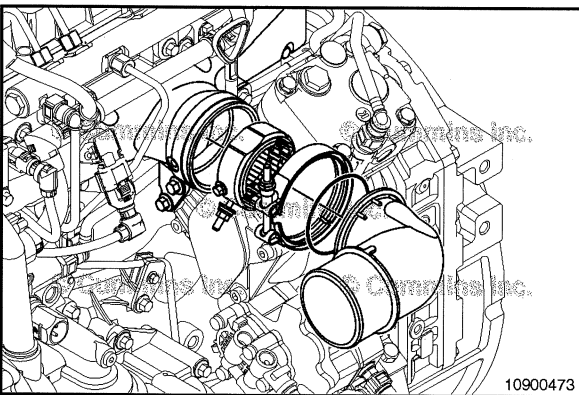
### Preparatory Steps



#### ▲ 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 cold starting aid, if equipped. Refer to Procedure 010-029 in Section 10.
- Disconnect the charge-air piping. Refer to Procedure 010-019 in Section 10.

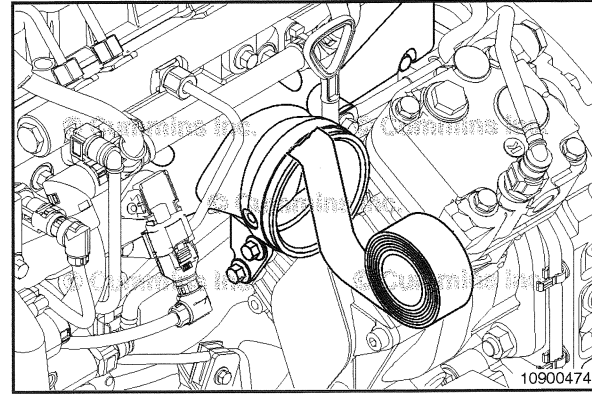


### Remove

Remove the mounting V-band clamp, air intake connection, o-ring seal, and cold starting aid, if equipped. Refer to Procedure 010-029 in Section 10.

**NOTE:** Make sure to leave manifold inlet edges exposed so that mounting surfaces can be properly cleaned.

Tape off the intake manifold cover opening or place a clean rag in the intake to prevent debris from entering the intake system.



### 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.

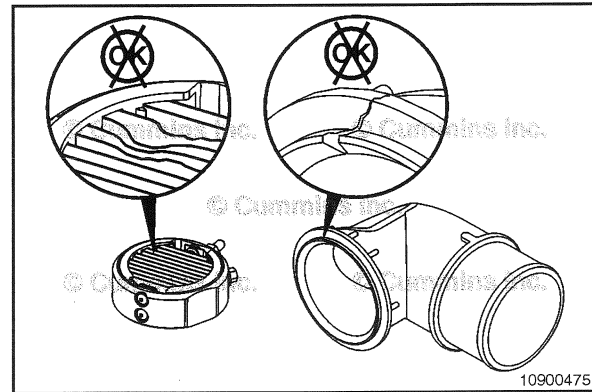
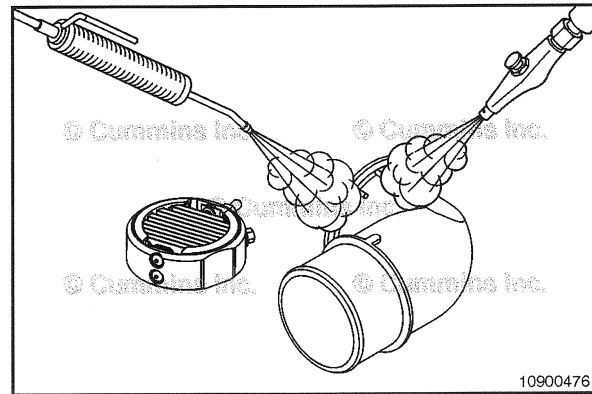
**⚠ WARNING ⚠**

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

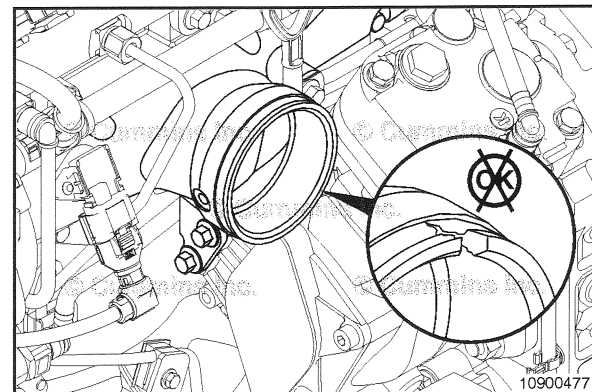
Clean the intake manifold cover and air intake connection with solvent.

Dry with compressed air.

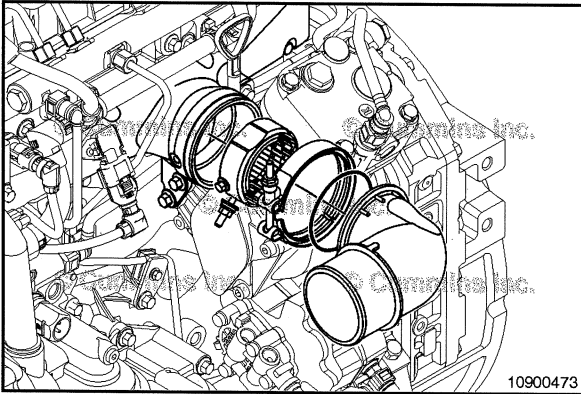
Inspect the cold starting aid and air intake connection sealing surfaces for cracks or other damage.



Remove the tape or rag from the intake manifold. Inspect the intake manifold cover, cold starting aid, and air intake connection sealing surfaces for cracks or other damage.





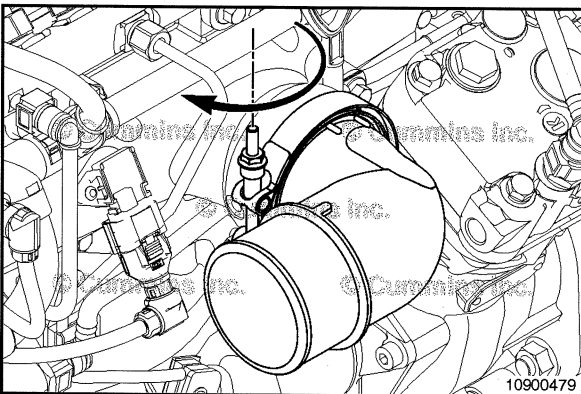


### Install



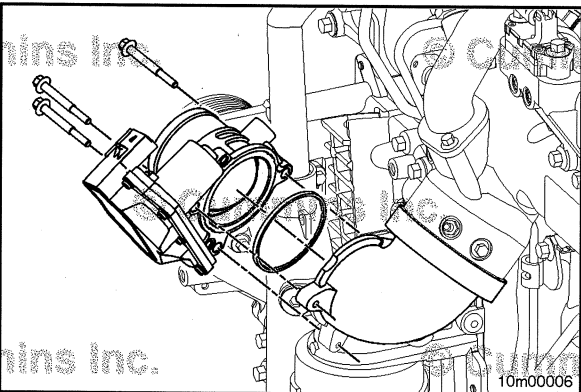
Position the cold starting aid, if equipped, using new gaskets. Refer to Procedure 010-029 in Section 10.

Install the air intake connection.



Tighten the V-band clamp on the air intake connection with a new o-ring.

**Torque Value:** 10 N•m [ 89 in-lb ]



Install the air control valve to the air intake manifold with a new o-ring.

Tighten the three capscrews.

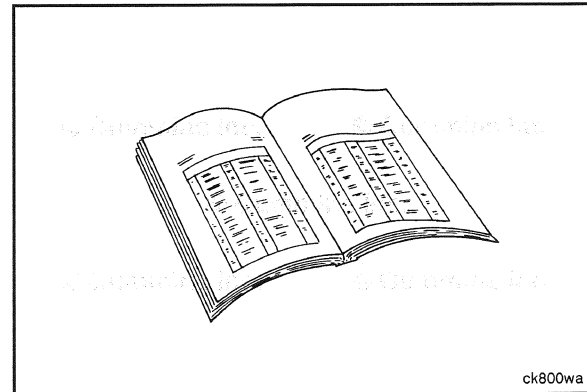
**Torque Value:** 7 N•m [ 62 in-lb ]

## 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.

- Connect the charge-air piping. Refer to Procedure 010-019 in Section 10.
- Install the electrical connection from the air control valve.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.

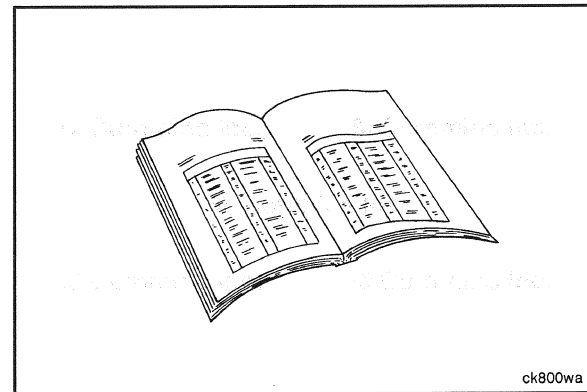


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## Turbocharger Compressor Outlet Connection (010-132)

### General Information

This procedure includes instructions on removal, cleaning/inspection, and installation of the turbocharger compressor outlet connection.



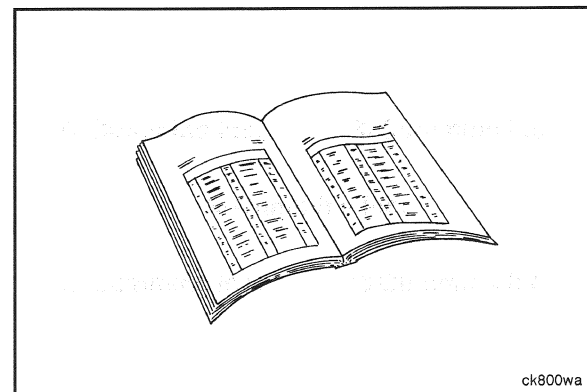
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## Preparatory Steps

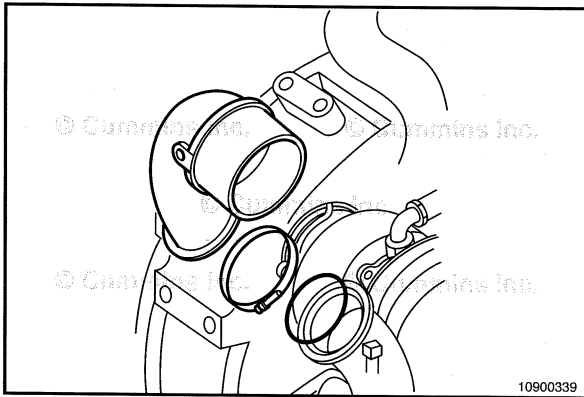
### ⚠ WARNING ⚠

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.
- Clean the outside of the turbocharger compressor outlet connection.
- Disconnect the charge-air piping and connections from turbocharger compressor outlet connection. Refer to Procedure 010-019 in Section 10.



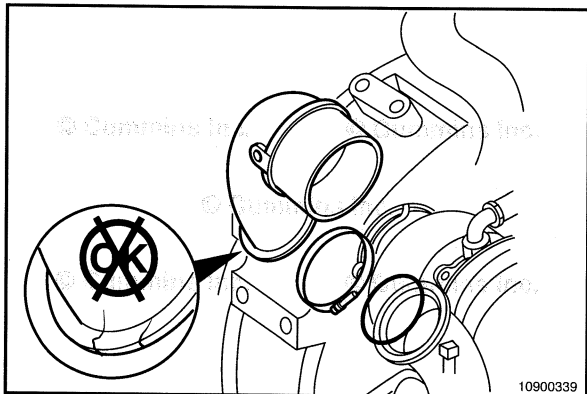
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### Remove

Loosen the clamp holding the turbocharger compressor outlet connection to the turbocharger.

Remove the turbocharger compressor outlet connection and seal, taking care **not** to drop the seal or any foreign matter into the turbocharger.



### Clean and Inspect for Reuse

#### ▲ WARNING ▲



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

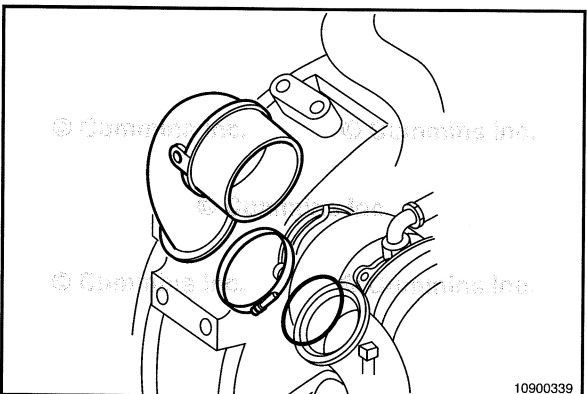
#### ▲ WARNING ▲

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.

Clean the turbocharger compressor outlet connection with solvent and dry with compressed air.

Inspect the turbocharger compressor outlet connection for cracks, other damage, or abnormal wear. Replace as necessary.

Discard the o-ring seal. It is **not** reuseable.



### Install

Install the turbocharger compressor outlet connection and o-ring seal.

Use a new o-ring seal.

Install the clamp and tighten to specification:

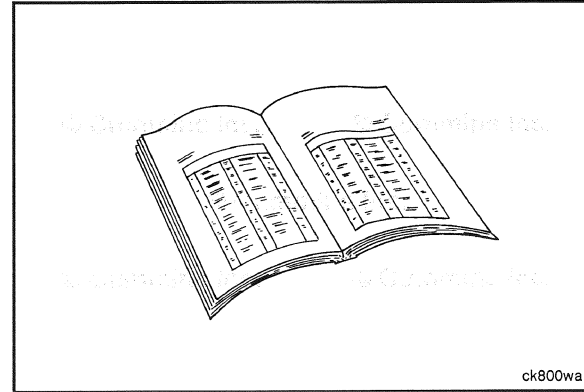
**Torque Value:** 10 N·m [ 89 in-lb ]

## 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 charge-air piping and connections from turbocharger compressor outlet connection. Refer to Procedure 010-019 in Section 10.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine at rated speed, using soapy water to check for leaks at the turbocharger compressor outlet connection joints.



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## Air Intake System Diagnostics (010-139)

### General Information

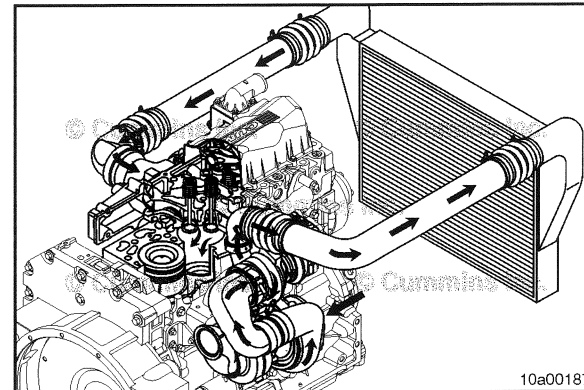
This engine uses exhaust gas recirculation (EGR) in the intake air system. Every component of the EGR system (EGR cooler, air transfer tube, etc.) up to the EGR connection is considered part of the exhaust system.

Before diagnostics of the air intake system begins, perform the following checks:

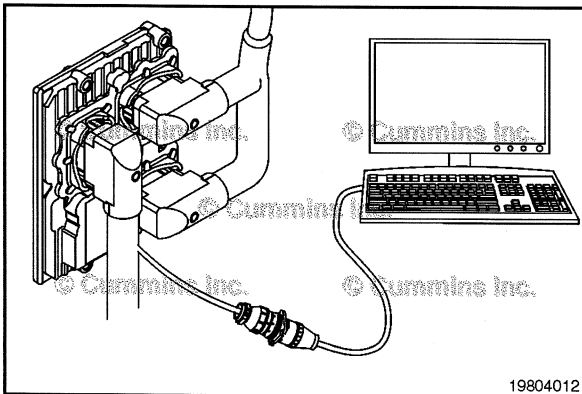
- Check for fault codes and reference the appropriate troubleshooting trees
- Make sure all intake pipe couplers are connected properly.
- Inspect the intake piping for any physical damage or cracks.
- Inspect the engine air filter for inlet restriction, contamination, or other damage. Refer to Procedure 010-014 in Section 10.

This procedure lists various symptoms and respective components to check, listed in the order of easy to difficult to inspect. If there are no clear symptoms, or more than one, follow the diagnostics in order until the complaint has been resolved.

**NOTE:** The exhaust system components are covered in the Exhaust Systems - Overview. Refer to Procedure 011-999 in Section F..

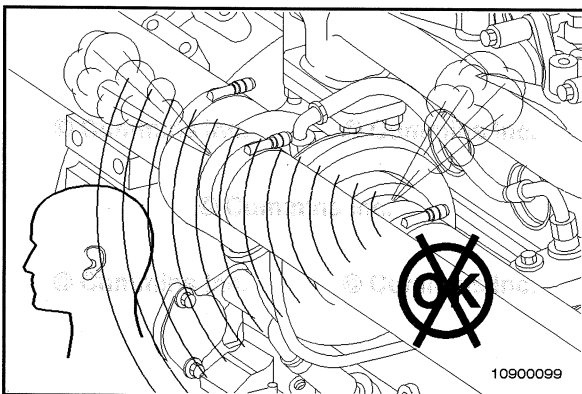


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Make sure the compressor intake and intake manifold temperature and pressure sensors are working properly. Use the following procedures for functionality checks for the intake manifold pressure/temperature sensor. Refer to Procedure 019-159 in Section 19.

Use the following procedures for functionality checks for the turbocharger compressor intake pressure/temperature sensor. Refer to Procedure 019-466 in Section 19.

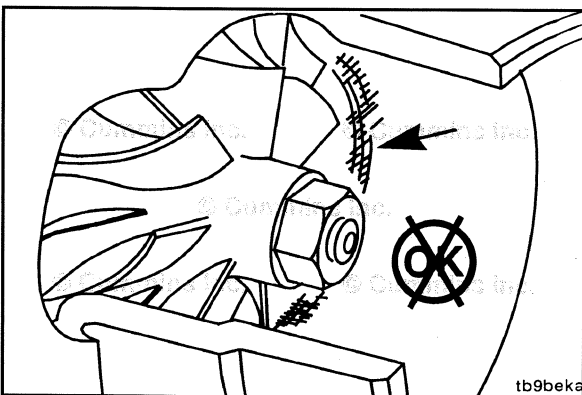


Leaks in the air system intake and/or exhaust components can produce excessive engine noise.

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.



### 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.

A malfunction of the internal components of the turbocharger can reduce its effectiveness. A bearing malfunction 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.

Lower pitched sounds or rattles, at slower engine speeds, can indicate that debris is in the system or that the rotor assembly is touching the housings. If there is a complaint for noise, low power, engine response, or oil consumption, verify the conditions under which the complaint occurred. Refer to Procedure 010-033 in Section 10.

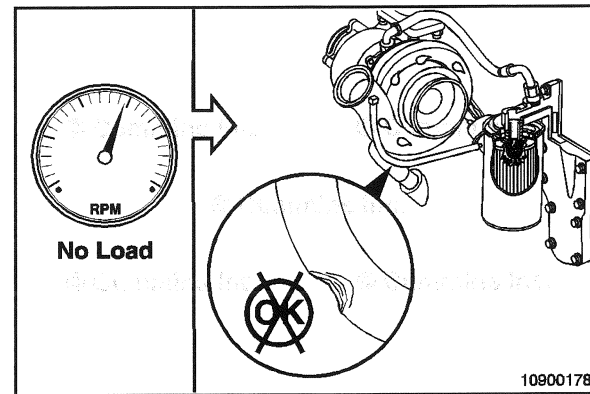
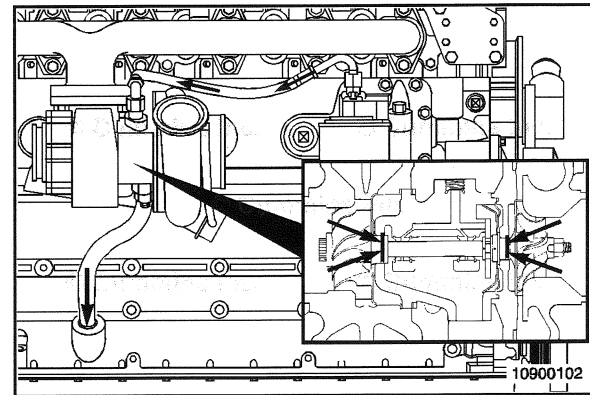
Seal rings are used on each end of the rotor assembly. The primary function of the seals is to prevent exhaust gases and compressed air from entering the turbocharger housing. Lubricating oil leakage from the seals is rare, but it can occur.

**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 for reuse.

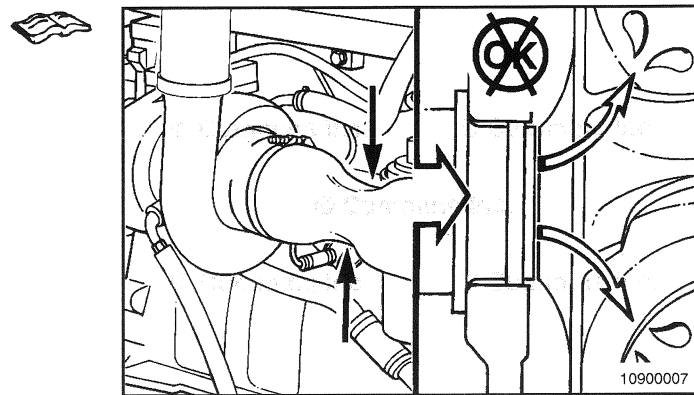
**NOTE:** If the engine experiences a turbocharger failure or any other occasion in which oil, debris, or coolant is put into the charge-air system, the EGR differential pressure sensor flow ports **must** be cleaned.

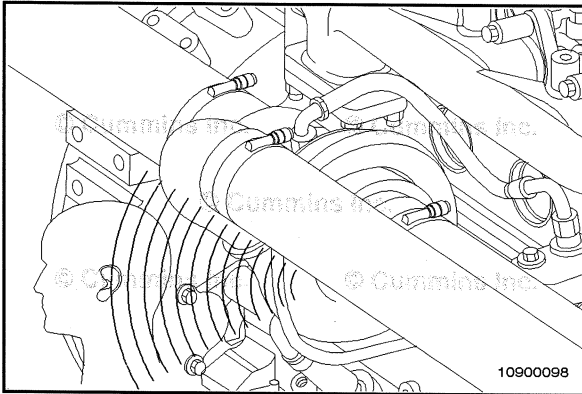
A restricted or damaged lubricating oil return line will cause the turbocharger housing to be pressurized, causing lubricating oil to migrate past the seal rings on both the intake and exhaust side of the turbocharger.



Additionally, 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 the oil from the intake system. Clean the intake manifold. Refer to Procedure 010-023 in Section 10. Clean the charge-air cooler. Refer to Procedure 010-027 in Section 10. Clean the EGR differential pressure sensor flow ports. Refer to Procedure 011-028 in Section 11.





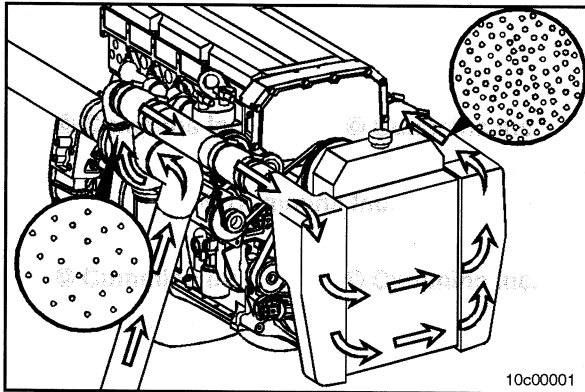
### Turbocharger Noise

It is normal for the turbocharger to emit a whining sound that varies in intensity, depending on turbine wheel speed.

Depending on engine requirements for exhaust temperatures and exhaust pressure, the sound may be most noticeable around idle speed conditions or slightly above.

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.

Turbocharger wastegate malfunctions or miscalibration of the turbocharger wastegate can result in excessively high or low boost pressures. Low boost pressure can cause excessive smoke and low power. High boost pressure can cause major engine damage.

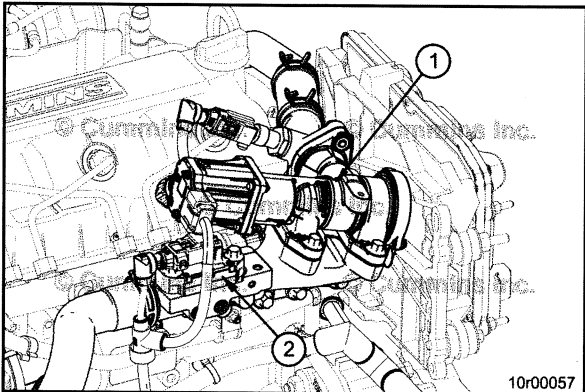


### Charge Air Cooled Engines

The charge-air cooler makes sure that the proper intake air density is achieved. External damage to the fins or excessive restriction or pressure losses can affect its performance and reduce engine performance.

Use the following procedure for inspection of the charge-air cooler. Refer to Procedure 010-027 in Section 10.

**NOTE:** The long-term integrity of the charge-air cooling system is the responsibility of the vehicle and component manufacturers.



### Air Intake System

The EGR valve (1) is mounted to the top of the air intake connection.

The EGR valve is an electric motor-driven valve that is controlled by the engine control module (ECM). The EGR valve uses a dual poppet valve to control the EGR flow into the air intake connection.

The amount of EGR flow is calculated by measuring the pressure differential across the exhaust gas entrance port in the air intake connection, just below the EGR valve outlet. A differential pressure sensor (2) mounted on top of the intake connection reads the pressure on each side of the exhaust gas entrance port through internal drillings in the air intake connection.

Soot in the exhaust gas entrance ports can affect the pressure readings which, in turn, will affect the calculated EGR flow. This can result in an improperly commanded EGR valve position.

Inspect and clean the intake air connection, if necessary. Refer to Procedure 010-080 in Section 10.

Use the following procedure for troubleshooting the exhaust system diagnostics related to the EGR system. Refer to Procedure 011-056 in Section 11.

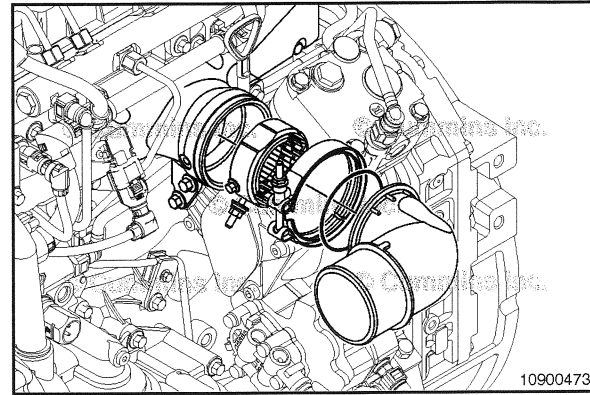
### Air Intake Manifold/Cold Starting Aid

**NOTE:** The style of the air intake connection can vary, depending on the application. Although the air intake connection may appear different, the function is the same.

The ON/OFF operation of the intake air heater is controlled by the ECM.

The ECM controls a single original equipment manufacturer (OEM)-supplied relay which provides power for the intake air heater when commanded. A symptom of a malfunctioning cold starting aid is a hard start in cold ambient temperatures and/or white smoke on engine startup. A plugged intake air heater element can also result in low power.

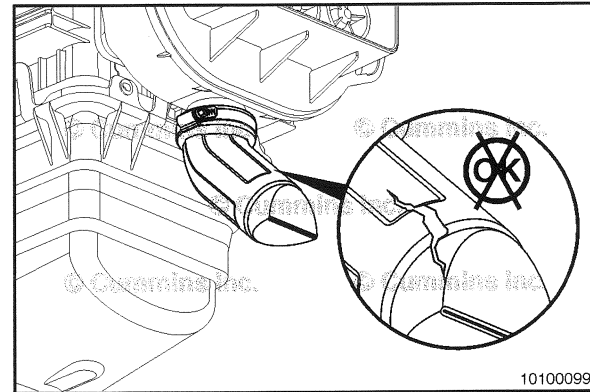
Use INSITE™ electronic service tool to verify the Cold Starting Aid function. The Intake Air Heater Override Test is located under ECM Diagnostic Tests.



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## Dust Ejection Valve (010-146) Maintenance Check

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



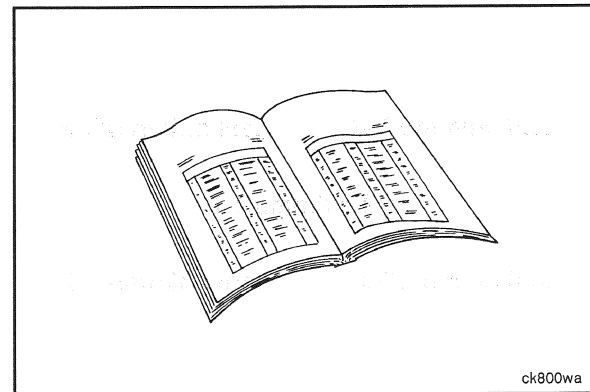
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## General Information

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.

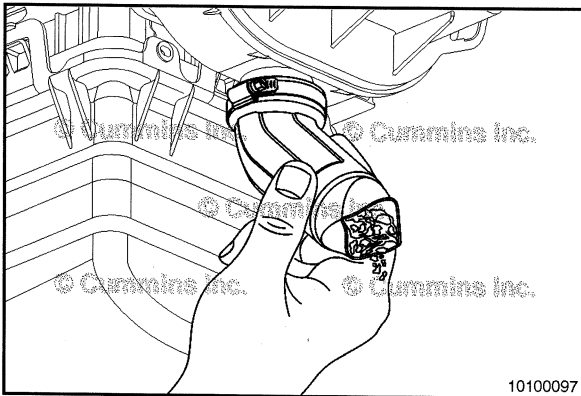
If an application is equipped with a pre-cleaner exhaust aspirator, a dust ejection valve will **not** be present, as the aspirator takes place of the dust ejection valve.

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.



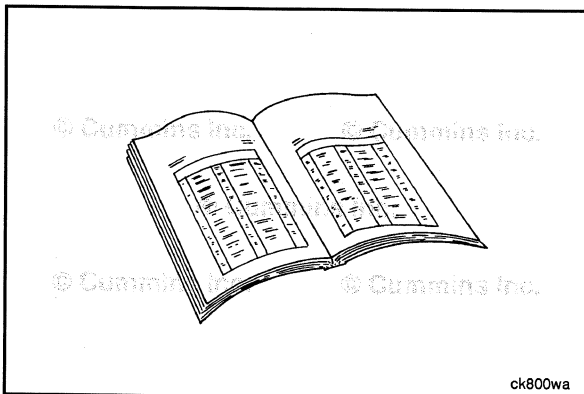
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### Clean

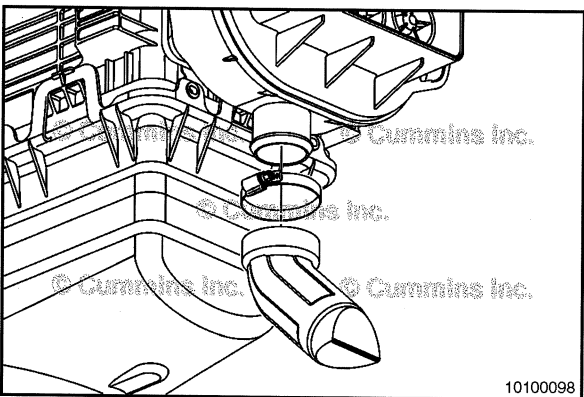
Purge the dust ejection valve of dust by squeezing the valve until it opens. This may have to be performed multiple times depending on the severity of dust or debris found in the valve. If debris is **not** able to be purged from the valve, remove the valve and clean out by hand. Reference the Remove section of this procedure.



### Preparatory Steps

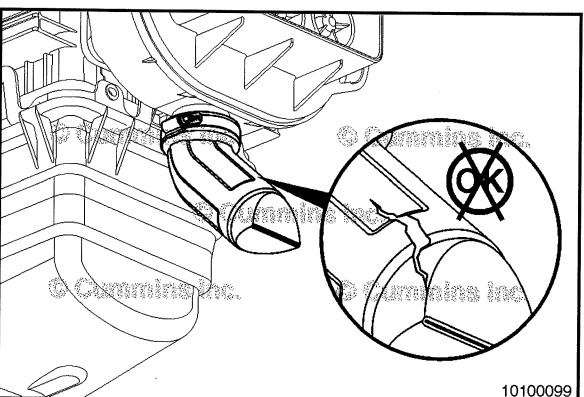
**NOTE:** Before servicing any intake air system component, (such as the air cleaner, pre-cleaner, hoses, ducting, etc.), clean the fittings, mounting hardware, and the area around the component to be removed.

- Shut the engine OFF.



### Remove

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



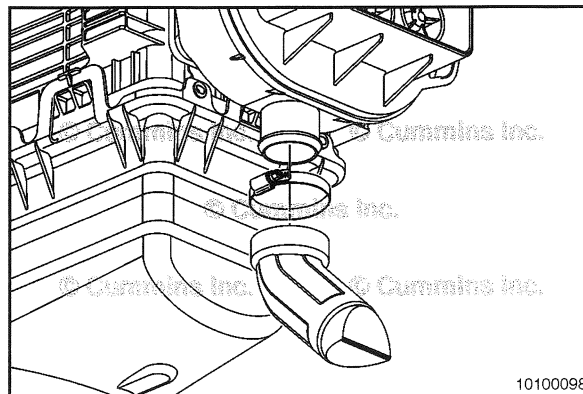
### Inspect for Reuse

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

### Install

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

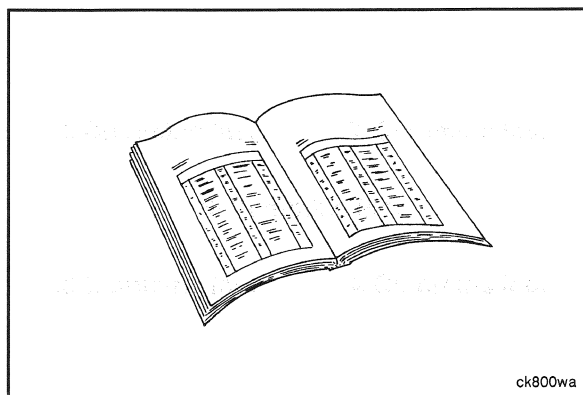
**Torque Value:** 5 N•m [ 44 in-lb ]



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### Finishing Steps

- Start the engine.
- Check for leaks.



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# Section 11 - Exhaust System - Group 11

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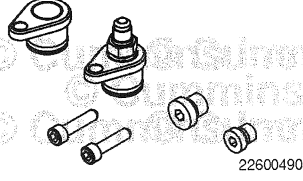
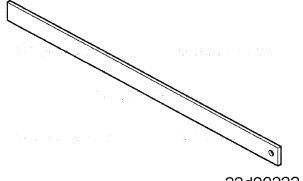
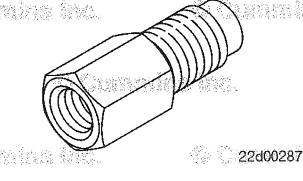
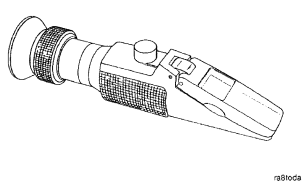
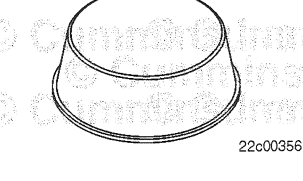
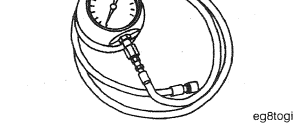
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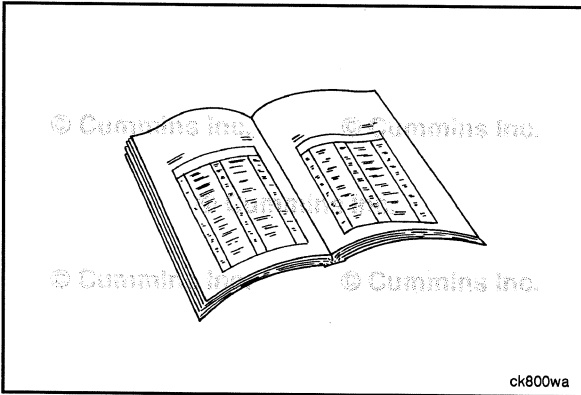
## Service Tools

### 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
2892313	<p align="center"><b>EGR Cooler Leak Test Kit</b></p> <p>Used to pressure test the EGR cooler on or off the engine using regulated compressed air.</p>	 <p align="right">22600490</p>
4918219	<p align="center"><b>Gauge, Straight Edge</b></p> <p>Used to check the exhaust manifold flanges.</p>	 <p align="right">22d00222</p>
4918576	<p align="center"><b>Exhaust Restriction/Pressure Adapter</b></p> <p>Used to convert the aftertreatment temperature sensor ports to 1/8 inch NPT pipe thread so that service tool ST-1273 can be used to measure exhaust pressure.</p>	 <p align="right">22d00287</p>
4919318	<p align="center"><b>Refractometer</b></p> <p>Used to measure the diesel exhaust fluid concentration level.</p>	 <p align="right">198109</p>
4919508	<p align="center"><b>Air Handling Clean Care Kit</b></p> <p>Contains a variety of protective caps to prevent contamination of vehicle air handling plumbing during service procedures.</p>	 <p align="right">22c00356</p>
ST-1273	<p align="center"><b>Pressure Gauge</b></p> <p>Used to measure exhaust restriction.</p>	 <p align="right">eg8togi</p>





## Exhaust Manifold, Dry (011-007)

### 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 ▲

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.

#### ▲ WARNING ▲

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

**NOTE:** Brush away all dirt from the around the area of the air handling connections to avoid contamination of the interior of the engine.

- Disconnect the batteries. See equipment manufacturer service information.
- Disconnect the air intake and exhaust piping. See equipment manufacturer service information.
- Drain the coolant. Refer to Procedure 008-018 in Section 8.
- Remove the exhaust pressure regulator. Refer to Procedure 011-105 in Section 11.
- Remove the turbocharger. Refer to Procedure 010-033 in Section 10.
- Remove the exhaust pressure sensor tube. Refer to Procedure 011-027 in Section 11.
- Remove the exhaust gas recirculation (EGR) cooler coolant lines. Refer to Procedure 011-031 in Section 11.
- Remove the EGR cooler. Refer to Procedure 011-019 in Section 11.
- Remove the EGR valve. Refer to Procedure 011-022 in Section 11.

### Remove

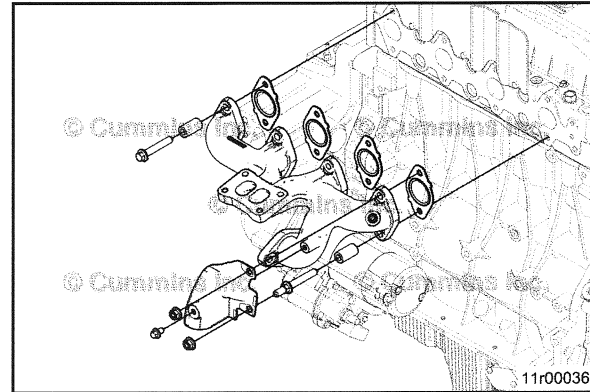
Remove the two upper mounting capscrews and install two guide studs, Cummins® Part Number 3163934, into the top center section mounting location.

Remove the heat shield, remaining exhaust manifold mounting capscrews, and spacers.

Remove the exhaust manifold.

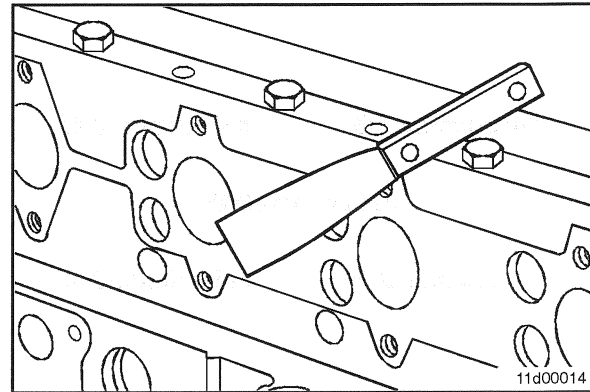
Remove and discard the gaskets.

Cover open points in the exhaust manifold and cylinder head with heavy tape, if the repair is delayed.



### Clean and Inspect for Reuse

Clean the sealing surfaces of the cylinder head and the exhaust manifold with a gasket scraper or a wire brush. Take caution to keep all debris out of the cylinder head.



### ⚠ WARNING ⚠

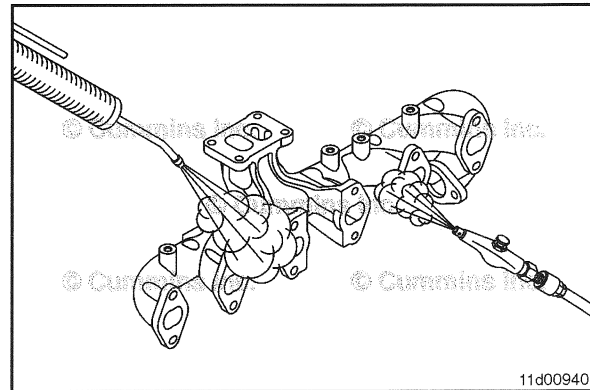
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

### ⚠ WARNING ⚠

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

Steam clean the exhaust manifold.

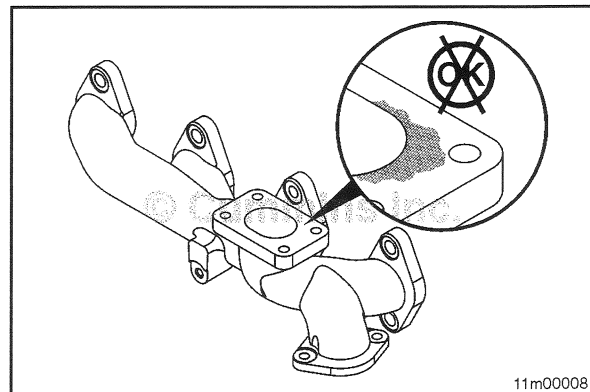
Dry with compressed air.

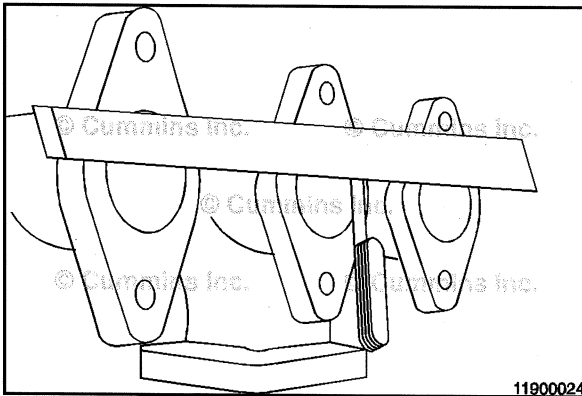


Inspect the cylinder head bosses and turbocharger mounting studs for damage. Replace as necessary.

Inspect the exhaust manifold turbocharger mounting flange for damage. Replace as necessary.

**NOTE:** A charge-air cooler malfunction can cause progressive damage to the exhaust manifold. If the exhaust manifold is damaged, check for charge-air cooler leaks. Refer to Procedure 010-027 in Section 10.



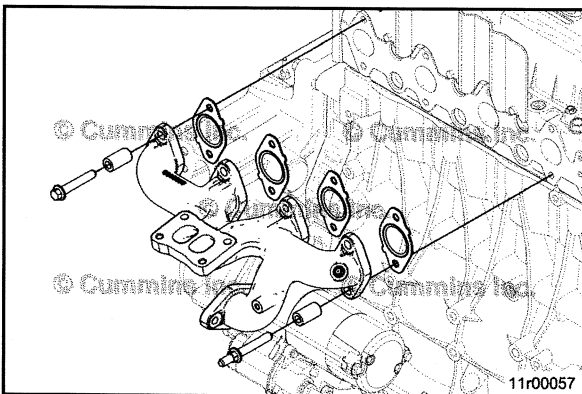


Use a precision straightedge, Cummins® Part Number 4918219, or equivalent, to check the manifold mounting surfaces for flatness. Lay the straightedge on edge across all ports and measure the flatness with a feeler gauge.

#### Exhaust Manifold Flatness

mm		in
0.20	MAX	0.008

If any port measures out of specification, replace the exhaust manifold.



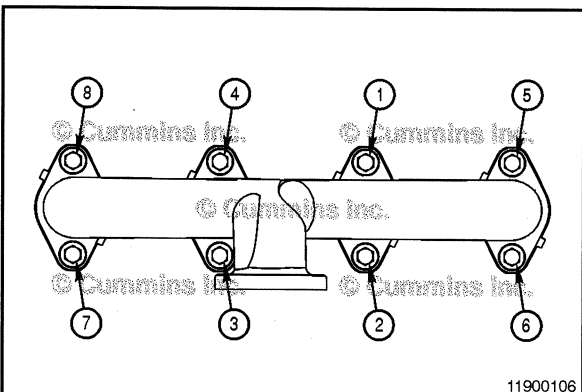
#### Install

Remove the tape from the open exhaust ports and cylinder head. Install two guide studs, Cummins® Part Number 3163934, into the center section mounting location.

Apply high-temperature anti-seize compound to the exhaust manifold capscrew threads.

Install new lockplates, if equipped.

Install the new gaskets, exhaust manifold, and spacers.



Follow the tightening sequence shown in the illustration.

Tighten the exhaust manifold mounting capscrews.

**Torque Value:** 53 N•m [ 39 ft-lb ]



Install heat shield.

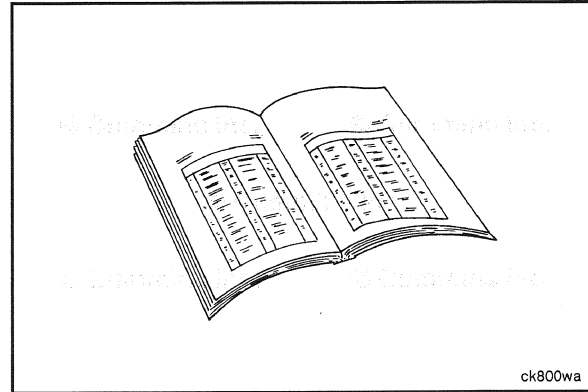
**Torque Value:** 23 N•m [ 204 in-lb ]

## 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 EGR valve. Refer to Procedure 011-022 in Section 11.
- Install the EGR cooler. Refer to Procedure 011-019 in Section 11.
- Install the EGR cooler coolant lines. Refer to Procedure 011-031 in Section 11.
- Install the turbocharger. Refer to Procedure 010-033 in Section 10.
- Install the exhaust pressure sensor tube. Refer to Procedure 011-027 in Section 11.
- Install the exhaust pressure regulator. Refer to Procedure 011-105 in Section 11.
- Fill the cooling system. Refer to Procedure 008-018 in Section 8.
- Connect the air intake and exhaust piping. See equipment manufacturer service information.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



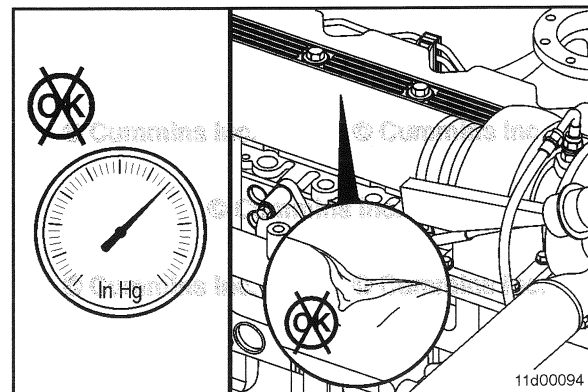
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## Exhaust Restriction (011-009)

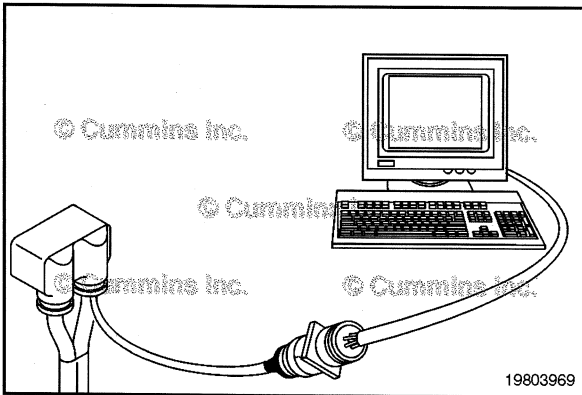
### General Information

When measuring exhaust restriction, it is preferred that the measurement point be within one pipe diameter of the turbocharger outlet.

If this requirement can **not** be met, make sure to inspect the exhaust outlet tubing between the turbocharger outlet and the exhaust pressure tap location for damage to the exhaust piping.

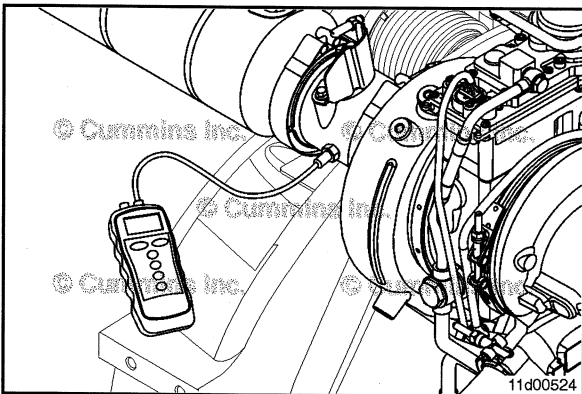


11d00094



### Initial Check

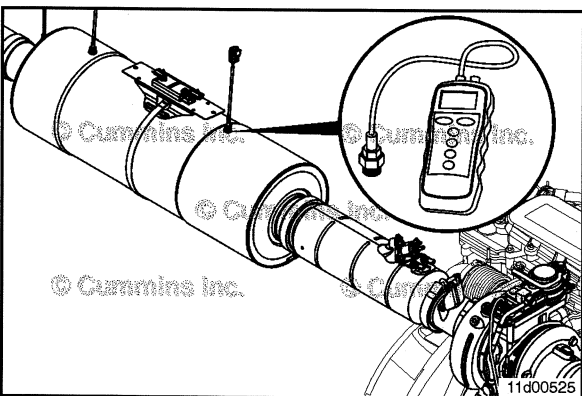
Use INSITE™ electronic service tool to check for fault codes. If any are present, follow the troubleshooting steps as outlined in the corresponding fault code troubleshooting procedure.



### Measure

If equipped, remove the pipe plug from the pressure tap located in the turbocharger exhaust outlet tubing or the inlet of the aftertreatment system.

Install the service tool pressure/vacuum module, Cummins® Part Number 3164491, used with digital multimeter, Cummins® Part Number 3164488, or deluxe digital multimeter, Cummins® Part Number 3164489 or equivalent, into the pressure tap location.



If the exhaust outlet tubing or the inlet of the aftertreatment system is **not** equipped with a pressure tap location, remove the first exhaust temperature sensor located in the aftertreatment system. Refer to Procedure 019-449 in Section 19.

Install an adapter fitting in the temperature sensor port, Cummins® Part Number 4918576 or equivalent, in the port. This will adapt the temperature sensor port to 1/8 inch NPT pipe threads.

Install the service tool pressure/vacuum module, Cummins® Part Number 3164491 or equivalent, into the pressure tap location.

Use digital multimeter, Cummins® Part Number 3164488 or equivalent, or deluxe digital multimeter, Cummins® Part Number 3164489 or equivalent, to obtain the exhaust restriction measurement.

**NOTE:** Install at least 12 inches of metal tubing between the exhaust pipe pressure tap and the pressure gauge to prevent exhaust from damaging the gauge and giving an inaccurate reading.

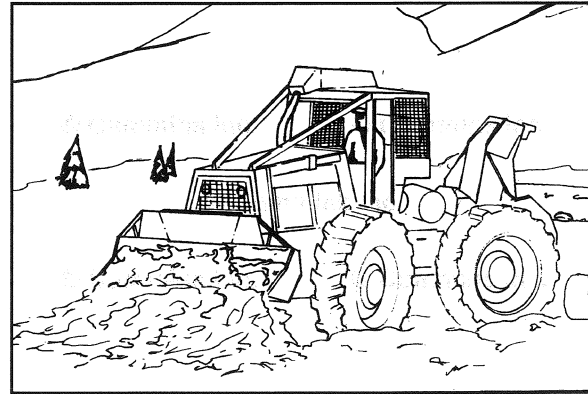
Operate the engine at rated speed and load and record the exhaust restriction. Refer to Procedure 018-020 in Section V.



If the exhaust restriction exceeds the specification:



- 1 Inspect the exhaust piping for damage. See equipment manufacturer service information.
- 2 Check for any fault codes related to the aftertreatment system indicating a possible damaged or plugged aftertreatment system.
- 3 Check for a damaged or restricted selective catalyst recirculation (SCR) decomposition tube. Refer to Procedure 011-062 in Section 11.



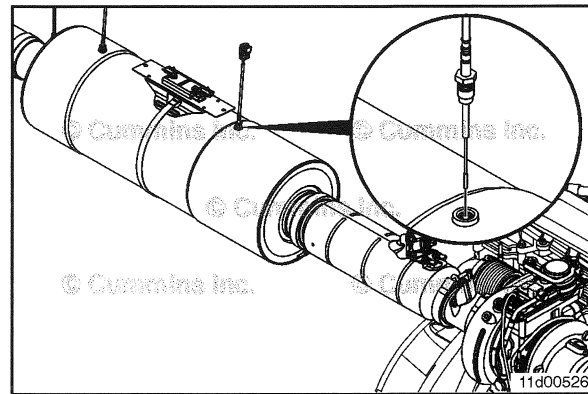
If equipped with an exhaust pressure tap, remove the test equipment and install the pipe plug. Coat the threads of the plug with high-temperature multi-purpose anti-seize compound prior to installation.



If an aftertreatment exhaust temperature sensor port was used, remove the test equipment and install the exhaust temperature sensor. Refer to Procedure 019-449 in Section 19.

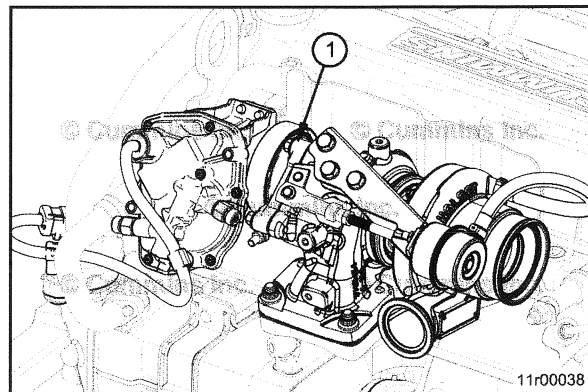


**NOTE:** Clear any inactive fault codes with INSITE™ electronic service tool once the testing is completed.



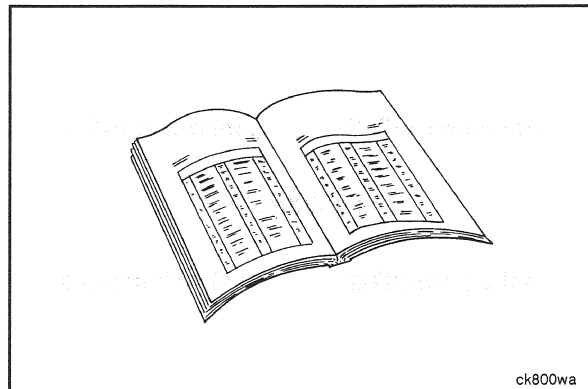
## Exhaust Outlet Connection (011-017) General Information

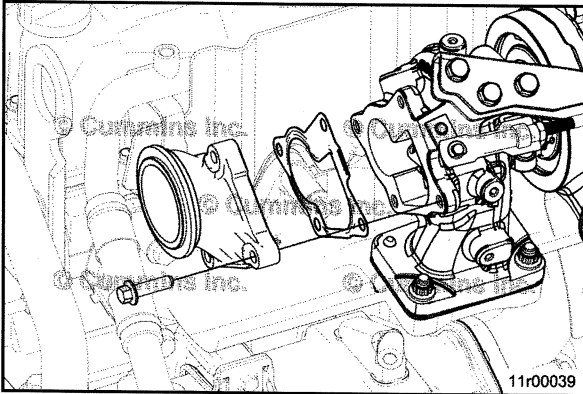
The exhaust outlet connection (1) is the connection that connects the turbocharger to the exhaust pressure regulator.



## Preparatory Steps

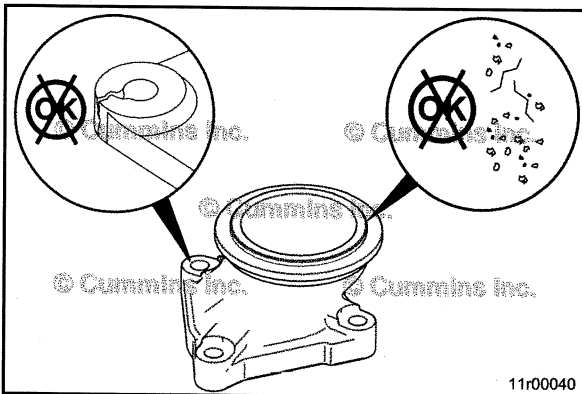
- Remove the exhaust piping from the flange of the exhaust pressure regulator. See equipment manufacturer service information.
- Remove the exhaust pressure regulator. Refer to Procedure 011-105 in Section 11.





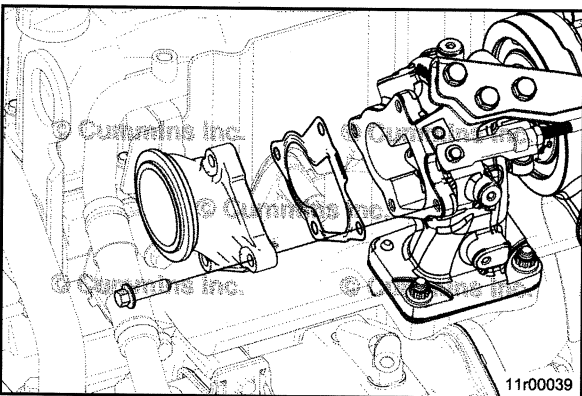
### Remove

- Remove the exhaust outlet connection capscrews.
- Remove the exhaust outlet connection.
- Discard the exhaust gasket.



### Clean and Inspect for Reuse

- Clean with solvent. Inspect all sealing surfaces for damage or other indications of leakage.
- Inspect the outlet connection for pitting and corrosion.

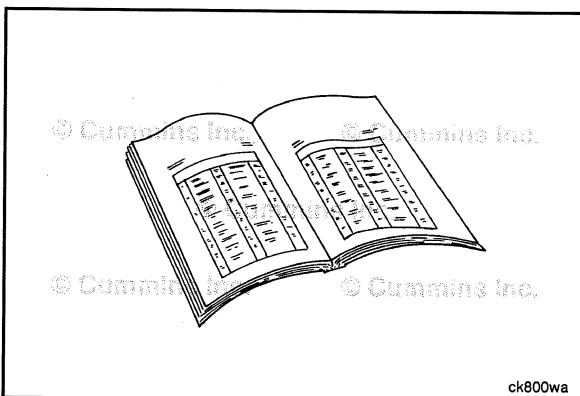


### Install

- Install a new gasket and the exhaust outlet connection to the turbocharger.
- Install the capscrews and tighten in a criss cross pattern.



**Torque Value:**  
M8 24 N•m [ 212 in-lb ]



### Finishing Steps

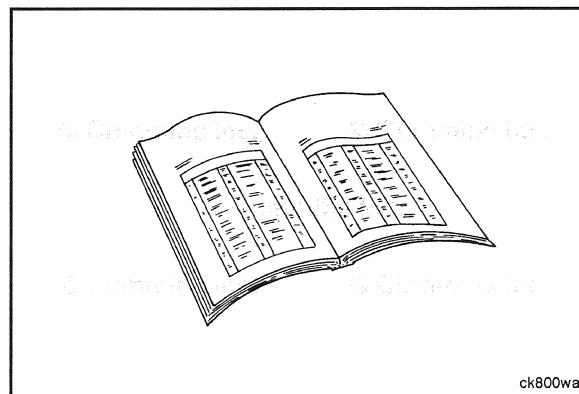


- Install exhaust pressure regulator. Refer to Procedure 011-105 in Section 11.
- Install the exhaust piping to the exhaust pressure regulator. See equipment manufacturer service information.
- Operate the engine and check for leaks.

## EGR Cooler (011-019)

### General Information

The exhaust gas recirculation (EGR) cooler processes a portion of the engine exhaust gas and reduces its temperature. This cooled exhaust gas is then ported and mixed with intake air at the intake manifold inlet.



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### Preparatory Steps

#### ⚠ WARNING ⚠

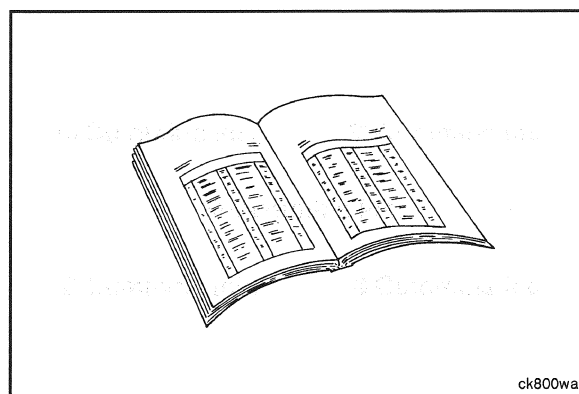
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

#### ⚠ WARNING ⚠

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.

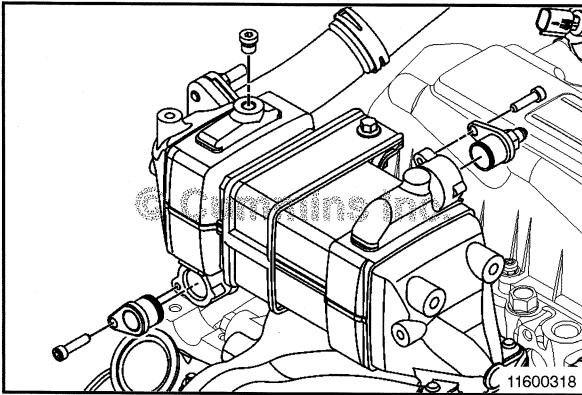
**NOTE:** Brush away any dirt from the area around the air handling connections to avoid contamination of the interior of the engine.

- Disconnect the batteries. See equipment manufacturer service information.
- Drain the coolant. Refer to Procedure 008-018 in Section 8.
- Remove the EGR connection tube. Refer to Procedure 011-025 in Section 11.
- Disconnect the EGR cooler coolant supply and return lines. Refer to Procedure 011-031 in Section 11.
- Disconnect the coolant vent line. See equipment manufacturer service information.
- Check the function of the engine coolant level sensor. Refer to Procedure 019-019 in Section 19.



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### Pressure Test

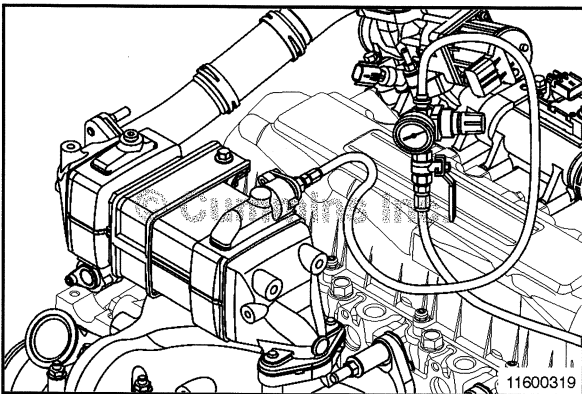
**NOTE:** The engine **must** be within 3°C or 5°F of ambient temperature to perform the test.

The EGR Cooler Leak Test Kit is Cummins® Part Number 2892313.

Cap off the coolant inlet by installing the leak test plugs, Cummins® Part Numbers 2892317 and 2892566.

Use capscrews, Cummins® Part Number 4895877, to secure the leak test plugs to the EGR cooler.

Remove the vent hose and fittings from the EGR cooler to install the straight thread plugs, Cummins® Part Number 4002056.



### ⚠ WARNING ⚠

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

**NOTE:** Air pressure regulator kit, Cummins® Part Number 3164231, or equivalent, is suitable for use during this step.

Install the air pressure regulator and hose assembly onto the test fitting installed in the vent hose location.

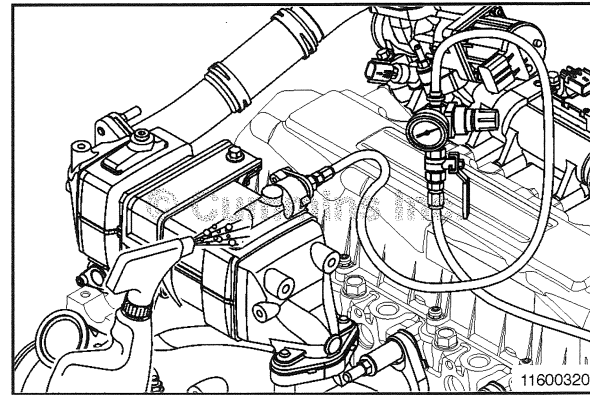
Install a ball type shutoff valve onto the inlet side of the air pressure regulator to allow the air supply to be shut OFF during testing.

**▲ WARNING ▲**

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



- Make sure the air pressure regulator and ball type valve are closed. Connect a compressed air supply to the pressure regulator.
- Apply 310 kpa [45 psi] of air pressure to the EGR cooler.
- Inspect for air escaping the EGR cooler assembly as a result of loose lines and fittings by spraying the exterior of the EGR cooler and all lines and fittings with a mixture of mild soap and water.
- Shut the air supply OFF to the regulator by using the ball valve and disconnect the compressed air supply.
- Record the time at which the air supply was shut OFF and the air pressure shown on the air pressure regulator gauge.
- If the EGR cooler is removed from the engine, submerge the EGR cooler, compressor hose, and regulator in a full bucket of water. Check the water for signs of air leaks (bubbles).
- If the EGR cooler has **not** been removed, periodically check the fittings for air leaks including the pressure regulator using the mixture of soap and water.
- If there are any air leaks found during the test, fix the leak and start the test over.
- Measure and record the air pressure after 20 minutes.
- If there is no pressure drop, the cooler is reusable.
- If the measured pressure drop is greater than 138 kPa [20 psi], replace the EGR cooler.
- If the measured pressure drop is 138 kPa [20 psi] or less, check all the fittings for air leaks to make sure that no air leaks are found on the test equipment and test again.
- If the pressure drops on the second test and there are no air leaks found on the test equipment, replace the EGR cooler.



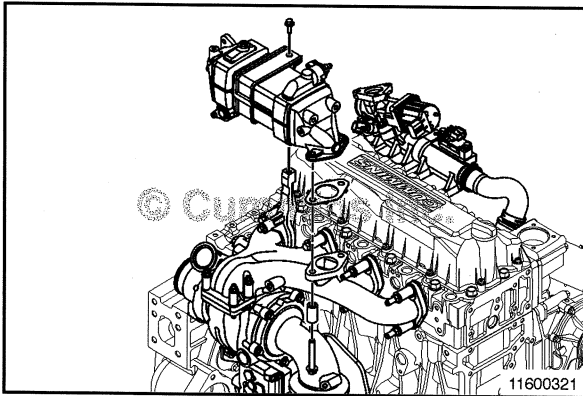
If the EGR cooler is **not** usable, check the following items:

- Pressure check the cooling system for leaks. Leaks can be in the OEM coolant plumbing, as well as on the engine, which can cause EGR cooler malfunction. Verify there are no issues with the cooling system (coolant leaks, water pump damage, fan drive damage, or similar). Refer to Procedure 008-020 in Section 8.
- Inspect the turbocharger turbine housing for signs of coolant deposits. Coolant deposits can typically be identified as dried white deposits coating the insides of the housings. Refer to Procedure 010-033 in Section 10.
- Inspect the EGR valve inlet for signs of coolant deposits. Clean if coolant is found. Refer to Procedure 011-022 in Section 11.
- Inspect the air intake connection for coolant. Refer to Procedure 010-022 in Section 10.
- If there is coolant contamination in the engine lubricating oil, change the engine lubricating oil. Refer to Procedure 007-037 in Section 7.

**NOTE:** If damage resulted in a hydraulic lock and the coolant level reached the intake manifold, it may be necessary to clean the charge-air cooler. See equipment manufacturer service information.

**NOTE:** If damage resulted in a hydraulic lock, it may be necessary to remove the injectors and evacuate coolant from the cylinder(s). Refer to Procedure 006-026 in Section 6.

If the EGR cooler is reusable, remove the parts supplied in the service kit and proceed to the Clean and Inspect for Reuse section of this procedure.



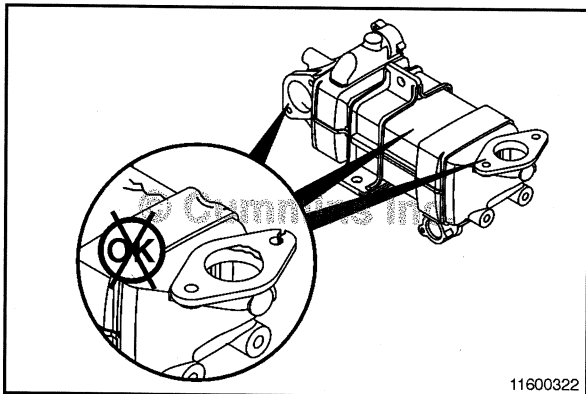
## Remove

Remove the EGR cooler-to-exhaust manifold capscrews and spacers and the EGR cooler strap mounting capscrews.

Remove the EGR cooler assembly.

Remove and discard gaskets.

Cover open connections with protective caps from the Air Handling Clean Care Kit, Cummins® Part Number 5298817.



## Clean and Inspect for Reuse

### ▲ WARNING ▲



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

Prior to cleaning, inspect the EGR cooler for internal leaks. If the EGR cooler is leaking internally, there could be coolant or signs of coolant (light colored deposits) in the EGR cooler.

Also, if the EGR cooler is leaking internally, there could be small amounts of soot in the coolant that has been drained from the vehicle.

Inspect the EGR cooler for signs of external leaks or cracks.

Scrape any gasket material from the EGR cooler inlet and outlet flanges with a gasket scraper.

**▲ 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.

Use the components from EGR Cooler Leak Test Kit, Cummins® Part Number 4918625, to aid in cleaning the EGR cooler internally.

Install the protective cover, Cummins® Part Number 3164937, over the exhaust gas outlet of the EGR cooler.

Completely fill the EGR cooler with safety solvent, then cap the exhaust gas inlet of the EGR cooler with the protective cover, Cummins® Part Number 3164936.

Position the EGR cooler on its side.

Allow the EGR cooler to soak for approximately 20 minutes.

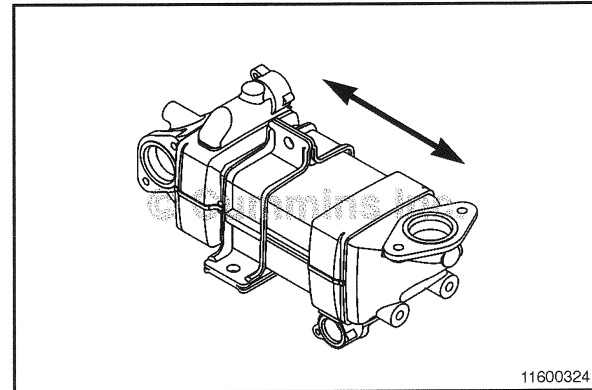
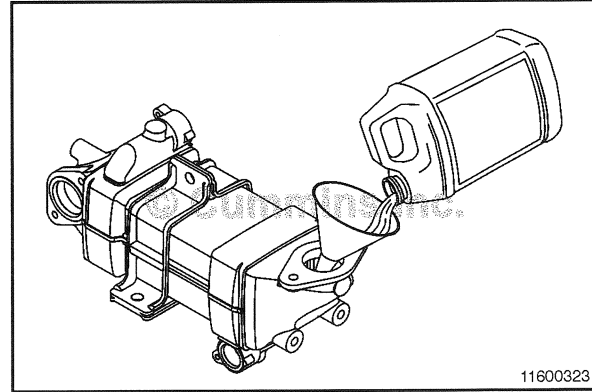
Drain approximately 25 percent of the liquid from the cooler and recap.

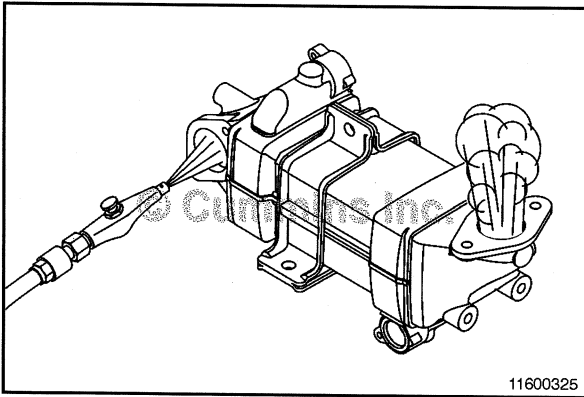
Shake the cooler by hand, from end to end, for approximately 30 seconds.

Remove the protective caps and drain the safety solvent from the EGR cooler. Properly dispose of the liquid.

Use compressed air to dry the inside of the EGR cooler and remove any loose debris or particles.

Install the protective cap, Cummins® Part Number 3164937, on the exhaust gas outlet of the EGR cooler.





**▲ WARNING ▲**

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

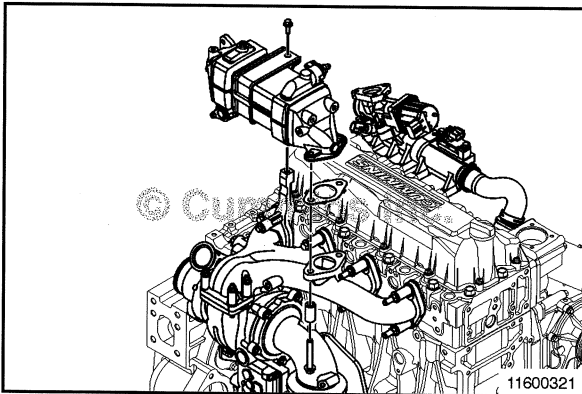
Fill the EGR cooler with water and install the protective cap, Cummins® Part Number 3164938, on the exhaust gas inlet of the EGR cooler.

Shake the cooler by hand, from end to end, for approximately 30 seconds.

Drain the liquid from the EGR cooler and properly dispose of it.

Use compressed air to dry the inside of the EGR cooler.

If any solvents or cleaners entered the coolant side of the EGR cooler, use clean water to flush the coolant side of the cooler to prevent these solvents or cleaners from entering the coolant.



**Install**

Install the EGR cooler assembly with a new gasket between the EGR cooler and exhaust manifold.



Install the capscrews and spacers that connect the EGR cooler to the exhaust manifold, hand-tight **only**.

Install the EGR cooler to the mounting bracket capscrews, hand-tighten **only**.

Tighten the EGR cooler inlet flange capscrews.

**Torque Value:** 43 N•m [ 32 ft-lb ]

Tighten the EGR cooler strap to mounting bracket capscrews.

**Torque Value:** 24 N•m [ 212 in-lb ]

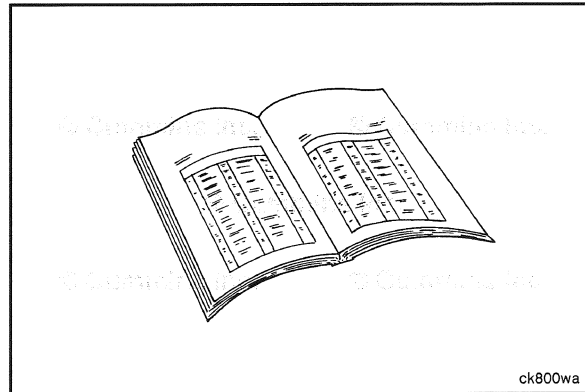
## Finishing Steps

### ⚠ WARNING ⚠

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

- Connect the EGR cooler coolant supply and return lines. Refer to Procedure 011-031 in Section 11.
- Install the EGR connection tube. Refer to Procedure 011-025 in Section 11.
- Connect the coolant vent line. See equipment manufacturer service information.
- 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.

If damage resulted in oil, excessive fuel, or excessive black smoke entering the exhaust system, the aftertreatment system **must** be inspected.



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## EGR Valve (011-022)

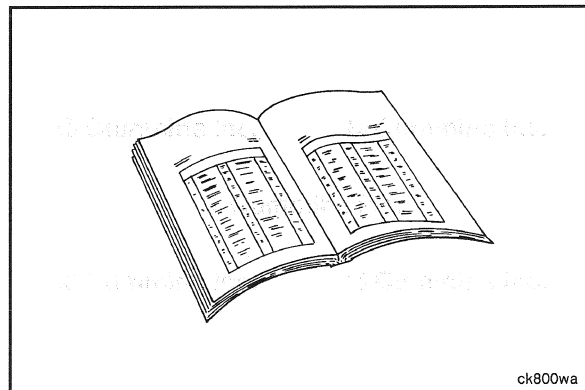
### Preparatory Steps

### ⚠ WARNING ⚠

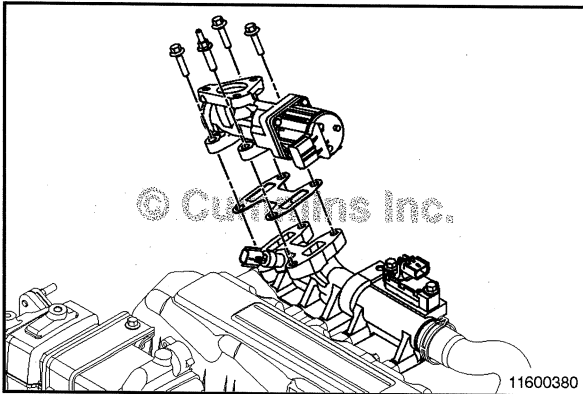
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

**NOTE:** Brush away all loose dirt from the around the area of the air handling connections to avoid contamination of the interior of the engine.

- Disconnect the batteries. See the equipment manufacturer service information.
- Disconnect the exhaust gas recirculation (EGR) connection tube from the EGR valve. Refer to Procedure 011-025 in Section 11.
- Disconnect the electrical connection from the EGR valve.



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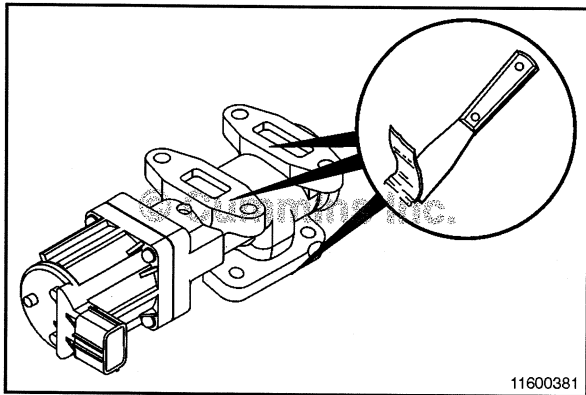
### Remove

Clean the area around the EGR valve with a clean cloth to help prevent debris from entering the air intake system when the EGR valve is removed.



Remove the four capscrews holding the EGR valve to the EGR valve mounting bracket. Remove the EGR valve.

Use protective caps from the Air Handling Clean Care Kit, Cummins® Part Number 4919498, or equivalent, or heavy tape to cover any open connections to prevent debris from entering the system.

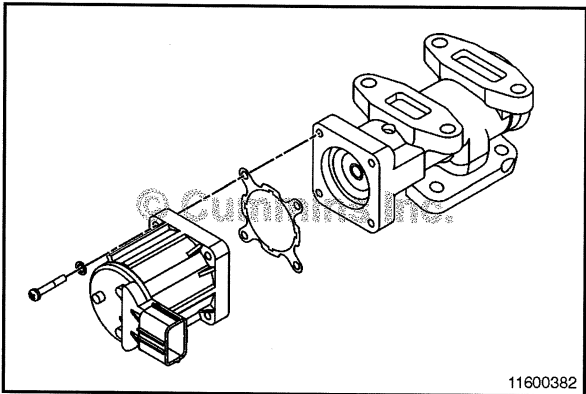


### Clean and Inspect for Reuse

Clean the EGR valve and air intake connection mounting surfaces of gasket material. Take care to keep any debris out of the air intake system.

**NOTE:** A light coating of carbon is common on the inside of the EGR valve, and does **not** need to be removed.

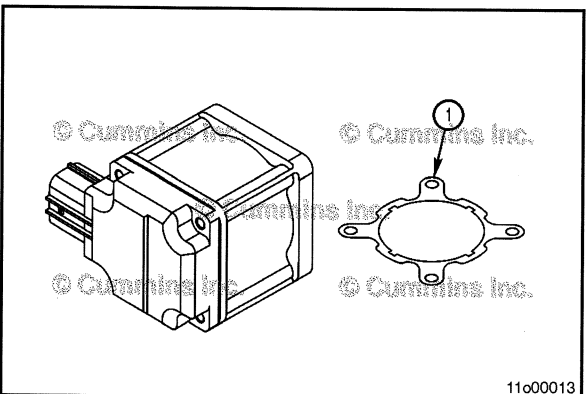
**NOTE:** The EGR valve can have a corrosion resistant coating on the inner surfaces. Do **not** scratch or remove this coating.



Remove the four capscrews that hold the EGR valve motor to the EGR valve base.

Remove the EGR valve motor. Take care to keep the shim with the motor.

**NOTE:** Note the orientation of the electrical connector with respect to the valve body. A witness mark on the outside of the motor case and valve body can be used to document the orientation. This orientation **must** be the same upon assembly.

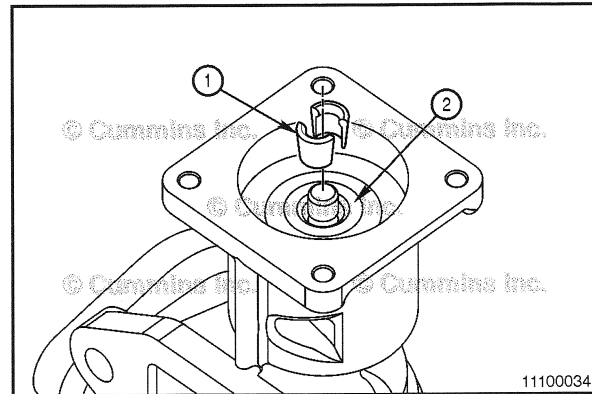


**NOTE:** The shim (1) is specific to the valve and can **not** be replaced. If the shim is lost or damaged, replace the EGR valve.

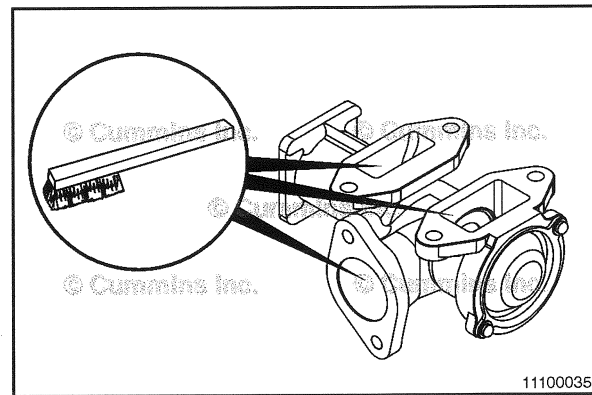
Use two fingers to press down on valve spring retainer (1) to unlock two valve keepers (2). If the valve keepers will **not** release using finger pressure, locate a 5/8" deep socket to the spring retainer (1). Gently tap on the socket with a small hammer to release the keepers, then use two fingers and press for keeper removal.



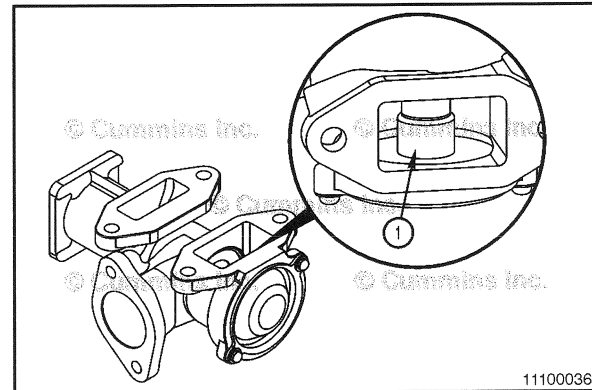
**NOTE:** The spring, spring keepers, and spring retainer can **not** be replaced. If the spring, spring keepers, or spring retainer are lost or damaged, replace the EGR valve.



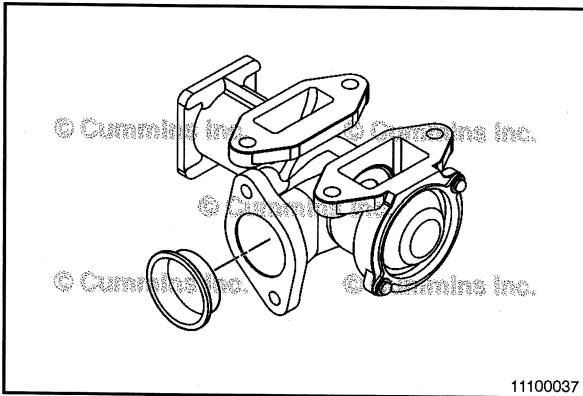
Clean the accumulated soot from the EGR valve inlet port and outlet ports with a nylon bristle and/or wire brush. Some deposits may need to be scraped out with a pick or scraping tool. Remove as much material as possible before applying any cleaner, without damaging the poppet sealing surfaces and the anti-corrosion finish, inside the EGR valve body.



Clear the area around the soot guard (1) in the outlet port with a 90 degree bent pick. Clear any deposited material all the way around the front and the back of the soot guard. Make sure that there is no deposited material on or around the soot guard that could hold the poppet shaft open.





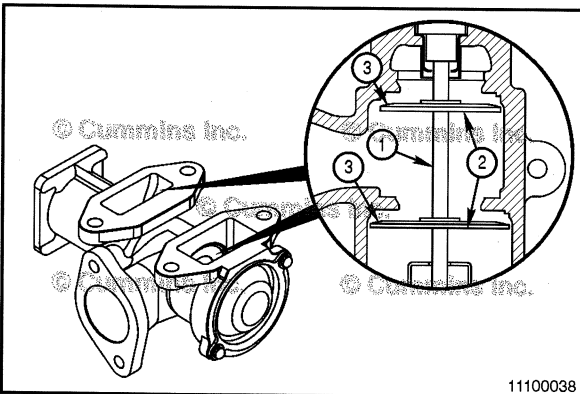


**▲ WARNING ▲**

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.

Spray carburetor cleaner into the EGR valve outlet ports to soak the inner surfaces. Use Clean Care Kit, Cummins® Part Number 4919501, to seal the EGR valve inlet. Fill the EGR valve cavity with carburetor cleaner. Soak for 5 minutes. Work the poppet shaft back and forth and turn it while the poppets are in contact with the valve seats (closed position) to help clean the valve. After 5 minutes, drain and properly dispose of the excess cleaner.

**NOTE:** Carburetor cleaner is the most effective solvent for this procedure. Do **not** substitute any other cleaning solvent.



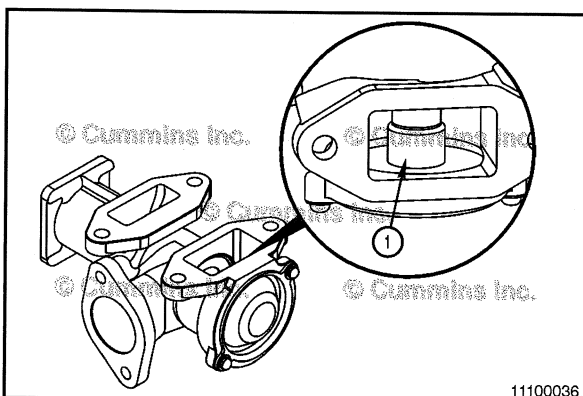
**▲ WARNING ▲**

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.

The EGR valve shaft stem (1) is comprised of two valve faces (2) on two valve seats (3). Use a small nylon or brass wire brush to lightly brush away loose soot from the stem (1), valve seat (3), and from the valve seat on the EGR valve housing. Take care **not** to damage the poppet sealing surfaces.

Spray additional carburetor cleaner, as needed, to clean the sealing surfaces.

**NOTE:** Carburetor cleaner is the most effective solvent for this procedure. Do **not** substitute any other cleaning solvent.



**▲ 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.

The soot guard (1) is comprised of outer and inner cylinders which **must** be able to close with a small gap at the bottom. Use a small nylon or brass wire brush to brush away deposits from the soot guard. Deposits can be on the back side of the soot guard causing the valve **not** to close fully.

Spray additional carburetor cleaner as needed to clean the sealing surfaces.

**NOTE:** Carburetor cleaner is the most effective solvent for this procedure. Do **not** substitute any other cleaning solvent.

**▲ 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

Drain any remaining carburetor cleaner from the EGR valve and properly dispose of the liquid.

Use compressed air to dry the inside of the EGR valve.

Repeat the cleaning steps, if necessary.

**NOTE:** An effectively cleaned valve will close with a metal sound when the poppet shaft is closed. A soft thud is an indication that deposits are still holding the EGR valve partially open.

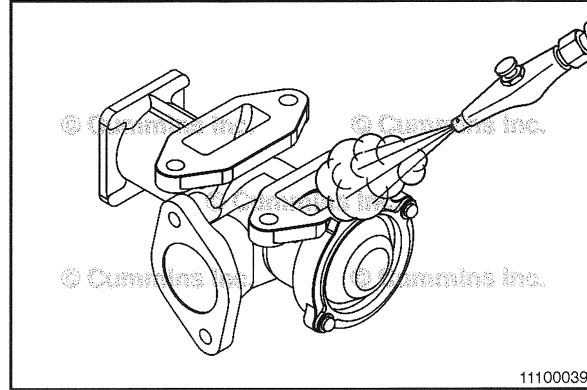
Install the spring, spring retainer, and spring keepers.

Install the EGR valve motor, shim, and four capscrews to the base.

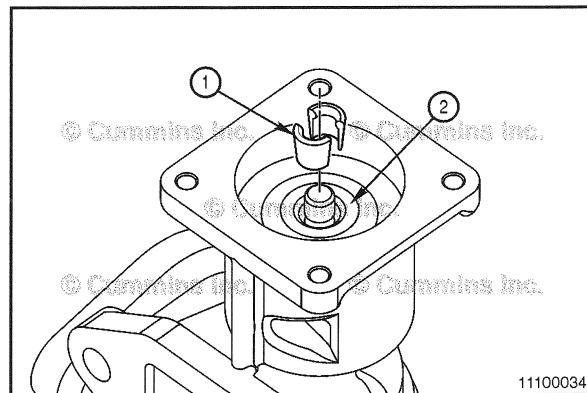
**Torque Value:**

EGR Motor Capscrews 2.5 N•m [ 22 in-lb ]

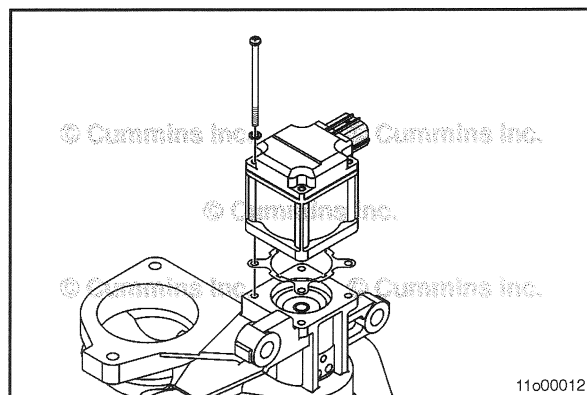
**NOTE:** The EGR valve motor electrical connector **must** be oriented in the same direction as it was when originally installed.



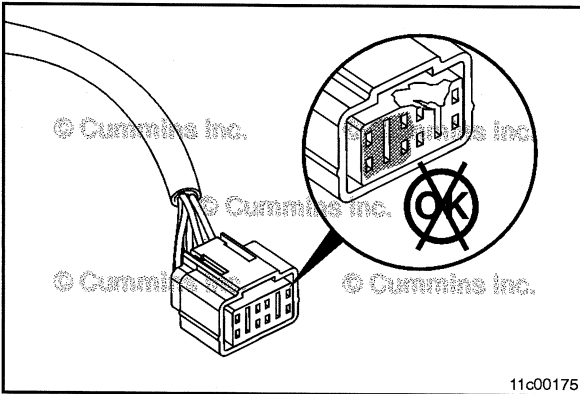
11100039



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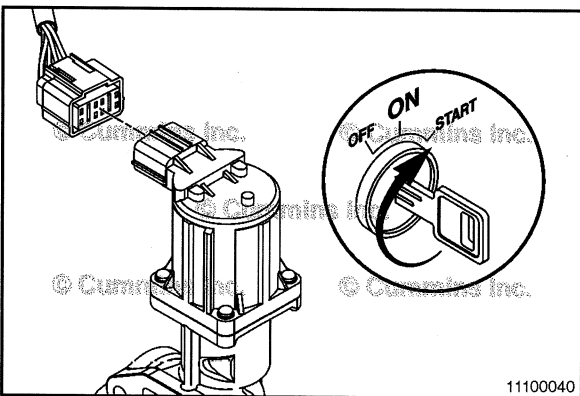


11c00012

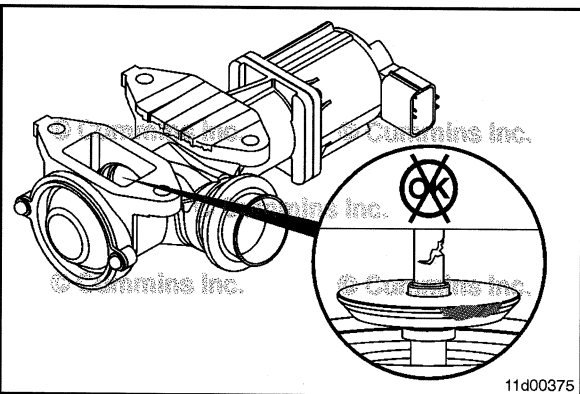


Inspect the engine wiring harness EGR valve actuator connector for corrosion, worn receptacles, or other damage.

Replace the engine wiring harness EGR valve connector if corrosion, worn receptacles, or other damage is found.



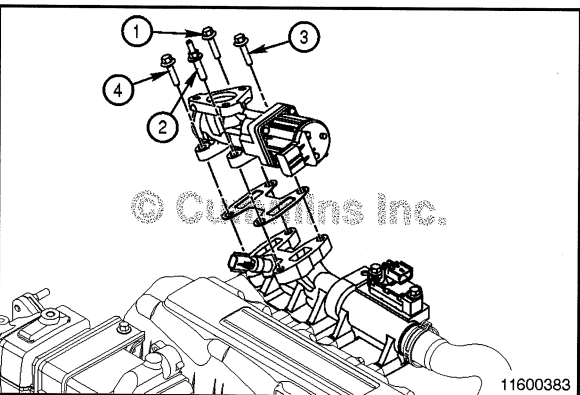
After cleaning the EGR valve, connect the electrical connector to the EGR valve and turn the ignition key ON. Do **not** start the engine. Check for active Fault Code 1896. If Fault Code 1896 persists after cleaning, replace the EGR valve.



Inspect the EGR valve seats and stem for galling, pitting, cracks, or excessive corrosion.

**NOTE:** Soot and condensation leaking from the weep hole on the EGR valve is considered normal and does **not** mean that the EGR valve needs to be replaced.

If the EGR valve shows signs of internal damage, replace the EGR valve assembly.



### Install

Install the EGR valve, with new mounting gaskets, onto the EGR valve mounting bracket.



Install the four cap screws holding the EGR valve to the air intake connection and tighten in a crisscross pattern.



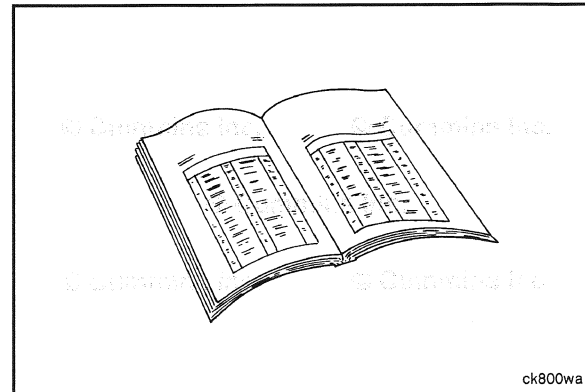
**Torque Value:** 18 N•m [ 159 in-lb ]

## 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 EGR connection tube from the EGR valve. Refer to Procedure 011-025 in Section 11.
- Connect the engine harness to the EGR valve.
- If a malfunction resulted in coolant, oil, excessive fuel or excessive black smoke entering the exhaust system, the aftertreatment system **must** be inspected.
- Connect the batteries. See the equipment manufacturer service information.
- Operate the engine and check for leaks.



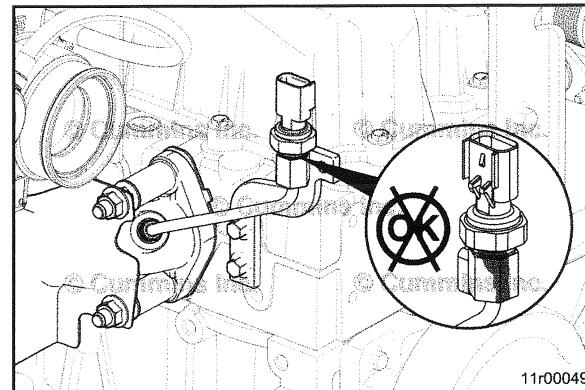
ck800wa

## Exhaust Gas Pressure Sensor Tube (011-027)

### Initial Check

Inspect the ports on the exhaust manifold and the exhaust pressure sensor for signs of leaks or damage. Leaks can be identified by soot streaks.

If leaks are found, tighten the fittings again. If the fittings are **not** loose, replace the exhaust gas pressure sensor tube.



11r00049

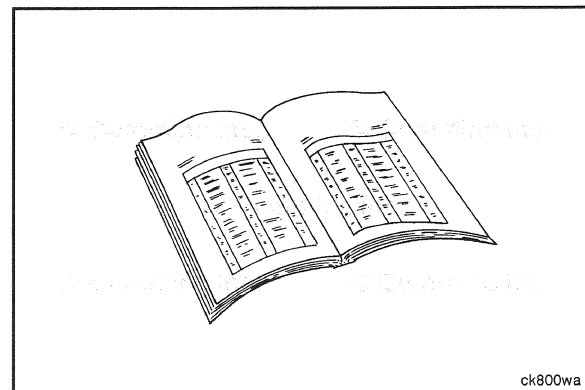
## Preparatory Steps

### ⚠ WARNING ⚠

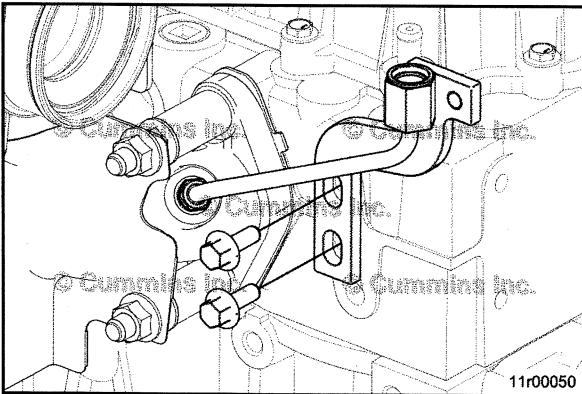
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

**NOTE:** Do **not** peel apart the adhesive of the tube to remove.

- Disconnect the battery cables. See equipment manufacturer service information.
- Disconnect the electrical connector from the exhaust pressure sensor and remove the exhaust pressure sensor. Refer to Procedure 019-370 in Section 19.

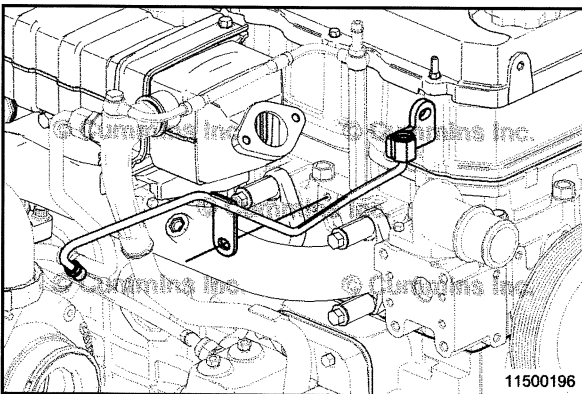


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### Remove

Remove the mounting capscrews securing the exhaust gas pressure sensor tube to the cylinder head.



### ▲ WARNING ▲

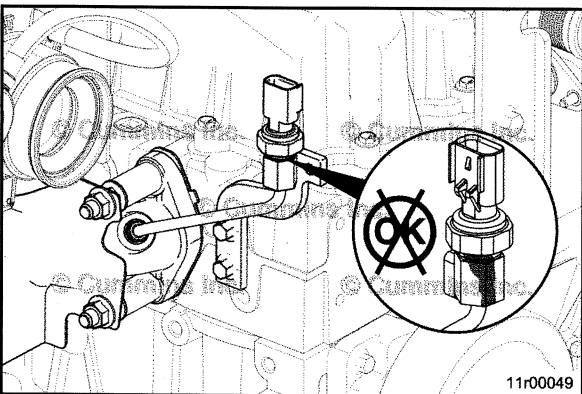
**Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.**



Use compressed air to clean around the fitting where the exhaust gas pressure sensor tube connects to the exhaust manifold.

Disconnect the exhaust gas pressure sensor tube from the exhaust manifold.

Remove the exhaust gas pressure sensor tube.



### Clean and Inspect for Reuse

### ▲ WARNING ▲

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

Clean the exhaust gas pressure sensor tube with solvent and dry with compressed air.

Inspect the tube for signs of leakage, damaged sealing areas, or plugging with soot.

If the tube is plugged with soot, use solvent and a pipe cleaner, or similar device, to remove the soot blockages in the tube.

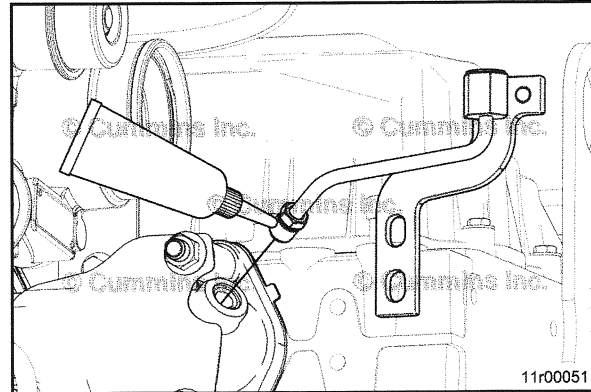
## Install

**NOTE:** Install a light coating of high temperature anti-seize compound to the threads of the exhaust gas pressure sensor tube prior to installation.

Loosely assemble all fasteners.

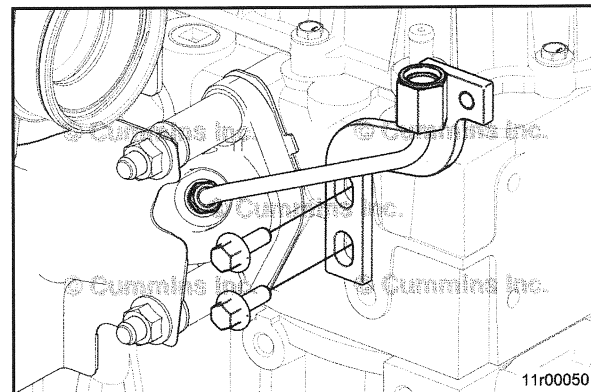
Install the exhaust gas pressure sensor tube to the port on the exhaust manifold.

**Torque Value:** 11 N•m [ 97 in-lb ]



Install the mounting capscrews securing the exhaust pressure sensor tube to the cylinder head and tighten.

**Torque Value:** 24 N•m [ 212 in-lb ]

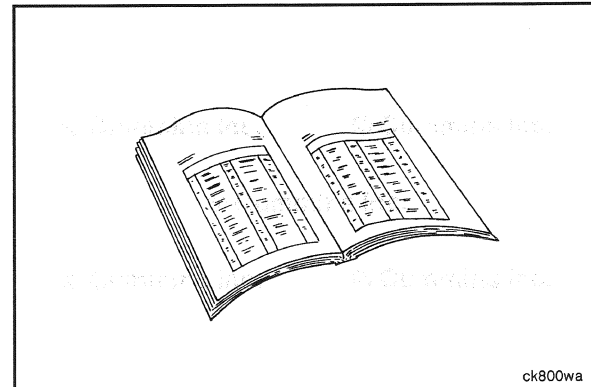


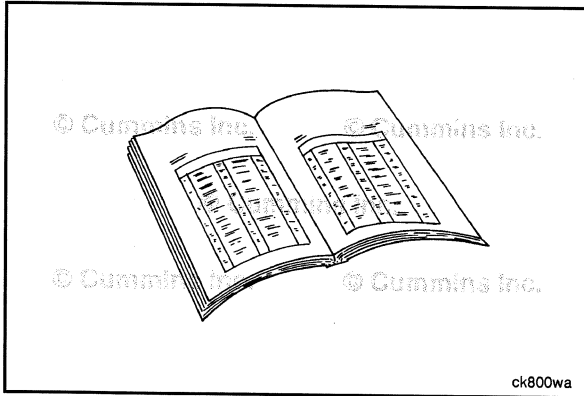
## Finishing Steps

### ▲ WARNING ▲

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

- Install the exhaust pressure sensor and connect the electrical connector to the exhaust pressure sensor. Refer to Procedure 019-370 in Section 19.
- Connect the battery cables. See equipment manufacturer service information.
- Operate the engine and check for leaks.





## EGR Differential Pressure Sensor Adapter (011-028)

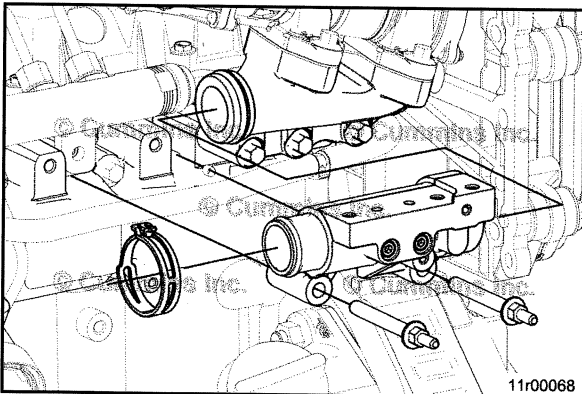


### Preparatory Steps

#### ⚠ 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 gas recirculation (EGR) differential pressure sensor from the engine wiring harness. Refer to Procedure 019-370 in Section 19.
- Remove the EGR differential pressure sensor from the adapter. Refer to Procedure 019-370 in Section 19.
- Remove the EGR crossover tube from the EGR differential pressure sensor adapter. Refer to Procedure 011-070 in Section 11.



### Remove

Remove the spring hose clamp from the inlet of the air transfer tube.

Remove the mounting capscrews.

Remove the EGR differential pressure sensor adapter from the air intake manifold.

## 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.

**NOTE:** Use a nylon brush when cleaning cross drillings and exhaust gas entrance ports. Do **not** use hard-wired brushes, as the exhaust gas ports are very sensitive measurement devices and should **not** be scratched. Make sure all carbon is removed from the ports as this could affect engine operation.

Check the EGR differential pressure sensor adapter for clogging.

If clogged, use compressed air to remove debris or soot buildup.

Clean the EGR differential pressure sensor flow ports with a pipe cleaner or similar device. Inspect the cross-drillings for soot blockage. If any of the EGR differential pressure sensor flow ports are blocked, be sure to clean the ports completely prior to installation.

Clean the outside of the adapter with safety solvent.

Remove the pipe plugs to clean the EGR differential pressure sensor cross-drillings. After cleaning the cross-drillings, install the pipe plugs. Use thread sealant, Cummins® Part Number 3375066, or equivalent, to prevent any leaks.

**Torque Value:** 10 N•m [ 89 in-lb ]

Dry with compressed air.

Inspect the EGR differential pressure sensor adapter for cracks or fretting.

Replace the EGR differential pressure sensor adapter if cracks are found.

## Install

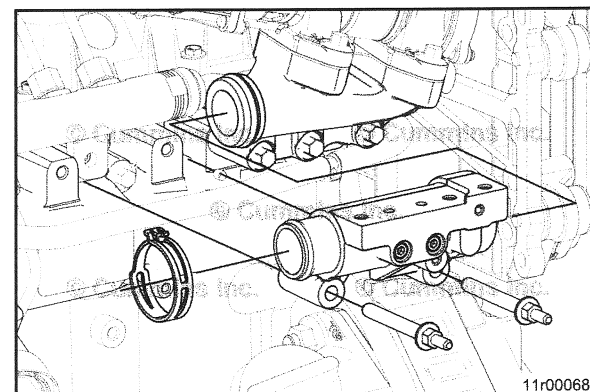
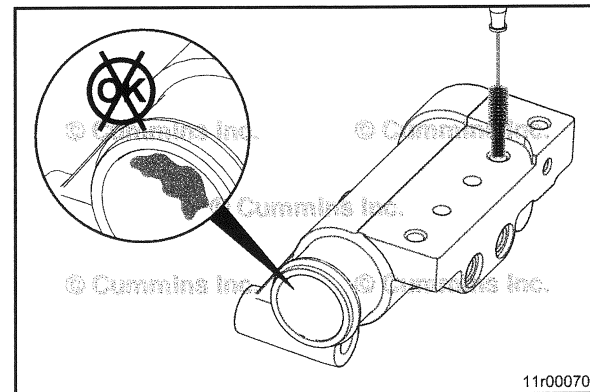
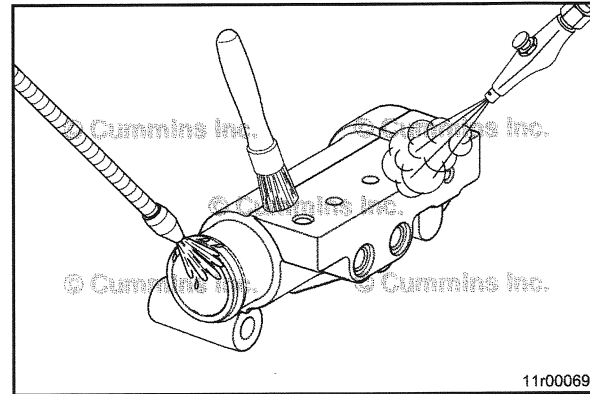
Position the adapter onto the air intake manifold, as illustrated in the graphic.

Install two mounting capscrews into the air intake manifold.

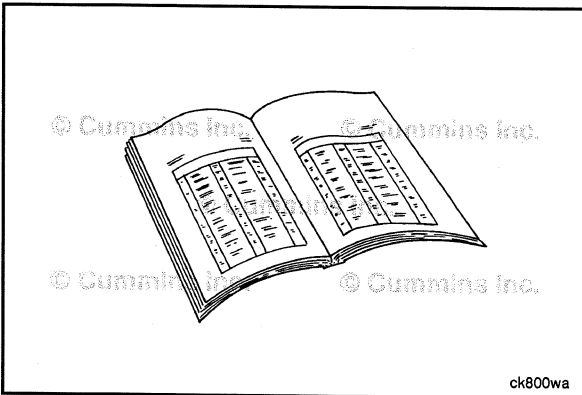
Tighten the capscrews.

**Torque Value:** 18 N•m [ 159 in-lb ]

Install the spring hose clamp onto the inlet of the air transfer tube.





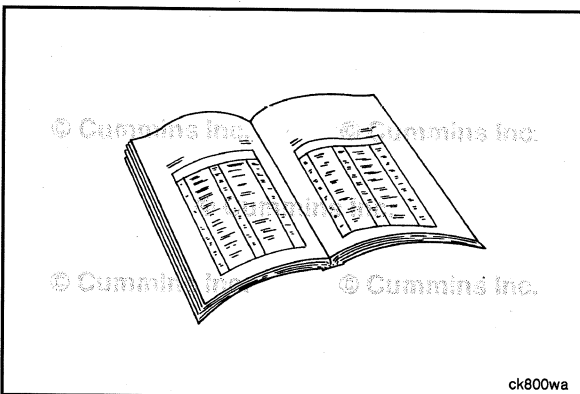


## Finishing Steps

### ▲ WARNING ▲

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

- Install the EGR crossover tube to the EGR differential pressure sensor adapter. Refer to Procedure 011-070 in Section 11.
- Install the EGR differential pressure sensor. Refer to Procedure 019-370 in Section 19.
- Connect EGR differential pressure sensor to the engine wiring harness. Refer to Procedure 019-370 in Section 19.
- Connect the batteries. See equipment manufacturer service information.



## EGR Cooler Mounting Bracket (011-029)

### 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 ▲

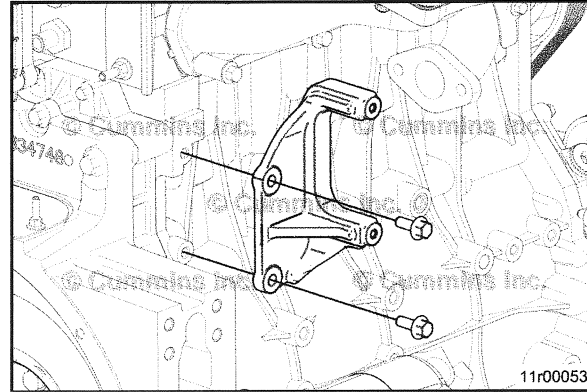
Do not remove the pressure cap from a hot engine. Wait until the coolant temperature is below 50°C [120°F] before removing the pressure cap. Heated coolant spray or steam can cause personal injury.

- Disconnect the batteries. See equipment manufacturer service information.
- Drain the coolant. Refer to Procedure 008-018 in Section 8.
- Remove the exhaust gas recirculation (EGR) connection tube. Refer to Procedure 011-025 in Section 11.
- Remove the exhaust gas pressure sensor tube. Refer to Procedure 011-027 in Section 11.
- Remove the EGR cooler coolant lines. Refer to Procedure 011-031 in Section 11.
- Remove the EGR cooler. Refer to Procedure 011-019 in Section 11.

## Remove

Remove the two EGR cooler support bracket mounting capscrews from the cylinder block.

Remove the EGR cooler mounting bracket.

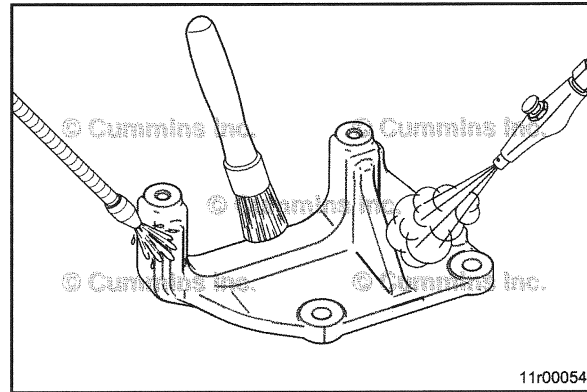


## Clean and Inspect for Reuse

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

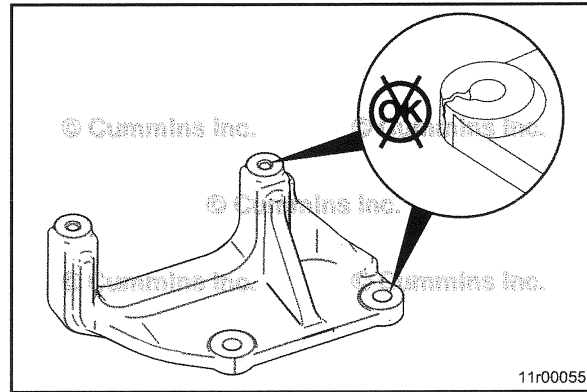
**⚠ WARNING ⚠**  
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturer's recommendations for use. Wear goggles and protective clothing to reduce the possibility of personal injury.

Clean the EGR cooler mounting bracket with solvent and dry with compressed air.



Inspect the EGR cooler mounting bracket for cracks or other damage.

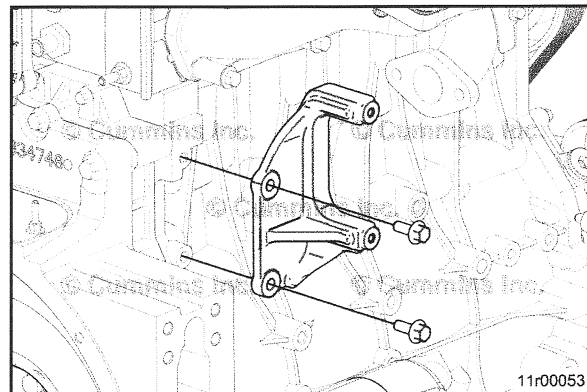
Replace the EGR cooler mounting bracket if damaged.

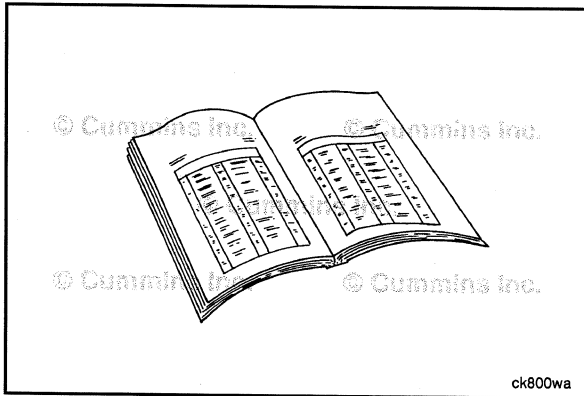


## Install

Install the two EGR cooler mounting bracket capscrews to the cylinder block.

**Torque Value:** 43 N•m [ 32 ft-lb ]





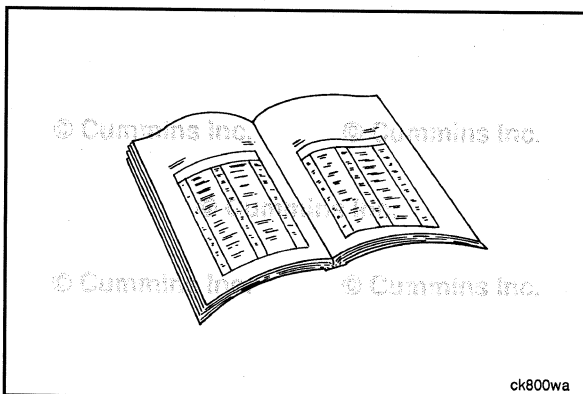
## Finishing Steps



### ▲ 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 EGR cooler. Refer to Procedure 011-019 in Section 11
- Install the EGR cooler coolant lines. Refer to Procedure 011-031 in Section 11
- Install the exhaust gas pressure sensor tube. Refer to Procedure 011-027 in Section 11.
- Install the EGR connection tube. Refer to Procedure 011-025 in Section 11
- 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.



## EGR Cooler Coolant Lines (011-031)

### 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.

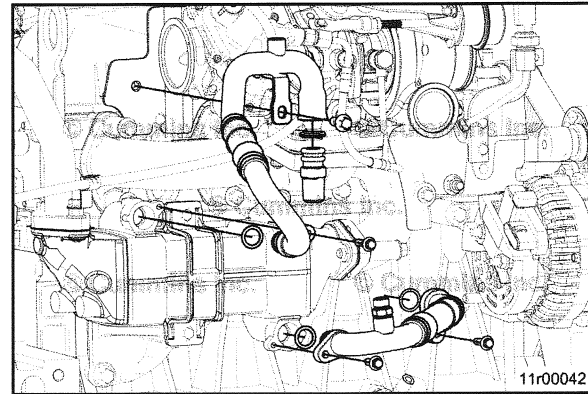
- Disconnect the batteries. See equipment manufacturer service information.
- Drain the coolant. Refer to Procedure 008-018 in Section 8.

## Remove

Remove the capscrew holding the coolant return tube to the exhaust gas recirculation (EGR) cooler.

Remove the coolant tube.

Remove the capscrews holding the coolant supply tube to the cylinder block and EGR cooler.

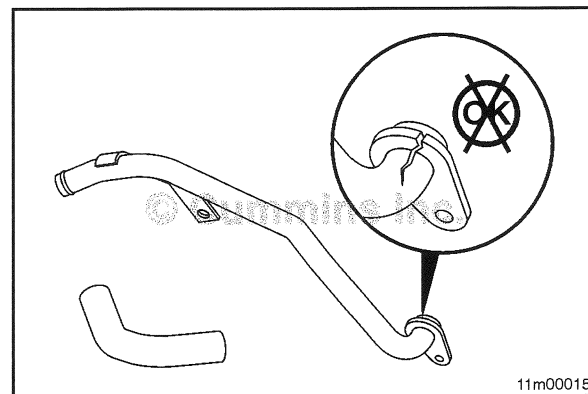


## Clean and Inspect for Reuse

Inspect the hoses and tubes for cracks, plugging, restrictions, and pinched areas. Replace if damaged.

Inspect the hose clamps for cracking. Replace if damaged.

Inspect the sealing ring for cracks. Inspect the o-ring groove for burrs or nicks that can cut the o-ring. Replace if damaged.



## Install

Lubricate all coolant tube o-rings with P80 lubricant before installation.

Install the o-rings on the end of the coolant return tube.

Install the coolant return tube.

Align the coolant tube to the securing position on the cylinder head and EGR cooler.

Install the support capscrew into the EGR cooler.

**Torque Value:** 9.5 N•m [ 84 in-lb ]

Install capscrew to support bracket attached to rocker cover heat shield.

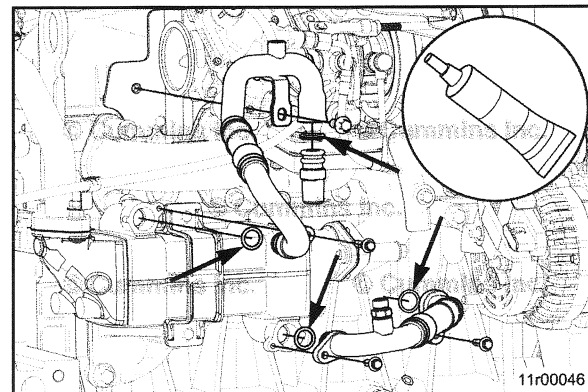
**Torque Value:** 24 N•m [ 212 in-lb ]

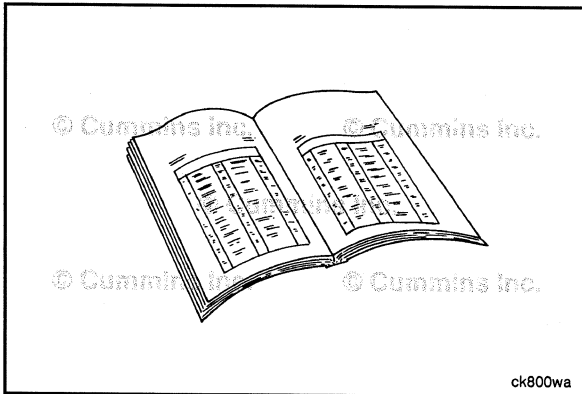
Install the coolant supply tube.

Align the coolant supply tube to the securing position on the cylinder block and EGR cooler.

Install the capscrews holding the coolant supply tube to the cylinder block and EGR cooler.

**Torque Value:** 9.5 N•m [ 84 in-lb ]





## Finishing Steps

### ▲WARNING▲



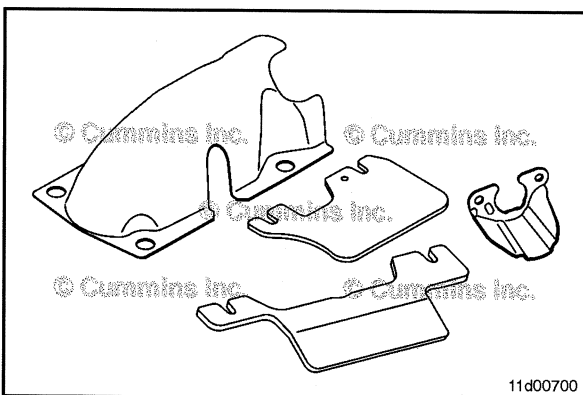
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



### ▲WARNING▲

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

- Fill the engine 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.



## Heat Shield (011-032)

### General Information



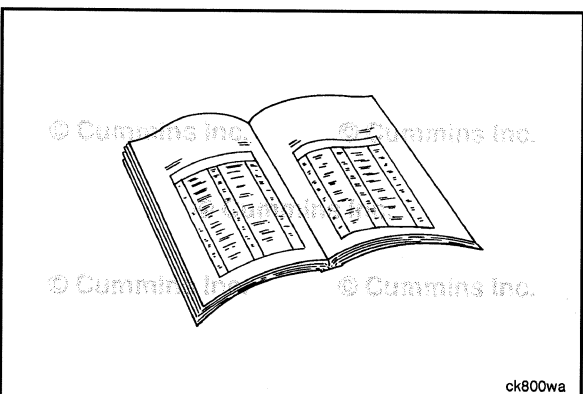
### ▲WARNING▲

The exhaust and exhaust components can remain hot after the engine is shut down. To reduce 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▲

Wear goggles and protective clothing to reduce the possibility of personal injury.

Heat shields reduce heat exposure to various components from the exhaust and exhaust gas recirculation (EGR) components.



## Preparatory Steps



### ▲WARNING▲

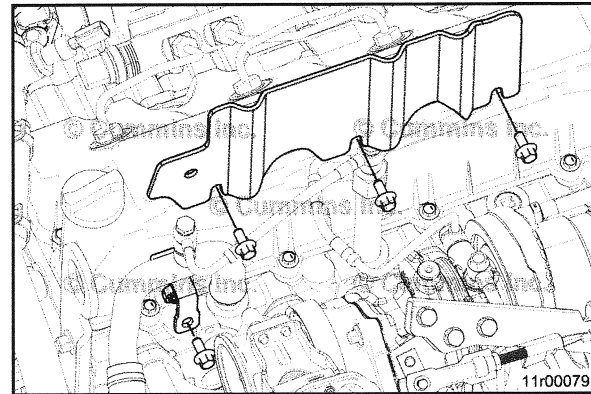
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries. See equipment manufacturer service information.

### Remove

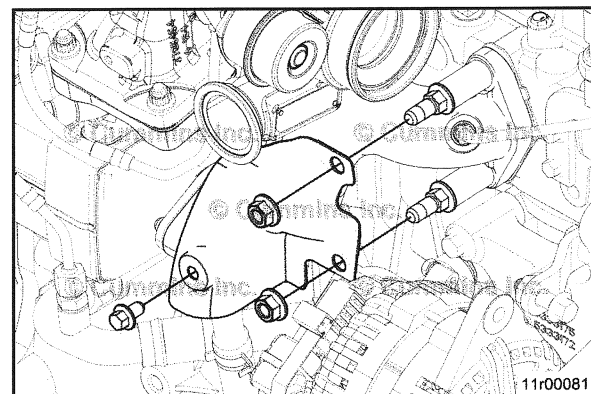
Remove the EGR coolant outlet tube support bracket mounting capscrew.

Remove rocker cover heat shield.

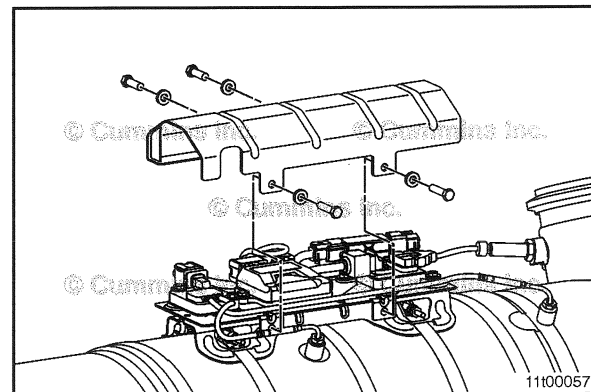


The exhaust manifold heat shield is mounted to the exhaust manifold with one capscrew and two flanged nuts.

Remove the heat shield.



The selective catalytic reduction (SCR) sensor table heat shield is **not** applicable to or required for all original equipment manufacturers (OEMs). The SCR sensor table heat shield mounts to the SCR sensor table.



### Clean and Inspect for Reuse

#### ▲ WARNING ▲

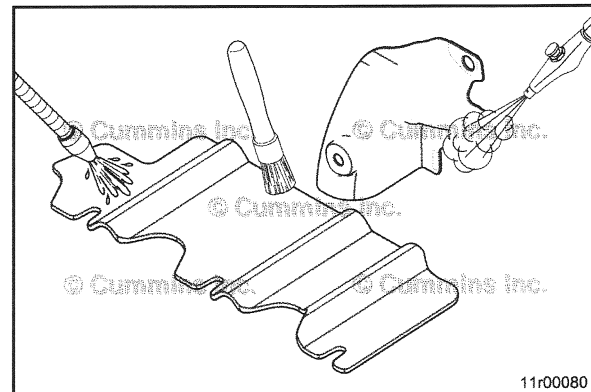
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

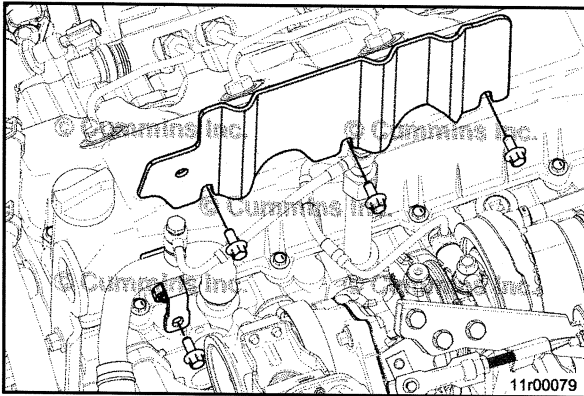
Inspect the heat shield for cracks or other damage.

Replace the heat shield if any damage is found.

Wash the heat shield in a hot, soapy water solution or steam clean if desired.

Dry with compressed air.





### Install

Install all heat shields.



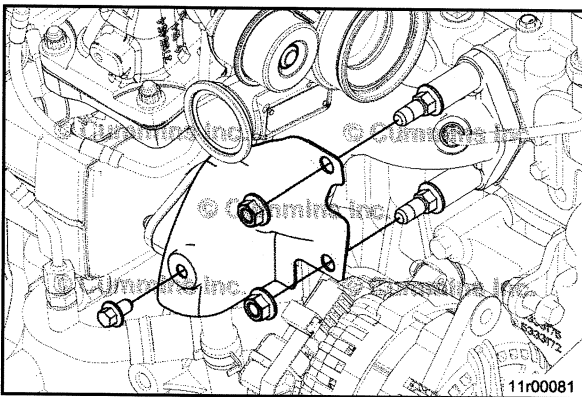
Rocker cover heat shield:

- Hand start three cap screws into the cylinder head.
- Align the heat shield slotted holes to the cap screws in the cylinder head and tighten from the center out.

**Torque Value:** 33 N•m [ 24 ft-lb ]

- Install EGR coolant outlet tube support bracket mounting cap screw.

**Torque Value:** 24 N•m [ 212 in-lb ]

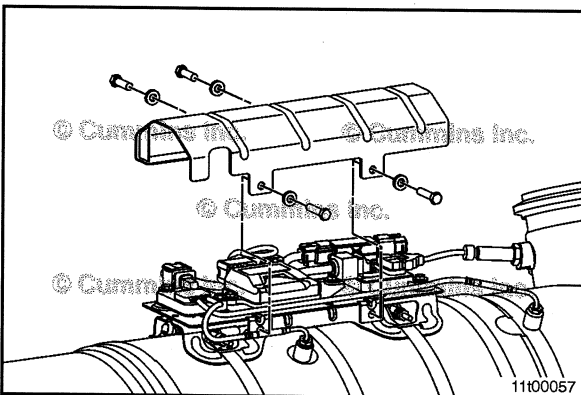


Exhaust manifold heat shield:

- Assemble and tighten the heat shield to the exhaust manifold with one cap screw and two flange nuts.



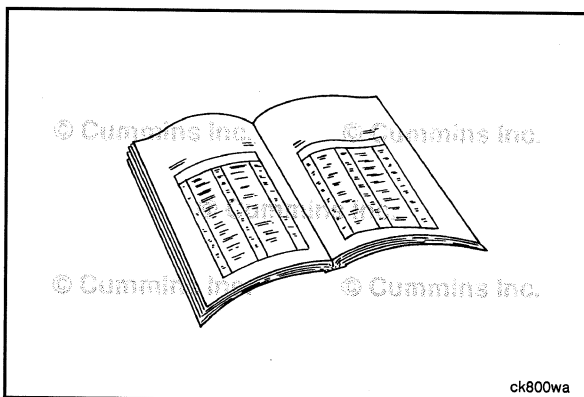
**Torque Value:** 24 N•m [ 212 in-lb ]



The SCR sensor table heat shield is **not** applicable or required for all OEMs. The SCR sensor table heat shield mounts to the SCR sensor table.

Mounting cap screw torque value:

**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.

## 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 ▲

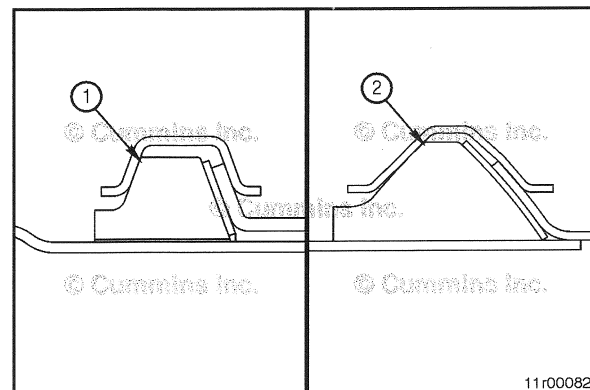
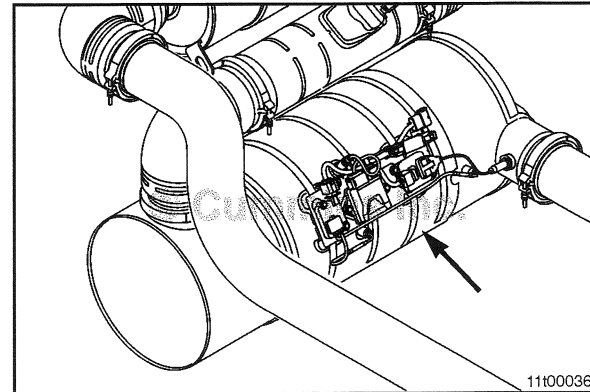
The catalyst elements contained in the aftertreatment system are made of brittle material. Do not drop or strike the side of the aftertreatment system, as damage to the catalyst element can result.

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.

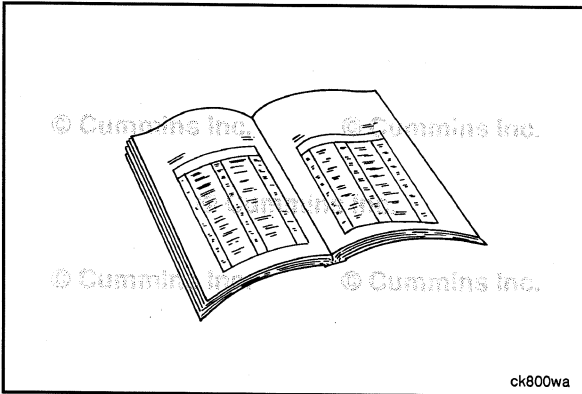
Different vehicles will require different aftertreatment configurations. Some of the aftertreatment selective catalytic reduction (SCR) catalysts can have elbows clamped to them.

Variations in vehicle aftertreatment configuration will drive the use of different flanges. The clamps and gaskets on either end of the aftertreatment SCR catalyst may be different from one another.

There are two types of flanged joints, full Marmon (1) and spherical Marmon (2). The spherical Marmon joints allow a small amount of misalignment and have a rounded cross section. The full Marmon™ joints are completely rigid and have a more edgy profile.







## 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 the 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.
- If equipped, remove the aftertreatment SCR heat shield. Refer to Procedure 011-032 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.

Support the aftertreatment decomposition tube to prevent it from being freely suspended after the aftertreatment SCR catalyst is removed. If supporting the tube 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.

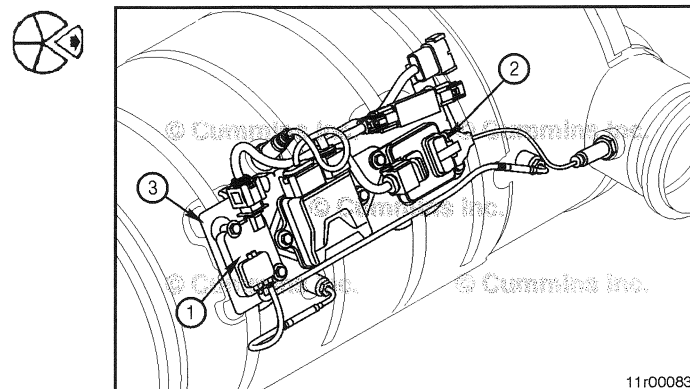
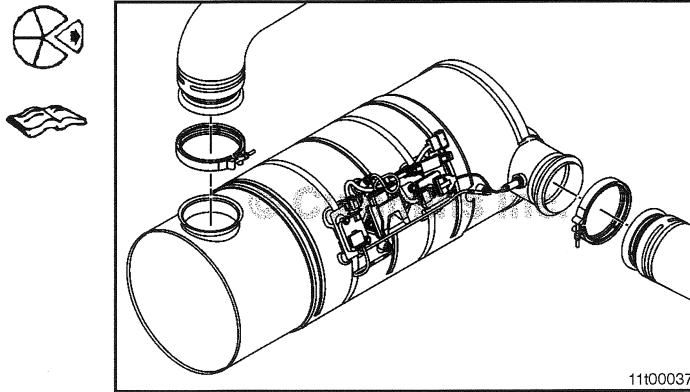
## Disassemble

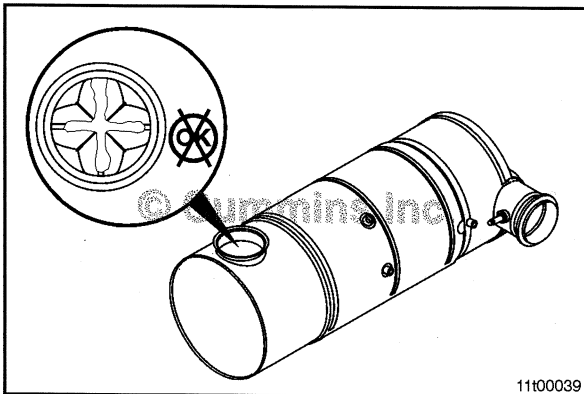
If the aftertreatment SCR catalyst is being replaced, complete the following procedures to remove the key parts of the aftertreatment SCR catalyst.

Disconnect and remove the aftertreatment exhaust gas temperature sensor assembly (1). Refer to Procedure 019-449 in Section 19.

Remove the aftertreatment outlet NOx sensor module and probe assembly (2). Refer to Procedure 019-451 in Section 19.

Remove the aftertreatment SCR catalyst temperature sensor interface module mounting bracket (3).





## 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.

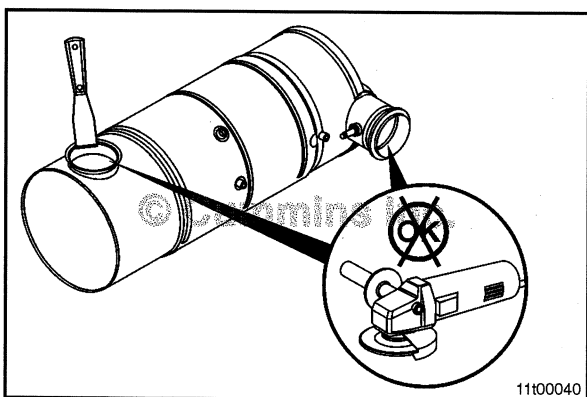
Inspect the aftertreatment SCR catalyst inlet for DEF deposits.

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 DEF 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.



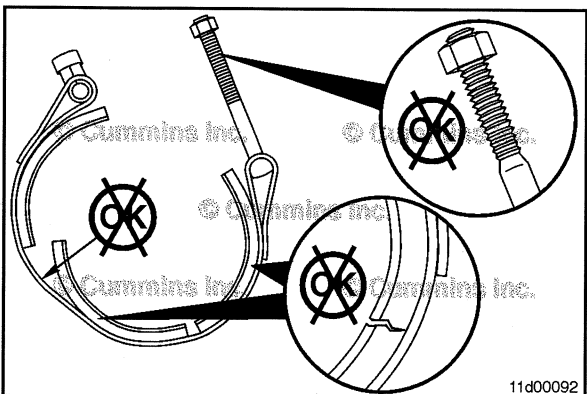
Inspect the exhaust flanges for corrosion or other damage.



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

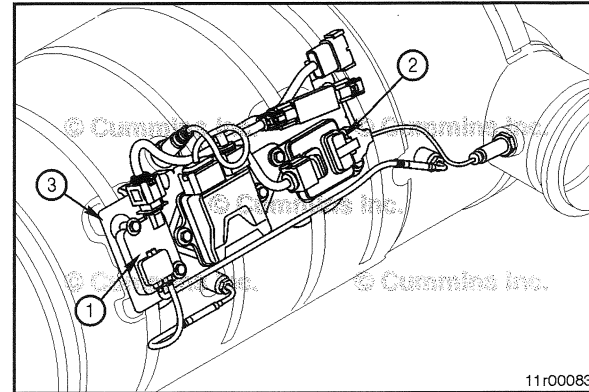
Install the aftertreatment SCR catalyst temperature sensor interface module mounting bracket (3).

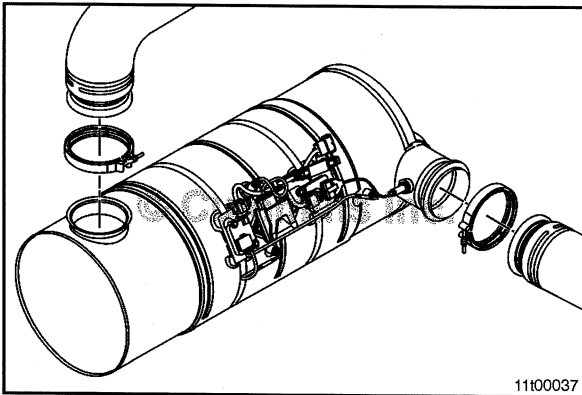
Install the aftertreatment outlet NOx sensor module (2) on the aftertreatment SCR catalyst temperature sensor interface module mounting bracket. Refer to Procedure 019-451 in Section 19.

Install the aftertreatment exhaust gas temperature sensor assembly (1). Refer to Procedure 019-449 in Section 19.

Install and connect the aftertreatment interface harness (1).

Install the aftertreatment SCR heat shield. Refer to Procedure 011-032 in Section 11.





## 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  $\pm 10$  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 anti-seize compound, Cummins® 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.

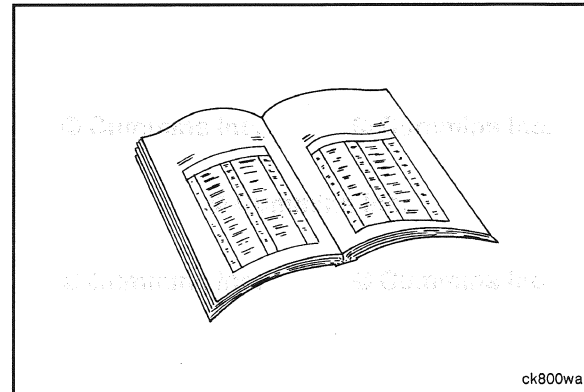
Tighten the exhaust hangers. See the equipment manufacturer service information.

## 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.

- Connect the batteries. See the 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.



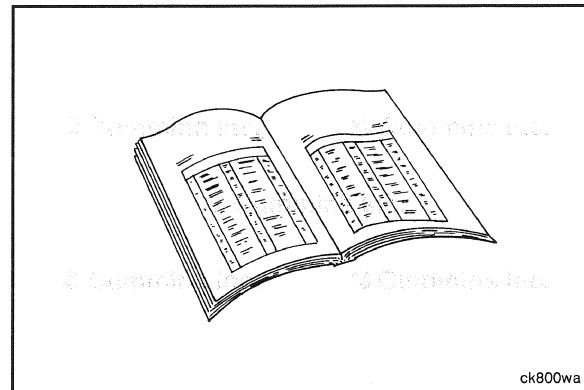
ck800wa

## EGR Valve Mounting Bracket (011-044)

### Preparatory Steps

#### Automotive With CM871

- Remove the exhaust gas recirculation (EGR) valve. Refer to Procedure 011-022 in Section 11.



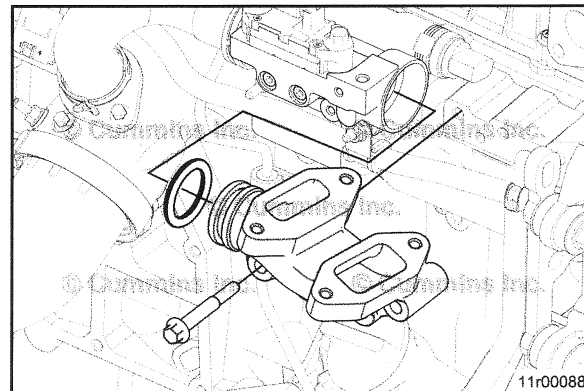
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### Remove

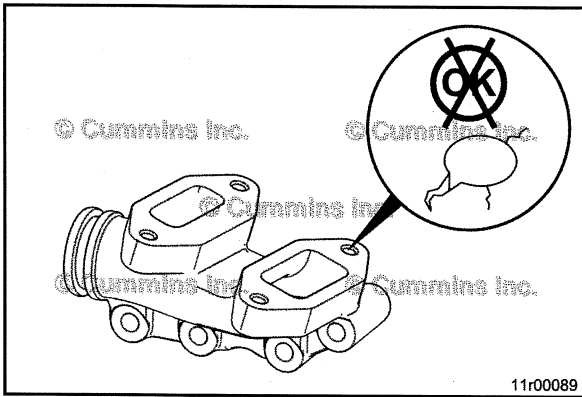
Remove the EGR valve mounting bracket capscrews from the intake manifold.

Remove the bracket from the bore of the differential pressure sensor module.

Discard the o-ring.

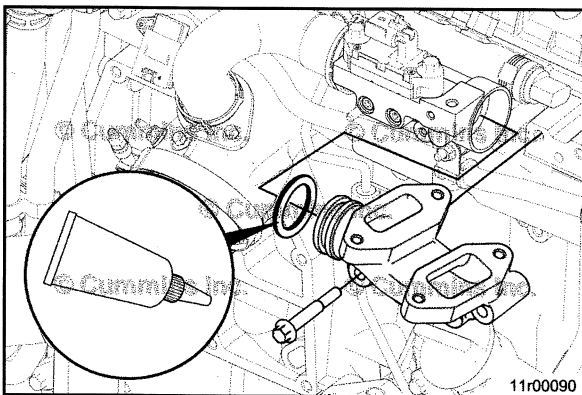


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### Clean and Inspect for Reuse

Inspect the ends, o-ring groove, and mating joints of the bracket for signs of fretting or material transfer, cracks, or other damage. Replace the EGR valve support bracket if fretting or material transfer, cracks, or other damage is found.



### Install

Install a new o-ring onto the groove of the EGR valve mounting bracket.

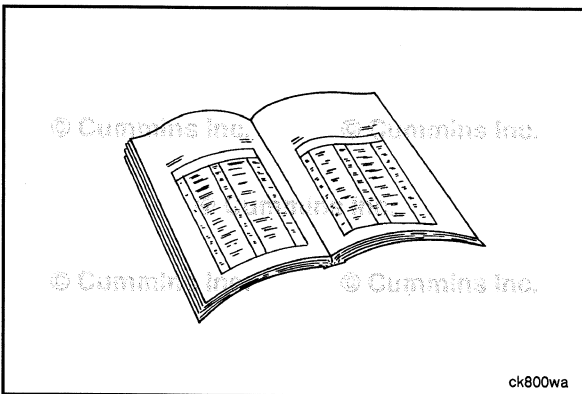


Lubricate the o-ring with P-80 rubber lubricant.

Insert the support bracket into the bore of the EGR differential pressure sensor module.

Install and tighten the capscrews to the intake manifold.

**Torque Value:** 18 N·m [ 159 in-lb ]



### Finishing Steps

- Install the EGR valve and a new EGR seal. Refer to Procedure 011-022 in Section 11.



- Operate the engine and check for leaks.



## Exhaust System Diagnostics (011-056) Test

### ⚠ 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. 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 add water or any other fluid besides what is specified to the diesel exhaust fluid (DEF) tank. The aftertreatment system may be damaged.

**NOTE:** This procedure is **only** for applications equipped with a Selective Catalytic Reduction (SCR) aftertreatment system.

Having the correct concentration of DEF is critical to the engine and aftertreatment system performing correctly.

Keeping the DEF clean is equally important to the engine and aftertreatment system performing correctly.

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 or unclean DEF; lack of maintenance of aftertreatment; improper storage, or shutdown practices; unauthorized modifications of the engine and aftertreatment. Cummins Inc. is also **not** responsible for failures caused by incorrect DEF or by water, dirt, or other contaminants in the DEF.

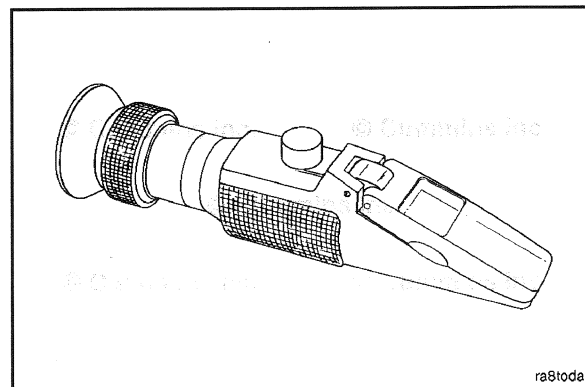
To test the concentration of the DEF, use the Cummins® DEF refractometer, Part Number 4919554. Follow the instructions provided with the service tool.

**NOTE:** The concentration of the DEF **must** be  $32.5 \pm 0.7$  percent by weight, however when using the Cummins® DEF refractometer service tool, the acceptable DEF measurement specification is  $32.5 \pm 1.5$  percent. This specification takes into consideration the refractometer tool tolerances, variability, and calibration when measuring DEF concentration.

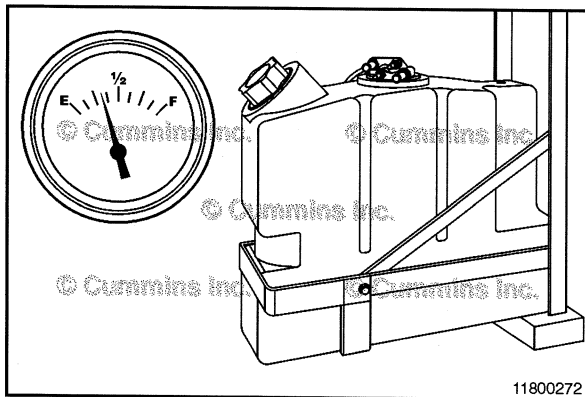
If the DEF concentration is found to be outside this specification, drain the DEF tank, flush it with distilled water, and then fill the tank with new and/or known good DEF. Check the DEF concentration.

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/damaged or the tank vent fails.
- Filling the aftertreatment DEF tank with the incorrect fluid.
- Filling the aftertreatment DEF tank with dirty and/or contaminated containers.

In the event the DEF becomes contaminated, inspect the DEF to determine the most likely source.

Obtain a sample from the DEF tank and pour it into an appropriate container. Make sure to obtain a sample from the highest fluid level.

Petroleum base 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 odors.

If contaminated, reference the information detailed later in this procedure.

Non-petroleum base liquids, such as, but not limited to:

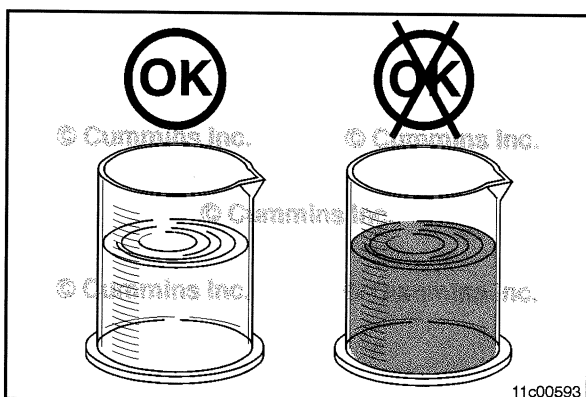
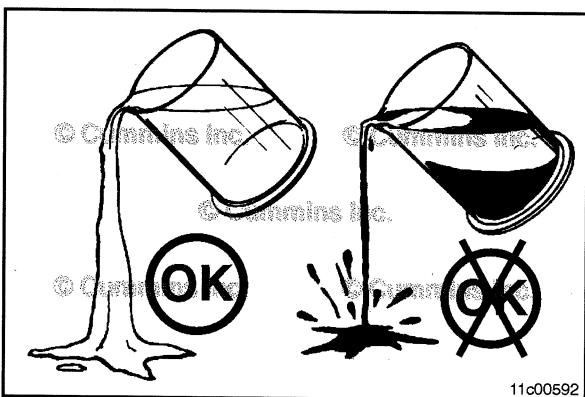
- Water
- Coolant
- Windshield washer fluid.

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 it with distilled water, and fill the tank with new and/or known good DEF. Check the DEF concentration after completing the fill. Reference the Test section of this procedure.

For other non-petroleum based liquids that may have been added to the DEF, those fluids typically 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 contaminated, reference the information detailed later in this procedure.



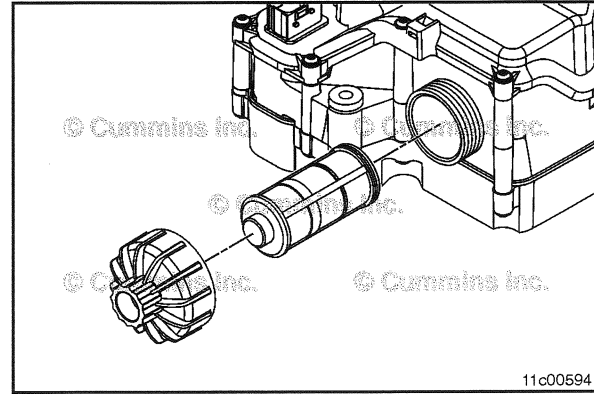
**QSF3.8 CM2350 F107**  
**Section 11 - Exhaust System - Group 11**

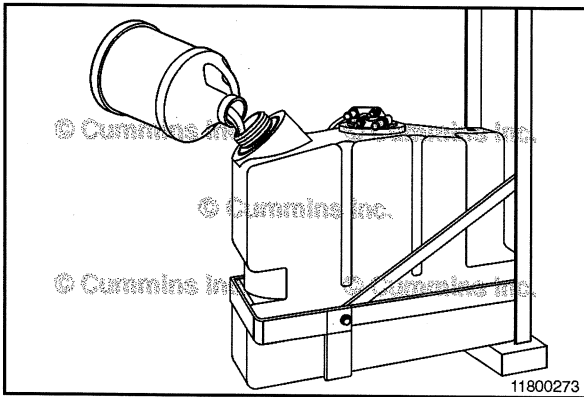
**NOTE:** Make sure to view and troubleshoot any fault codes that occur during the following steps with INSITE™ electronic service tool. Reference the QSF3.8 CM2350 F107 Fault Code Troubleshooting Manual, Bulletin 4367319.

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, flush it with distilled water, and replace the DEF in-tank filter. See equipment manufacturer service information for specific information on servicing the DEF tank.

After the DEF tank has been cleaned, fill with new and/or known good DEF. Check the DEF concentration after completing the fill. Reference the Test section of this procedure.





**NOTE:** Any discarded contaminated fluids and/or parts should be disposed of according to local area ordinances.

If the contaminated fluid did go through the dosing system:

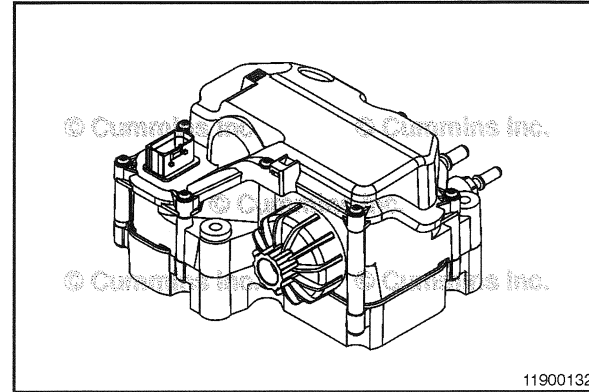
- 1 Drain the DEF tank, flush with several fills of water until it is clean and clear of contamination. Replace the DEF in-tank filter. See equipment manufacturer service information for specific information on servicing the DEF tank.
- 2 Clean and rinse the aftertreatment DEF dosing unit filter with distilled water. Refer to Procedure 011-060 in Section 11.
- 3 Fill the aftertreatment DEF tank with distilled water.
- 4 Perform INSITE™ electronic service tool DEF Dosing Unit Override Test. Repeat the test until the distilled water flows clear. Use the Cummins® DEF refractometer, Part Number 4919554, to check the concentration of the distilled water after being sprayed out of the dosing system. If the system is free of contaminants, distilled water will register zero percent concentration. Refer to Procedure 011-063 in Section 11.
- 5 Drain the distilled water from the DEF tank and fill with new and/or known good DEF. Check the DEF concentration after completing the refill, reference the Test section of this procedure.
- 6 Replace the aftertreatment DEF dosing unit filter. Refer to Procedure 011-060 in Section 11.
- 7 Use the following procedure to test the performance and spray pattern of the aftertreatment DEF dosing valve and perform INSITE™ electronic service tool DEF Dosing Unit Override Test. Residual water in the dosing system can possibly lower the DEF concentration being sprayed. Continue to perform the DEF Dosing Unit Override Test until DEF is sprayed out of the dosing system. Use the Cummins® DEF refractometer, Part Number 4919554, to check for proper concentration of the DEF. Refer to Procedure 011-063 in Section 11.
- 8 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 control valve. Any unused DEF is then routed back to the aftertreatment DEF tank. Use the following procedure for further information on the aftertreatment DEF dosing system. Refer to Procedure 011-999 in Section 11.

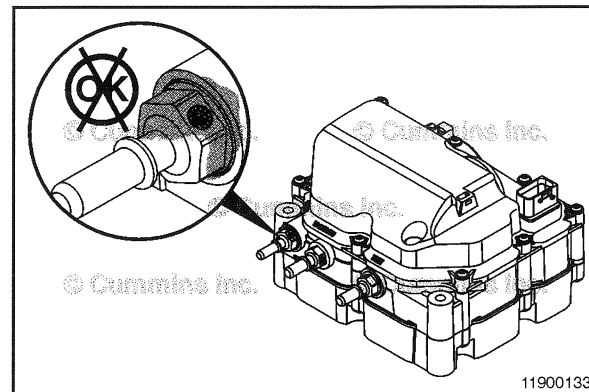
**NOTE:** The aftertreatment DEF dosing unit has a serviceable filter. Refer to Procedure 011-060 in Section 11. If the aftertreatment diesel exhaust fluid dosing unit is damaged, the entire assembly **must** be replaced.



### Initial Check

Check the diesel exhaust fluid lines going to and returning from the dosing unit for any signs of a leak. Diesel exhaust fluid will form a white deposit around leaky fittings.

If deposits are found, inspect the diesel exhaust fluid line connection fittings for damage. See equipment manufacturer service information.



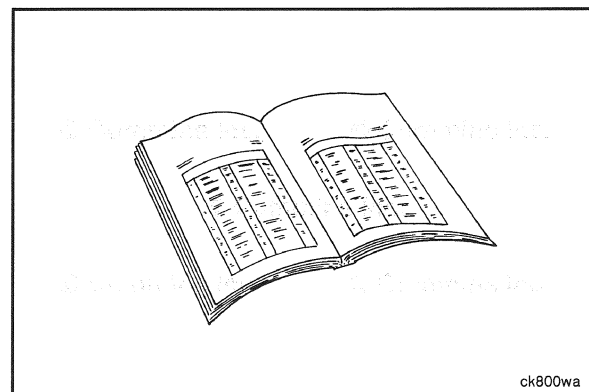
### Preparatory Steps

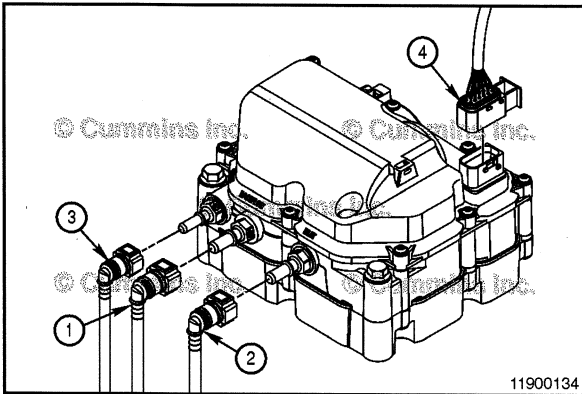
#### ⚠ CAUTION ⚠

Wait for the aftertreatment diesel exhaust fluid dosing unit to completely purge its system if the engine was recently running. This can be accomplished by keying off and waiting for the selective catalytic reduction (SCR) system to cool. The diesel exhaust fluid dosing unit will make an audible pumping noise, similar to a lift pump, within five minutes after being keyed off.

- Disconnect the batteries. See equipment manufacturer service information.

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





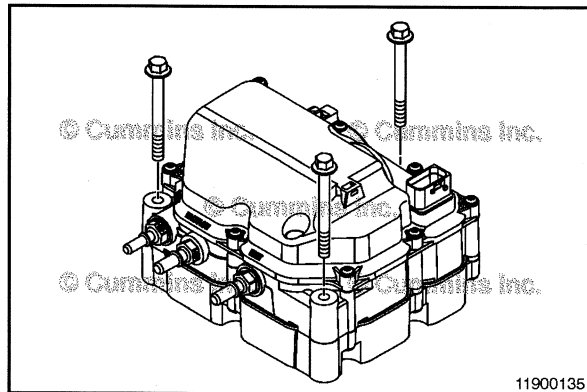
Label and mark each DEF to its mating connector or the aftertreatment dosing control unit. If the lines are connected incorrectly, the system will **not** work properly and will light a fault lamp.

Disconnect the DEF lines and electrical connections that are attached to the dosing unit:

- 1 DEF return to the tank
- 2 DEF supply to the aftertreatment DEF dosing unit
- 3 DEF supply to the aftertreatment DEF dosing valve
- 4 12-pin Tyco connector.

The DEF lines are connected to the dosing unit by quick release fittings which may vary between vehicle manufacturers. See equipment manufacturer service information for a detailed removal process.

Cap the connectors of the aftertreatment DEF dosing unit to prevent contamination.



## Remove

Locate the aftertreatment DEF dosing unit on the vehicle.

The aftertreatment DEF dosing unit is secured to the chassis by three mounting capscrews. Depending on the installation, it can be easier to remove the DEF lines and connectors either before or after the removal of the dosing unit. See equipment manufacturer service information for DEF line removal.

Wipe the front of the aftertreatment DEF dosing unit with a clean, damp cloth to remove any contamination and reduce the risk of contamination entering the dosing unit.

Remove the three mounting bolts.

Record the information from the dataplate located on the top of the dosing unit. Note the voltage of the unit.

**NOTE:** Do **not** interchange 12 and 24-VDC aftertreatment DEF dosing units.

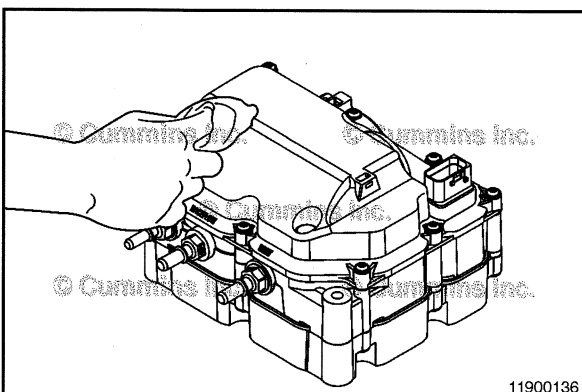
## Clean and Inspect for Reuse

**NOTE:** This unit is **not** serviceable. Do **not** open the case. Return the unit to a Cummins® Authorized Repair Location.

Do **not** immerse the unit in any kind of solution.

Do **not** wash with any detergents.

Use **only** a clean, damp cloth to wipe the unit.



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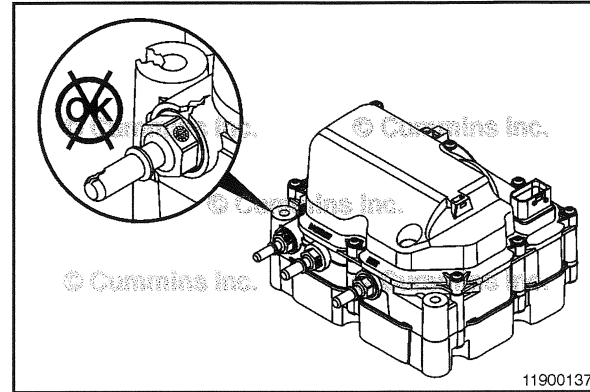
Inspect the outside of the unit. If there are any cracks or damage to the exterior of the case, electrical connectors, or the DEF quick disconnect connectors, replace the dosing unit.



Check all the connections, lines, and fittings for any signs of leaks or damage.

Refer to Procedure 011-060 in Section 11.

Repair and replace the connections, as necessary.



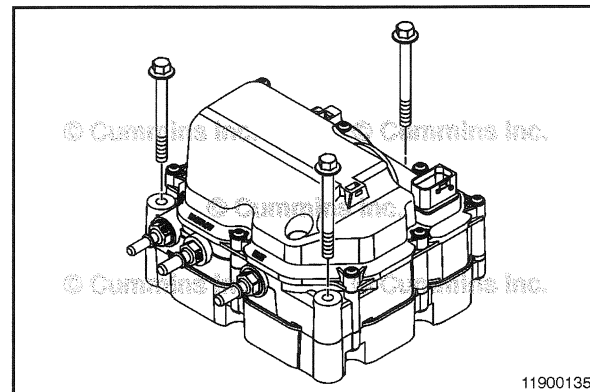
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**Install**

**NOTE:** Make sure the unit is kept free from any contamination during installation to the vehicle. To reduce the possibility of false DEF leak reports, use a clean, damp cloth to wipe any spilled DEF.



Attach the aftertreatment DEF dosing unit to the OEM mounting bracket and secure with the three cap screws. See equipment manufacturer service information.

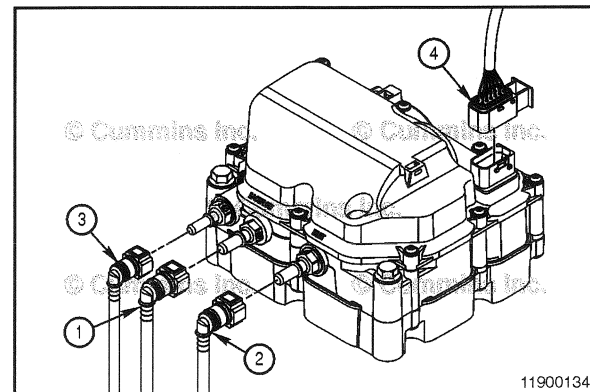


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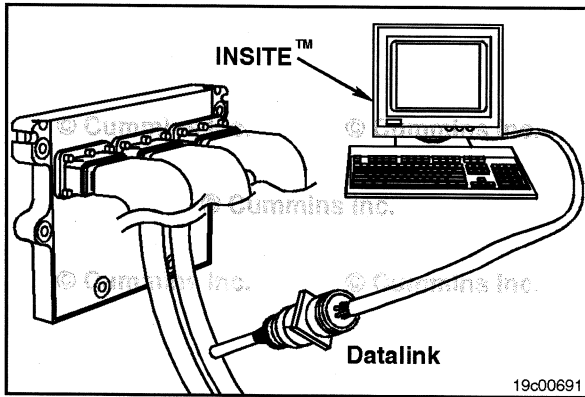
Install the electrical connections and DEF lines to the aftertreatment DEF dosing unit.



- 1 DEF return to the tank
- 2 DEF supply to aftertreatment DEF dosing unit
- 3 DEF supply to aftertreatment DEF dosing valve
- 4 12-pin Tyco connector.



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## Test

### ⚠ WARNING ⚠

Do not stand directly above a container of diesel exhaust fluid, especially in the presence of an environment of low air flow as this can affect breathing.

Aftertreatment Diesel Exhaust Fluid Dosing Unit Override Test:

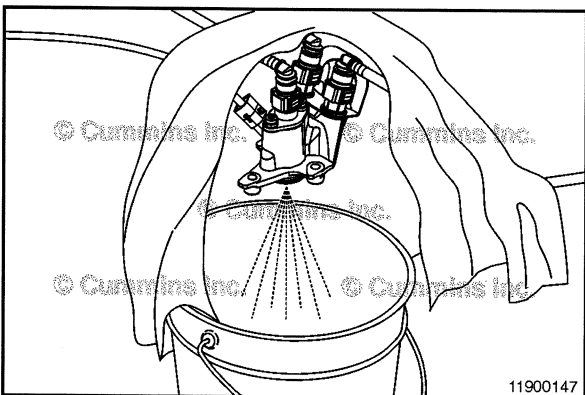
The purpose of this test is to run the aftertreatment DEF dosing unit through a dosing cycle and check for a specified amount of DEF solution delivered in a specified time. The test can be accessed through INSITE™ electronic service tool under Aftertreatment Diagnostic Tests. The aftertreatment DEF dosing unit override test is a fully automated test.

This test **must only** be run with the vehicle stationary, in neutral, with the keyswitch in the ON position.

There are three main states to the SCR aftertreatment cycle:

- 1 Priming
- 2 Dosing
- 3 Purging.

Remove the aftertreatment DEF dosing valve from the exhaust system. Refer to Procedure 011-059 in Section 11.



Place the valve into a graduated container of 4 liters [1 gal].

Place a clean shop towel or cover over the valve and graduated cylinder to prevent spillage.

The test runs for 5 minutes. After the test, measure the amount of DEF injected into the container.

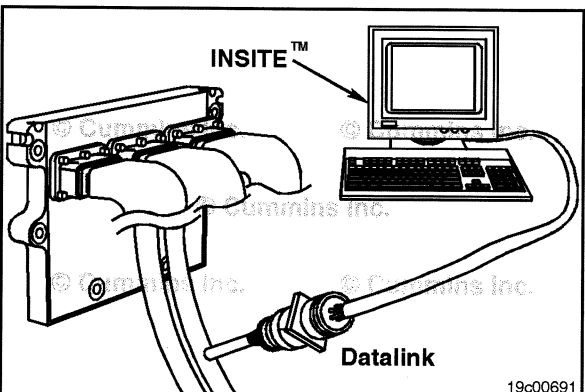
### Diesel Exhaust Fluid Injection Volume

ml		fl-oz
106	MIN	3.6
144	MAX	4.9

If the amount of DEF is **not** within specification:

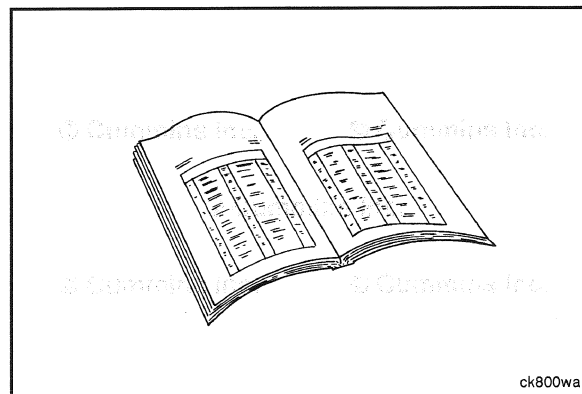
- Check to be sure the aftertreatment DEF dosing unit is priming properly.
- Check for blockages or restrictions in the dosing unit lines.
- Check for restrictions in the aftertreatment DEF dosing unit filter. Refer to Procedure 011-060 in Section 11.
- Perform the test again. If the amount of DEF is **not** within specification, replace the aftertreatment DEF dosing unit.

Install the aftertreatment DEF dosing valve in the exhaust system. Refer to Procedure 011-059 in Section 11.



## Finishing Steps

- Connect the batteries. See equipment manufacturer service information.
- Start and operate the engine.
- Check for active fault codes.



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## Aftertreatment Diesel Exhaust Fluid Dosing Valve (011-059)

### General Information

#### ⚠CAUTION⚠

Use care when handling and/or disconnecting the diesel exhaust fluid (DEF) line from the aftertreatment DEF dosing valve. The DEF supply connector of the aftertreatment DEF dosing valve can be easily damaged.

The aftertreatment DEF dosing valve (1) is used to spray DEF into the exhaust flow prior to the intake of the selective catalytic reduction (SCR) catalyst (2). The aftertreatment DEF dosing valve is located on the decomposition tube (3), mounted on a flange with three capscrews.

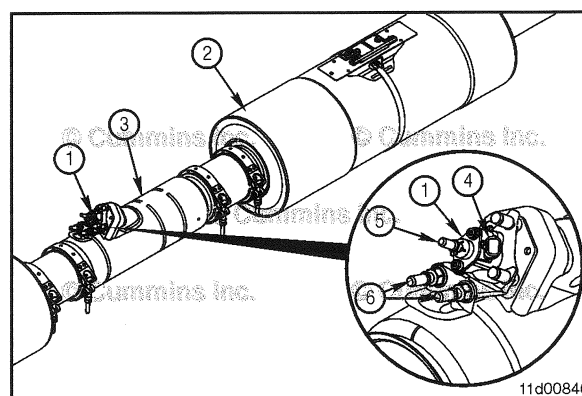
**NOTE:** The same aftertreatment DEF dosing valve is used for 12 volt and 24 volt systems.

There are four primary connections at the aftertreatment DEF dosing valve:

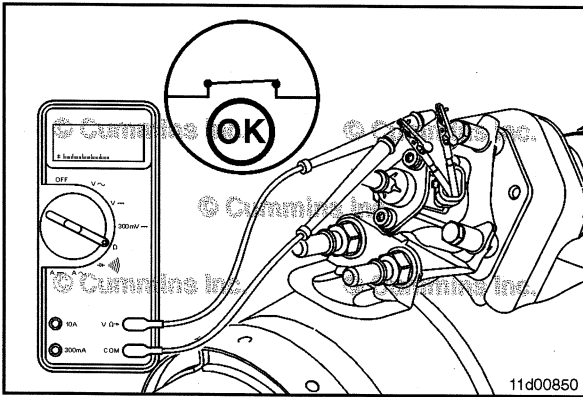
- (4) A 2-pin electrical connection.
- (5) A DEF supply line, which connects the aftertreatment DEF dosing valve to the aftertreatment DEF dosing unit.
- (6) The coolant supply and return connections are interchangeable. They connect the aftertreatment DEF dosing valve to the engine cooling system.

For further information on the operation of the aftertreatment DEF dosing valve, reference the following procedure. Refer to Procedure 011-999 in Section F.

For information on handling incorrect or contaminated DEF, reference the following procedure. Refer to Procedure 011-056 in Section 11.







## Measure

### Resistance Check



Use a multimeter to check the resistance of the aftertreatment DEF dosing valve.

**NOTE:** Repair connector, Cummins® Part Number 3164098 or equivalent, can be used as a test lead.

Resistance Specification:  $12 \pm 0.6$  ohms.

**NOTE:** The resistance **must** be measured at room temperature (approximately 25°C [77°F]).

If the measured value is **not** within specifications, replace the aftertreatment DEF dosing valve.

If the measured resistance is out of specification, the aftertreatment DEF dosing valve may have been overheated.

Inspect the outside of the aftertreatment DEF dosing valve for signs of discoloration from excessive heat.

Inspect for inadequate or lack of coolant flow to the aftertreatment DEF dosing valve. Verify there are no leaks, blockages, or restrictions in the coolant supply and return lines between the engine and the aftertreatment DEF dosing valve.

To check the coolant passages internal to the aftertreatment DEF dosing valve, reference the Clean and Inspect for Reuse section of this procedure.

## Initial Check

### ▲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 cause serious personal injury. 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▲

Do not use the flow test portion of INSITE™ electronic service tool diesel exhaust fluid (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.

A DEF leak in this area may come from:

1. The connection between the DEF line and the aftertreatment DEF dosing valve.

**NOTE:** Do **not** remove the DEF dosing valve (1) from the assembly (2). It is **not** a serviceable part.

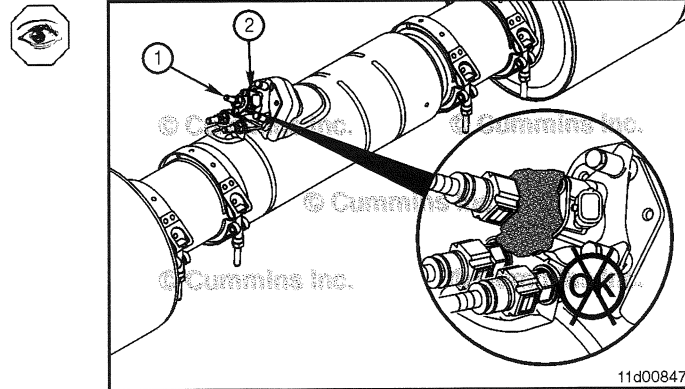
2. The DEF dosing valve joints between the valve and the valve assembly body.

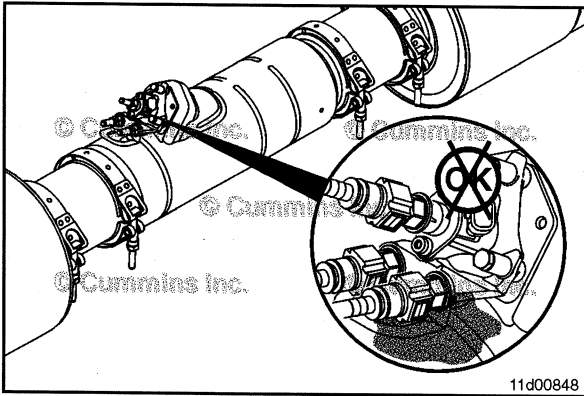
Due to deposit buildups possibly masking the source of the leak, it may be necessary to remove the deposits and clean the area with warm water.

**NOTE:** The aftertreatment DEF dosing system will **not** prime until the correct temperatures are reached.

Test drive the vehicle for a minimum of 15 minutes to get the SCR system up to temperature. Check the area again for the source of the leak.

Once the source of the DEF leaks and/or deposits are identified, reference the Clean and Inspect for Reuse section of this procedure.





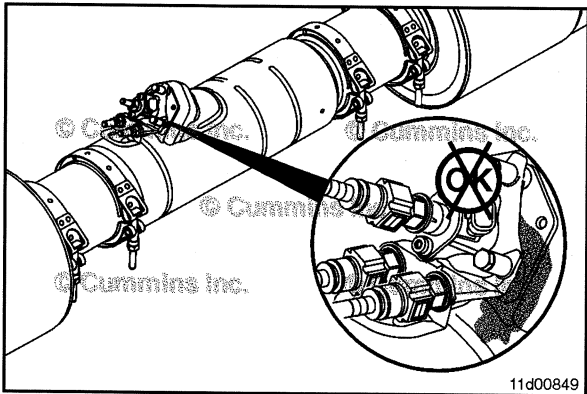
Inspect the dosing valve body and coolant fittings at the aftertreatment DEF dosing valve.

Inspect for signs of leaks and/or deposits.

If the aftertreatment DEF dosing 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 008-018 in Section 8.

If leaks and/or deposits are identified, reference the Clean and Inspect for Reuse section of this procedure after the connections are removed.

**Service Tip:** If removal of the coolant fittings and/or heat shield is necessary, remove/loosen the coolant fitting prior to removing the aftertreatment DEF dosing valve. Reference the Preparatory Steps and Disassemble sections 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, reference 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 diesel exhaust fluid (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 ▲

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

### ▲ WARNING ▲

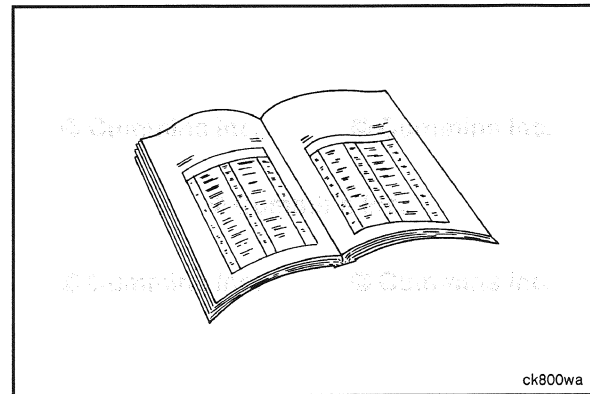
During regeneration, exhaust gas temperature can reach 800°C [1500°F], and exhaust system surface temperature can exceed 700°C [1300°F], which is hot enough to ignite or melt common materials, and to cause serious personal injury. The exhaust and exhaust components can remain hot after the vehicle has 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. Make sure that no combustible materials are located where they are likely to come in contact with hot exhaust or exhaust components.

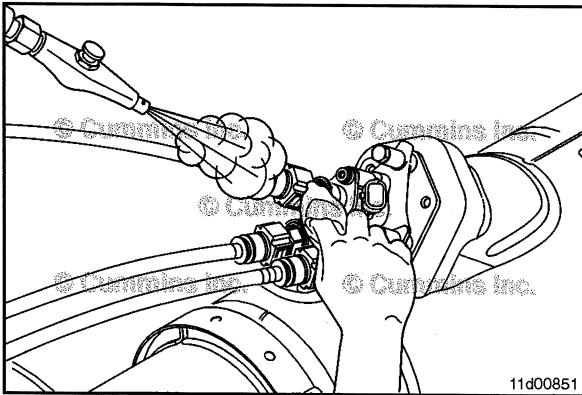
### ▲ WARNING ▲

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

**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.





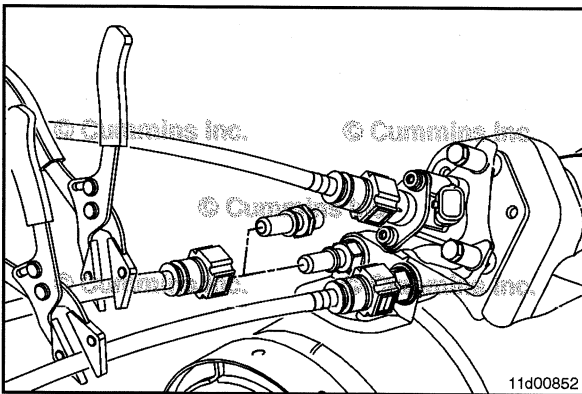
**▲ WARNING ▲**

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

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 aftertreatment decomposition tube, so that debris does **not** fall into the aftertreatment decomposition tube 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.



**Do not drain the cooling system.** Use one of the following two methods to prevent draining the cooling system when the aftertreatment DEF dosing valve coolant lines are disconnected.

Use the following instructions for method number 1.

**NOTE:** Prior to pursuing this method, inspect the aftertreatment DEF dosing valve coolant lines to make sure they are flexible hose material that will **not** be damaged when using the coolant hose pinch-off pliers.

Use a pair of coolant hose pinch-off pliers. Clamp both of the aftertreatment DEF dosing valve coolant lines.

Place a container under the aftertreatment DEF dosing valve. A small quantity of coolant may drain from the coolant lines when disconnected.

**NOTE:** The coolant supply/return and DEF lines are supplied by the original equipment manufacturer (OEM). The removal of these lines may vary by OEM. The fittings on the aftertreatment DEF dosing valve are set up for quick disconnect style fittings.

Disconnect the coolant lines. See equipment manufacturer service information.

Insert coolant line plugs, Cummins® Part Number 4919576, into the disconnected coolant lines. The coolant hose pinch-off pliers can be removed.

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Use the following instructions for method number 2.

Determine the appropriate radiator/coolant expansion tank cap adapter for the vehicle being serviced. The list of available caps and applications can be found in Section 14 of the Service Products Catalog.

Install the adapter on the radiator/coolant expansion tank. Connect an automotive hand-held vacuum pump and apply 76 mmHg [3 inHg] of vacuum.

**NOTE:** Depending on the cooling system configuration, more vacuum may be required to keep the cooling system in balance, especially on systems where there is a significant height difference between the aftertreatment DEF dosing valve and the radiator/coolant expansion tank fill location.

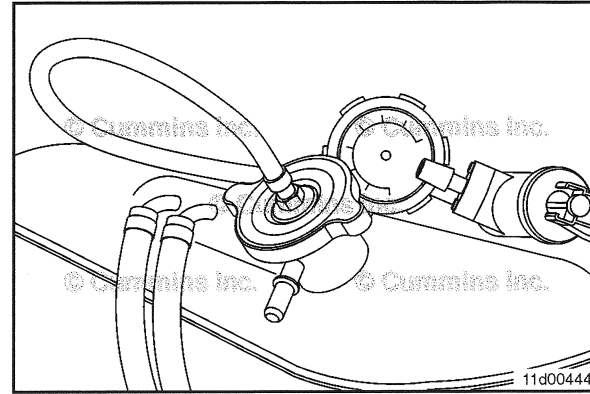
**NOTE:** The coolant supply and DEF lines are supplied by the OEM. The removal of these lines may vary by OEM. The fittings on the aftertreatment DEF dosing valve are set up for quick disconnect style fittings.

Place a container under the aftertreatment DEF dosing valve. A small quantity of coolant may drain from the coolant lines when disconnected.

Disconnect the coolant lines. See equipment manufacturer service information.

Insert coolant line plugs, Cummins® Part Number 4919576 or equivalent, into each of the disconnected coolant lines.

The vacuum pump can be removed.



**⚠ 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:

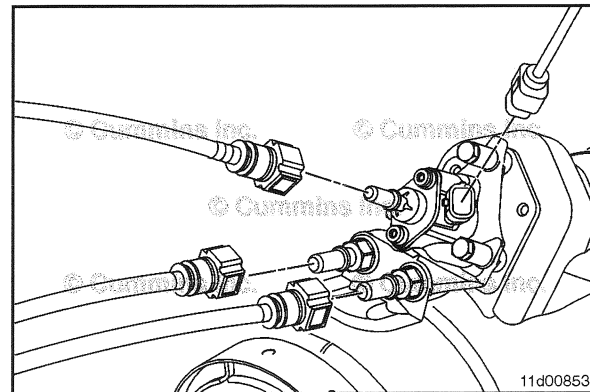
Place a small plastic container under the aftertreatment DEF dosing valve to catch any residual DEF prior to disconnecting the DEF supply line.

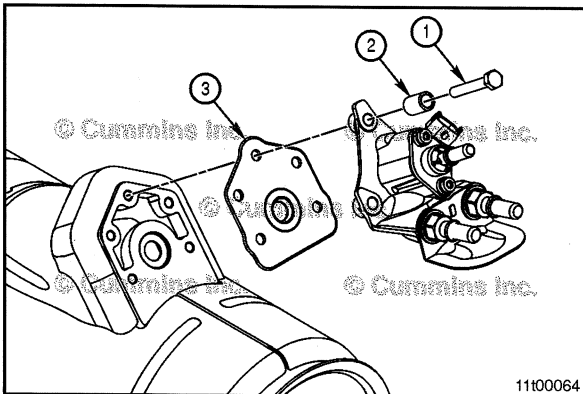
(1) Disconnect the DEF line. See equipment manufacturer service information.

**NOTE:** Protect the coolant and DEF ports with plastic caps to prevent entrance of dirt and debris.

Press the tab on the electrical connector and pull to disconnect the 2-pin electrical connector.

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 the cap screws (1) and spacers (2) that mount the aftertreatment DEF dosing valve to the decomposition tube.

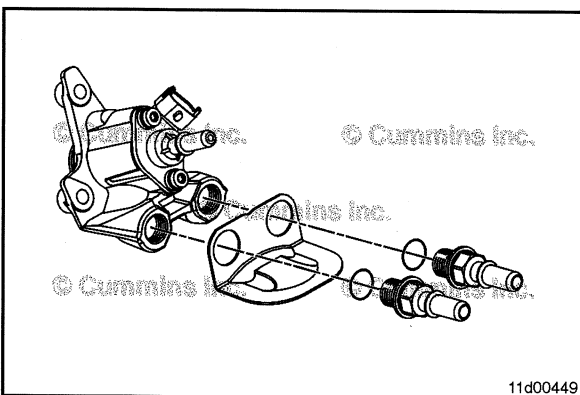
Remove the aftertreatment DEF dosing valve.

Remove the insulated gasket (3).

Discard the gasket.

**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.

**NOTE:** Plug the aftertreatment DEF lines to reduce the possibility of debris entering the system.



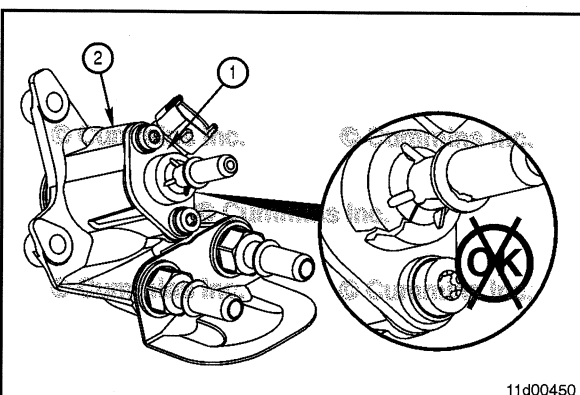
## Disassemble

**NOTE:** The aftertreatment DEF dosing valve should **only** be disassembled if a symptom has been identified that indicates further investigation is required.

Remove the two coolant fittings from the aftertreatment DEF dosing valve.

Remove the o-rings from the coolant fittings and discard.

Remove the heat shield.



## Clean and Inspect for Reuse

**NOTE:** Do **not** remove the DEF dosing valve (1) from the assembly (2). It 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.

**NOTE:** 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.

**NOTE:** 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.

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**NOTE:** The heat shield and coolant fittings are serviceable items of the aftertreatment DEF dosing valve.

If leaks/deposits are found at the coolant line connections during the Initial Check section of this procedure, 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. For specifications, refer to Service Bulletin, Cummins® Coolant Requirements and Maintenance, Bulletin 3666132.

**NOTE:** If damage/corrosion is found, inspect the coolant line connector(s). See equipment manufacturer service information.

Inspect the base of the coolant fittings.

Inspect the heat shield for cracks or heavy corrosion.

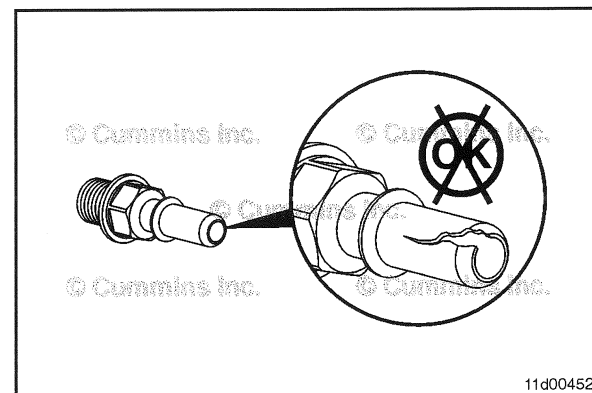
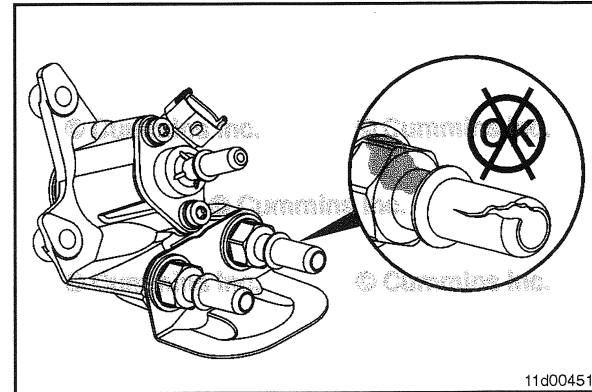
Replace as required. Reference the Disassemble section of this procedure.

If the coolant fittings were removed from the aftertreatment DEF dosing valve assembly, inspect the threads and o-ring sealing surfaces of the following for pitting and corrosion:

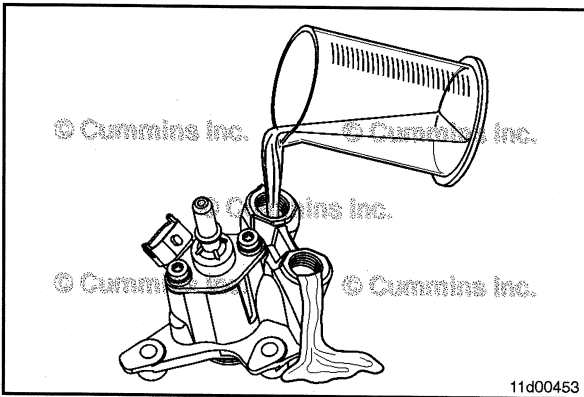
- Coolant fittings
- Coolant ports in the aftertreatment DEF dosing valve assembly.

Clean with an abrasive pad, Cummins® 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 component.







**⚠ 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 submerge the aftertreatment DEF dosing valve in solvent or water. Damage to the aftertreatment DEF dosing valve will result.

**NOTE:** If not already removed, remove the coolant fittings from the aftertreatment DEF dosing valve. Reference the Disassemble section of this procedure.

Clean the aftertreatment DEF dosing valve coolant passages with a safety solvent. Use a pipe cleaner to clean the passageways.

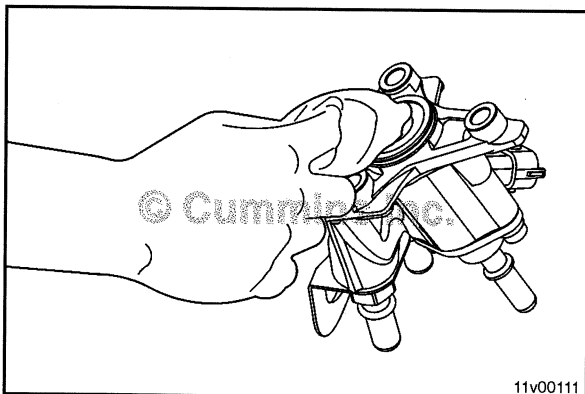
Do **not** spill solvent on the dosing valve.

With the aftertreatment DEF dosing valve positioned so the coolant ports are pointing upward, pour safety solvent in one coolant port until the safety solvent begins to flow out of the opposite port.

Tip the aftertreatment DEF dosing valve so the safety solvent flows out of the port **not** filled. Verify that the safety solvent flows out of this port as one continuous stream.

If safety solvent does **not** flow as one continuous stream, the coolant passage may still be restricted or blocked. Repeat the cleaning process again and inspect. If there is no change, replace the aftertreatment DEF dosing valve.

Dry with compressed air.



**⚠ 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.

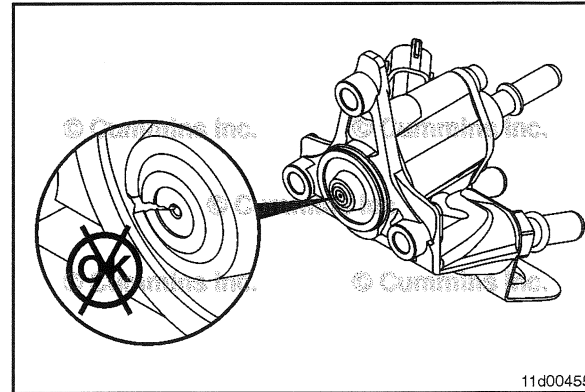
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Inspect the dosing valve tip for cracks or other damage. Replace if damage is found.



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:

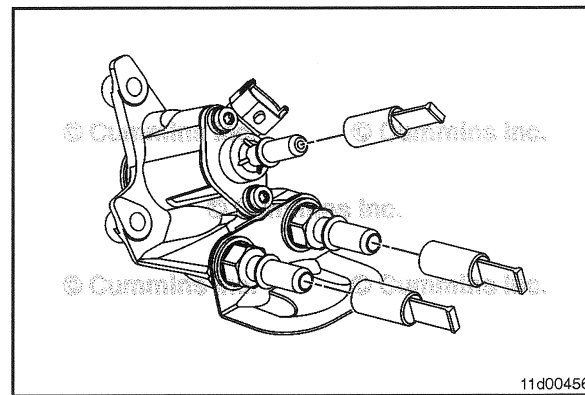
- The bottom of the aftertreatment DEF dosing valve around the gasket sealing surface for signs of heavy corrosion, pitting, and/or surface damage. Replace the aftertreatment DEF dosing valve if damage is found.
- The aftertreatment DEF dosing valve mounting surface on the decomposition tube. Refer to Procedure 011-062 in Section 11.



11d00455

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), mileage, and vehicle identification number (VIN)).

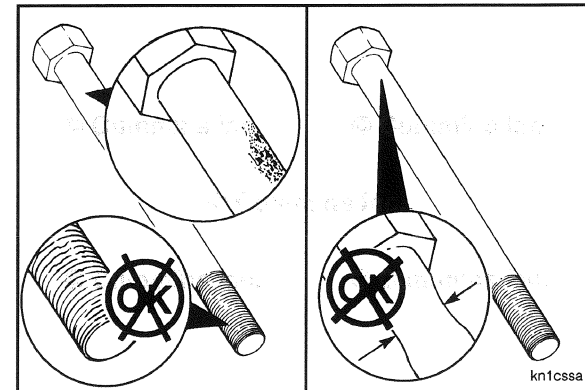


11d00456

Inspect the capscrews for damaged threads, corroded surfaces, or a reduced shank diameter (due to capscrew stretching).



Replace if damage is found.



kn1cssa

**Assemble**

Install new o-rings onto the two coolant fittings. Lubricate the o-rings with assembly lubricant, Cummins® Part Number 3163086 or equivalent.



Install the heat shield.



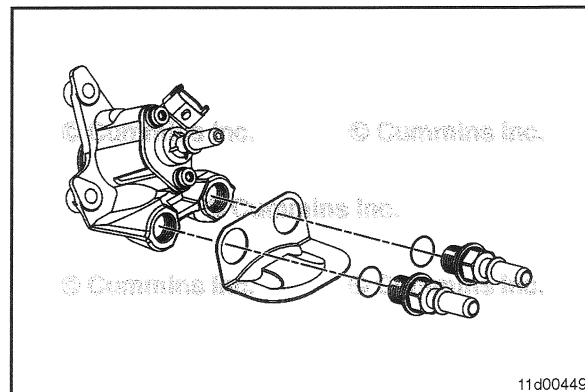
Install the coolant fittings onto the aftertreatment DEF dosing valve.



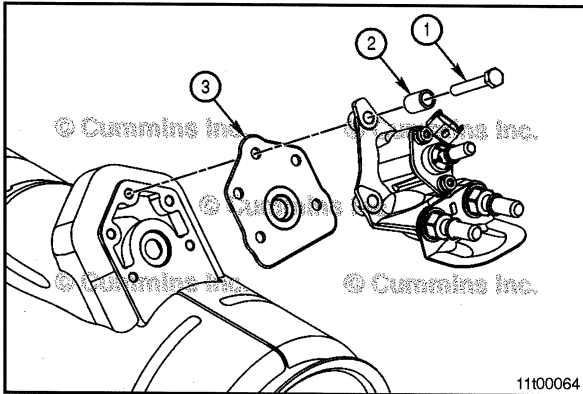
Tighten the coolant fittings.

**Torque Value:** 6 N•m [ 53 in-lb ]

**Service Tip:** If removal of the coolant fittings and/or heat shield was necessary, install the coolant fittings after installing the aftertreatment DEF dosing valve. Reference the Install section of this procedure.



11d00449



### Install

Remove any protective caps.



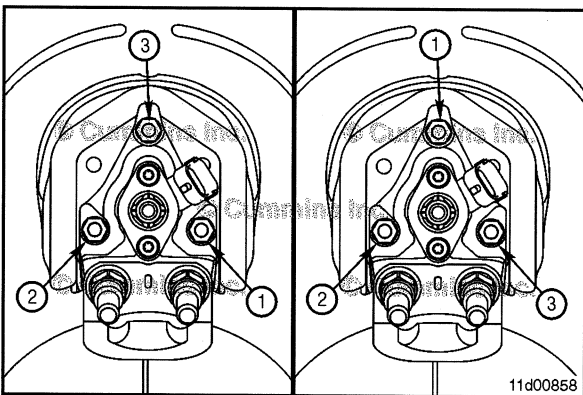
Make sure the aftertreatment DEF dosing valve spray port is free of debris.

Apply a coat of high temperature anti-seize compound to the threads of the aftertreatment DEF dosing valve mounting cap screws.

Install the insulated gasket (3) with the metallic side facing the aftertreatment DEF dosing valve. The insulated gasket can be held to the aftertreatment DEF dosing valve by inserting the cap screws (1) and spacers (2) into the square holes on the gasket to aid in alignment and installation.

**NOTE:** If the aftertreatment decomposition tube has been loosened or removed during the repair, confirm its orientation before installing the DEF dosing valve. Refer to Procedure 011-062 in Section 11.

Install the aftertreatment DEF dosing valve onto the decomposition tube.



Tighten the cap screws by hand at first until the gasket is seated properly in the aftertreatment decomposition tube flange. Use the sequence shown in the left illustration.

Tighten the cap screws in the sequence shown in the right illustration.

**Torque Value:** 9 N•m [ 80 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 ⚠

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.

**NOTE:** Remove any protective caps and/or covers from the electrical, coolant, and DEF ports just prior to making the connection.

Make the connections at the aftertreatment DEF dosing valve in the following order:

(1) The 2-pin electrical connector.

**NOTE:** The coolant supply and DEF lines are supplied by the OEM. The installation of the lines may vary by OEM. The fittings on the aftertreatment DEF dosing valve are set up for quick disconnect style fittings.

(2) Use the same method as used in the Preparatory Steps section to prevent draining the cooling system when the aftertreatment DEF dosing valve coolant lines are disconnected.

Remove the coolant line plugs, Cummins® Part Number 4919576, from each of the disconnected coolant lines.

Connect the coolant supply and return lines. See equipment manufacturer service information.

Remove all tools used.

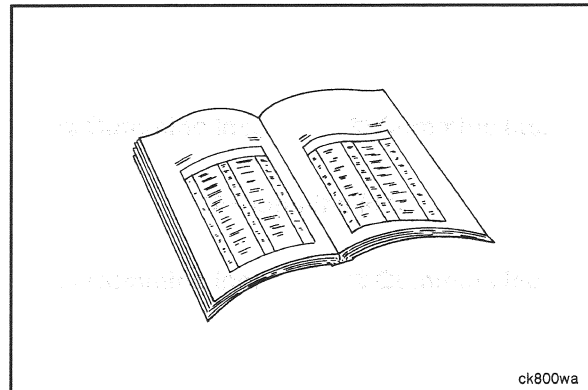
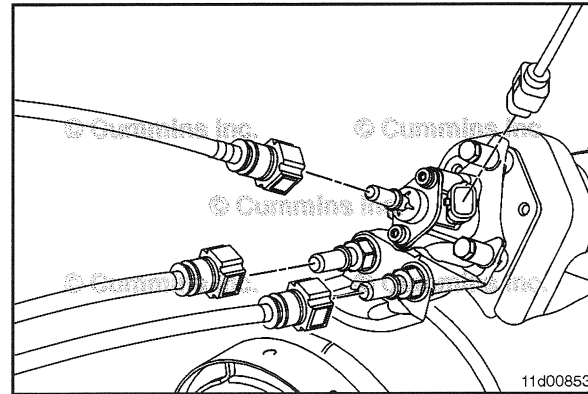
(3) Connect the DEF line. See equipment manufacturer service information.

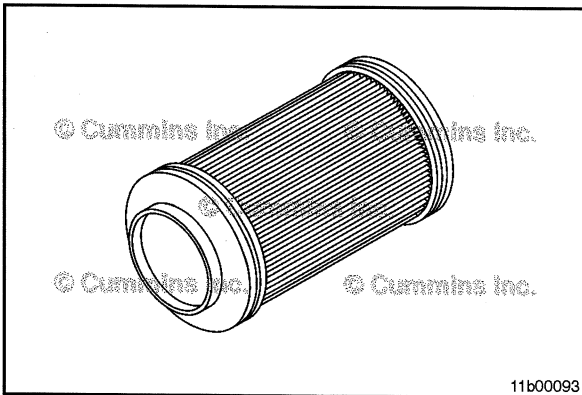
Once all connections are made, give each a slight pull to make sure they are securely installed.

- 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.

**NOTE:** The aftertreatment DEF dosing system will not prime until the correct SCR temperatures are reached. To verify that the system is correctly installed and has no leaks, induce a stationary regeneration to get the SCR system up to temperature.

- Operate the engine and check for leaks.





## Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter (011-060)

### General Information

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

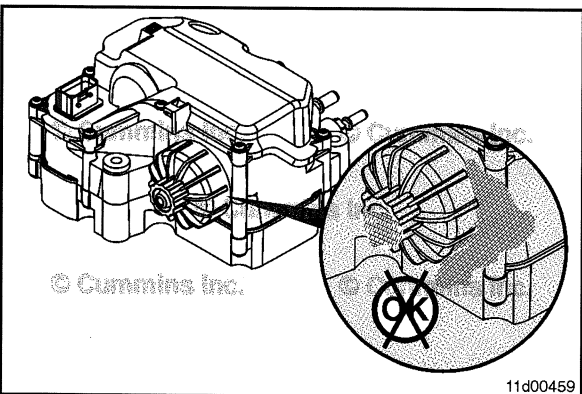
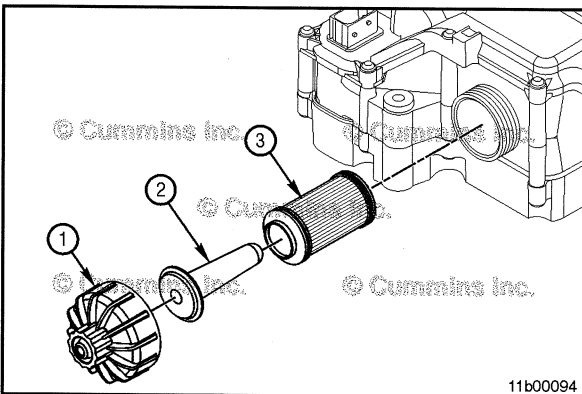
Debris can cause permanent damage and premature failure to either the aftertreatment DEF dosing unit or the aftertreatment DEF dosing valve. The aftertreatment DEF dosing unit filter is a maintenance item.

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

Use the following procedure for handling incorrect or contaminated DEF.

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

- 1 Aftertreatment DEF dosing unit filter cap
- 2 Aftertreatment DEF dosing unit filter equalizing element
- 3 Aftertreatment DEF dosing unit filter element.



### Initial Check

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

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

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

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

## Preparatory Steps

### ⚠ WARNING ⚠

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

### ⚠ WARNING ⚠

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

### ⚠ WARNING ⚠

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

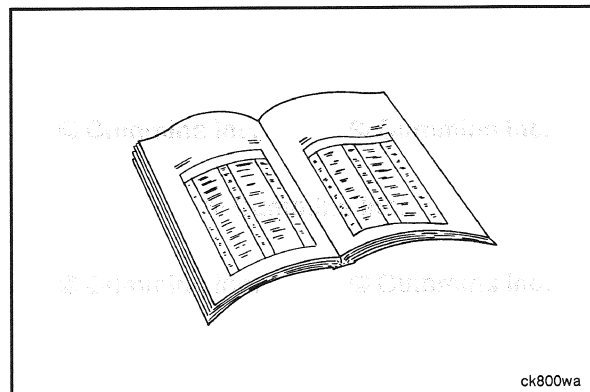
### ⚠ WARNING ⚠

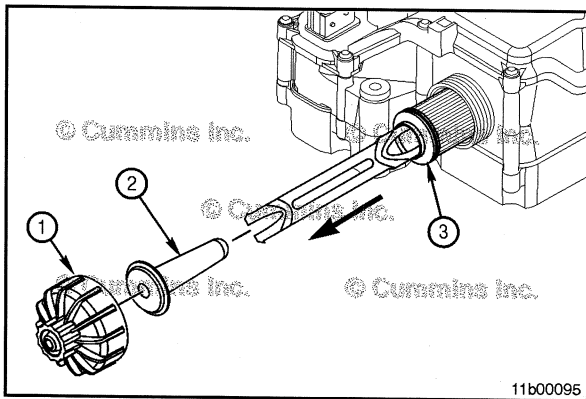
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

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

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

- Disconnect the batteries. See equipment manufacturer service information.





## Remove

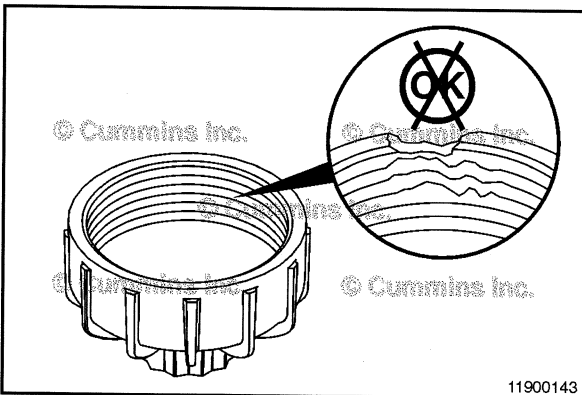
**NOTE:** There may be residual DEF in the filter housing. A collection container placed below the DEF filter cap is recommended.

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

Remove the aftertreatment DEF filter equalizing element (2).

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

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



## Clean and Inspect for Reuse

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

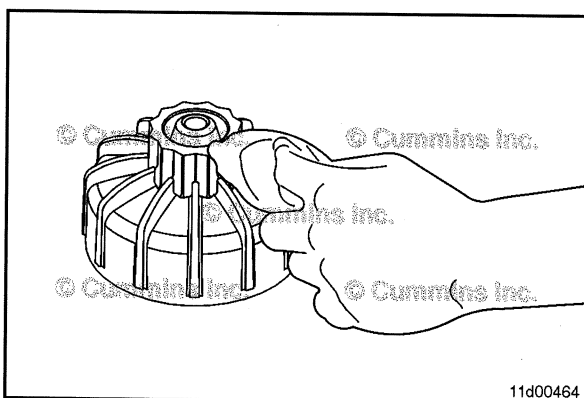


Check the condition of the threads on the aftertreatment DEF dosing unit cap.

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

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

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



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

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

## Install

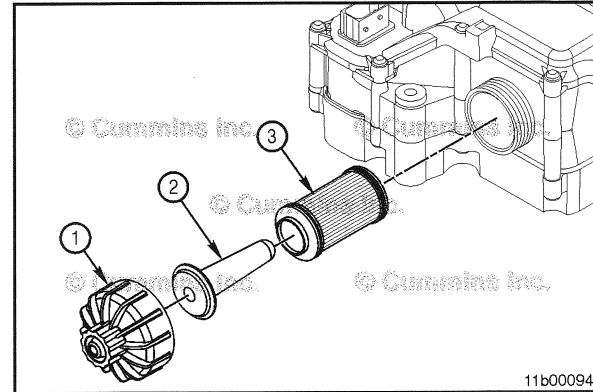
**NOTE:** Lubrication of the DEF filter o-rings is **not** required.

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

Insert the assembly into the aftertreatment DEF dosing unit.

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

**Torque Value:** 20 N•m [ 177 in-lb ]



## Finishing Steps

### ⚠ WARNING ⚠

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

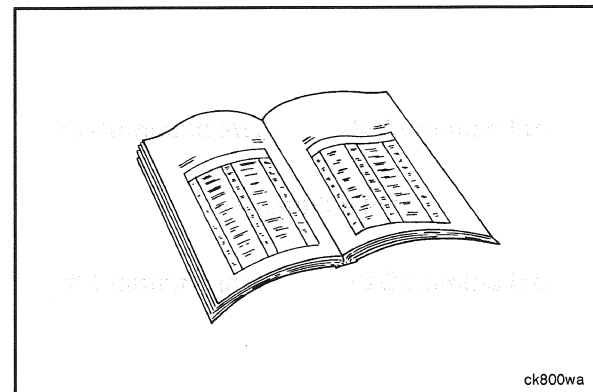
### ⚠ CAUTION ⚠

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 DEF into the exhaust system at temperatures too low to evaporate, resulting in deposit formations in the exhaust system.

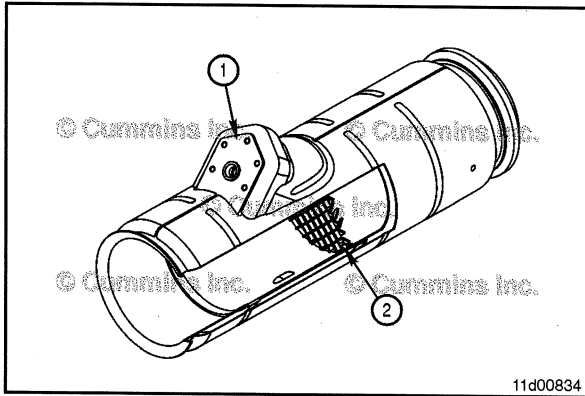
**NOTE:** The aftertreatment DEF dosing system will **not** prime until the correct selective catalytic reduction (SCR) temperatures are reached. To verify that there are no DEF leaks, test drive the vehicle for a minimum of 15 minutes to get the SCR system up to temperature.

**NOTE:** The aftertreatment DEF dosing system will **not** prime until the correct SCR temperatures are reached. To verify that there are no DEF leaks, initiate a stationary regeneration to get the SCR system up to temperature.

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







## Aftertreatment Decomposition Tube (011-062)

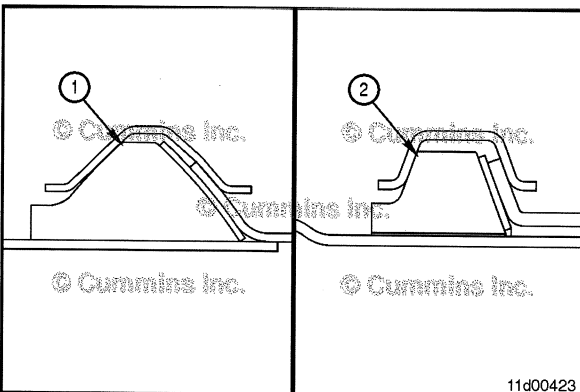
### General Information

The decomposition tube is the section of exhaust pipe between the aftertreatment diesel particulate filter (DPF) and aftertreatment selective catalytic reduction (SCR) catalyst. The aftertreatment decomposition tube is designed to help atomize and mix the diesel exhaust fluid (DEF) being sprayed into the exhaust stream for complete NOx conversion.

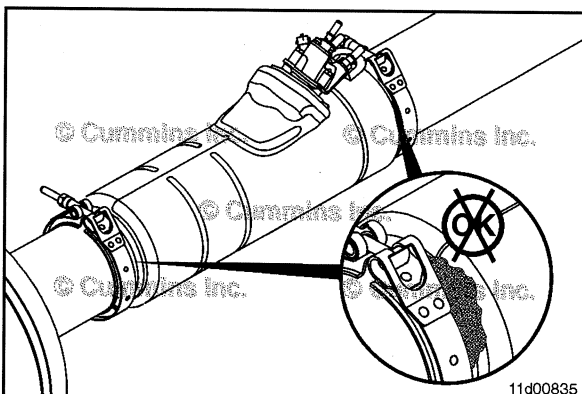
The aftertreatment decomposition tube is composed of two important areas.

- 1 The aftertreatment DEF dosing valve mount - the position at which the aftertreatment DEF dosing valve is mounted and allowed to spray DEF into the exhaust stream.
- 2 The aftertreatment decomposition tube mixer - creates a swirl pattern exhaust stream to help mix the DEF and engine exhaust.

Different vehicles will require different aftertreatment configurations. Some of the aftertreatment decomposition tubes may have elbows clamped to either end of the tube.



A variation in vehicle aftertreatment configuration will drive the aftertreatment to have different flanges. The clamps and gaskets on either end of the aftertreatment decomposition tube may be different from one another. There are two types of flanged joints, spherical Marman and full Marman. The spherical Marman (1) joints allow a small amount of misalignment and have a rounded cross section. The full Marman (2) joints are completely rigid and have a more edgy profile.



### Initial Check

Inspect all the joints for any signs of leaks. Leaking DEF will leave white deposits. If a DEF leak is found, reference the Clean and Inspect for Reuse section of this procedure.

## Preparatory Steps

### ▲ 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 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 ▲

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 ▲

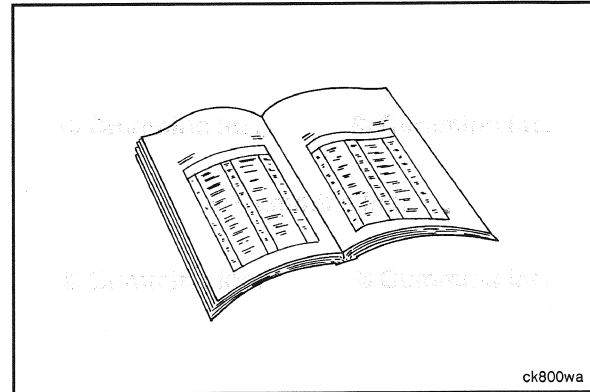
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

### ▲ CAUTION ▲

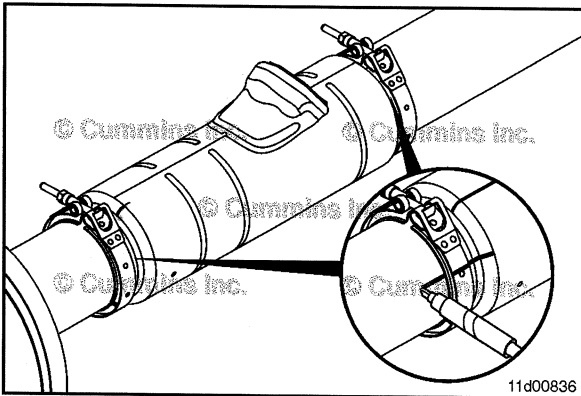
The aftertreatment DEF dosing valve is a fragile item. Use great care when handling this part. Avoid putting stresses on the fluid connectors, as damage to the component may result.

**NOTE:** It is acceptable to remove the aftertreatment dosing valve without removing the DEF and coolant lines. Support the aftertreatment DEF dosing valve. Do **not** let it suspend freely, for it may damage the fluid connectors and lines.

- Disconnect the batteries. See equipment manufacturer service information.
- Clean the area with shop air. Remove any debris from the aftertreatment decomposition tube.
- If applicable, remove the aftertreatment DEF dosing valve guard from the aftertreatment decomposition tube. Refer to Procedure 011-059 in Section 11.
- Remove the aftertreatment DEF dosing valve from the aftertreatment decomposition tube. Refer to Procedure 011-059 in Section 11.



ck800wa



### Remove

#### ⚠ 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.

**NOTE:** Before removing the aftertreatment decomposition tube, note the location and orientation of the aftertreatment decomposition tube and related components. Apply identifying markings to aid in installation.

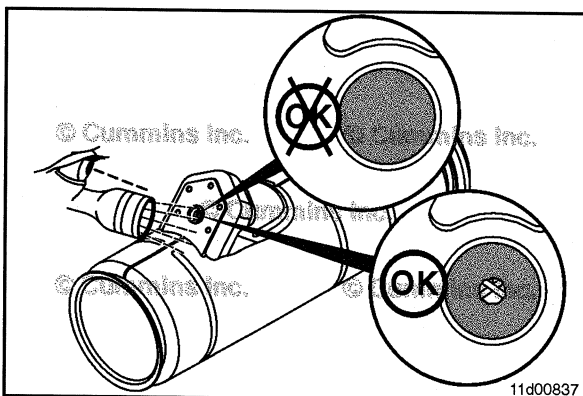
**NOTE:** In some applications the aftertreatment decomposition tube may be welded to the aftertreatment SCR or aftertreatment elbow.

**NOTE:** Depending on the exhaust configuration it may be necessary to loosen exhaust hangers or remove additional elbows and exhaust piping securing the rest of the aftertreatment before removing the aftertreatment decomposition tube.

Remove the exhaust clamps from both ends of the aftertreatment decomposition tube.

Remove the aftertreatment decomposition tube.

Discard the gaskets.



### Clean and Inspect for Reuse



**NOTE:** If troubleshooting a fault code that has a step that indicates to check the aftertreatment decomposition for DEF deposits, clean the aftertreatment decomposition tube of DEF deposits, regardless of the inspection criteria in the steps below.

Inspect the aftertreatment DEF dosing valve spray port in the aftertreatment decomposition tube for DEF deposits.

If the DEF spray port is completely blocked by DEF deposits, clean the aftertreatment decomposition tube according to the cleaning steps later in this procedure.

If the aftertreatment DEF dosing valve spray port is blocked with DEF deposits, there may be issues with the aftertreatment dosing valve. Refer to Procedure 011-059 in Section 11.

Inspect the aftertreatment DEF dosing valve spray chamber in the aftertreatment decomposition tube. If there is a DEF deposit protruding into the main decomposition tube area that has a free flow path for a pressurized DEF stream and there are no active fault codes, no action is required.

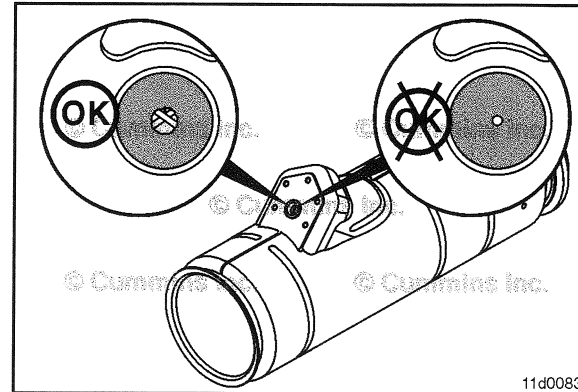


**NOTE:** Use a light source when looking into the aftertreatment decomposition tube to inspect for a free flow path for a pressurized DEF stream.

It is **not** uncommon to see three holes in a DEF deposit. This is a formation of the three injection holes on the nozzle of the aftertreatment DEF dosing valve.

If there is a DEF deposit that is protruding into the main decomposition tube area that is restricting the free flow path for a pressurized DEF stream, clean the aftertreatment decomposition tube according to the cleaning steps later in this procedure.

If the aftertreatment DEF dosing valve spray chamber is blocked with DEF deposits, there may be issues with the aftertreatment dosing valve. Refer to Procedure 011-059 in Section 11.

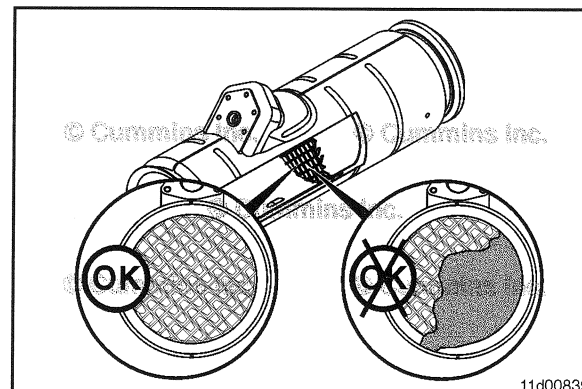


Inspect the aftertreatment decomposition tube main area around the mixer. If the mixer area is less than 50 percent blocked by DEF deposits, no action is necessary.



If the DEF deposits in the mixer area are blocking more than 50 percent of the aftertreatment decomposition tube, regardless if any related active fault codes are present, the aftertreatment decomposition tube **must** be cleaned. Reference the cleaning steps below.

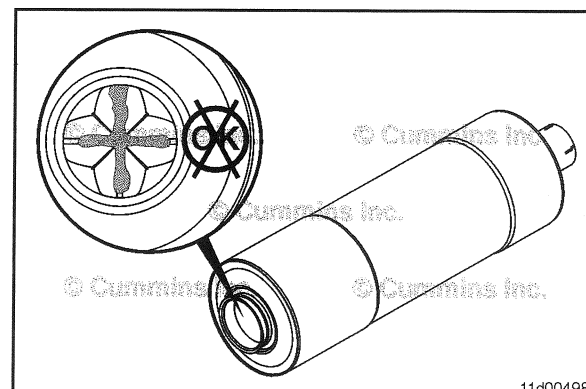
If the DEF deposits in the mixer area are blocking more than 50 percent of the aftertreatment decomposition tube, there may be issues with the aftertreatment dosing valve. Refer to Procedure 011-059 in Section 11.

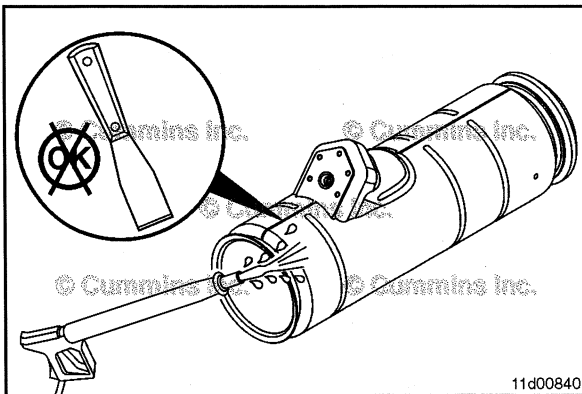


Inspect the intake of the aftertreatment SCR catalyst for DEF deposits. Refer to Procedure 011-036 in Section 11.



Inspect any additional elbows or exhaust pipes connected to the aftertreatment decomposition tube for DEF deposits. Reference the cleaning steps below.





**⚠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.



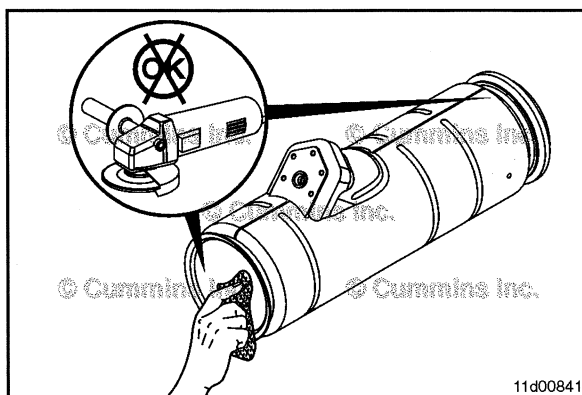
If DEF deposits are present, carefully scrape with a non-metallic object to remove the majority of the DEF deposits.

Use a pressure washer to dissolve the remaining DEF deposits.

**NOTE:** It is acceptable to have a small amount of DEF deposits remaining in the mixer area after the cleaning steps. The remaining DEF deposits can be removed by performing a stationary regeneration. Reference the Finishing Steps below.

Use **only** water to remove deposits.

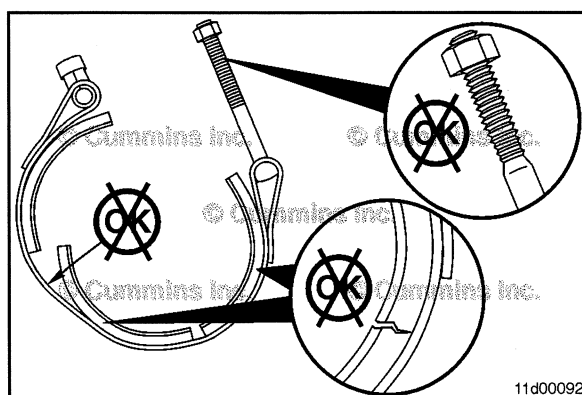
Do **not** submerge the aftertreatment decomposition tube in water or solvents which can saturate the insulation.



Inspect the exhaust flanges for corrosion or other damage.

Use an abrasive pad to remove any residual gasket material from the flanges on the aftertreatment decomposition tube.

Do **not** grind on the flange surface. This can damage the flange and cause the connection to leak.



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.

Replace the V-band clamp or mounting strap if damage is found.

**⚠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.

Inspect for old gasket/isolator material or corrosion.

Clean with an abrasive pad.

Check the threaded capscrew holes for damaged threads.

If the capscrew holes are damaged, the aftertreatment decomposition tube can be repaired.

Inner coil threads M6 X 1 can be used to repair any damaged threads.

Use **only** the wire type coil inserts because the amount of material around the threaded capscrew hole is limited.

Follow the manufacturer's recommended guidelines to install the coiled threaded insert.

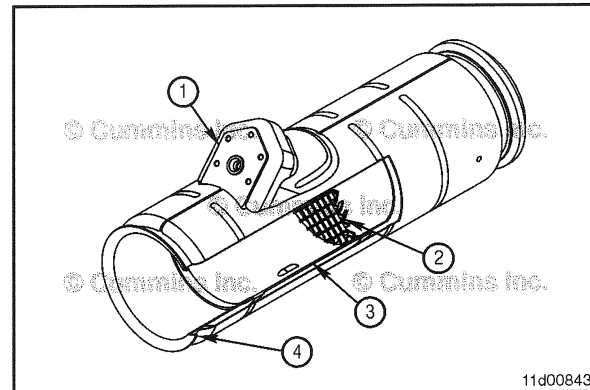
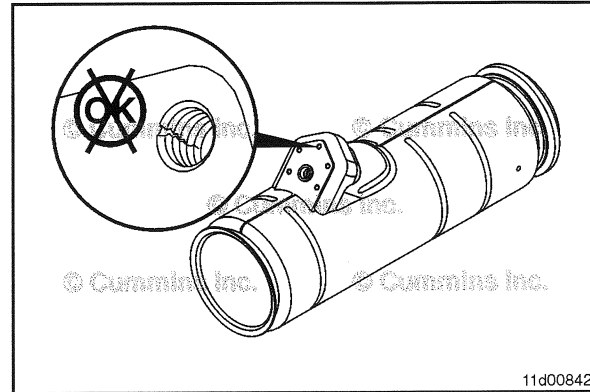
**NOTE:** The aftertreatment decomposition tube should be smooth and free from scratches and other damage.

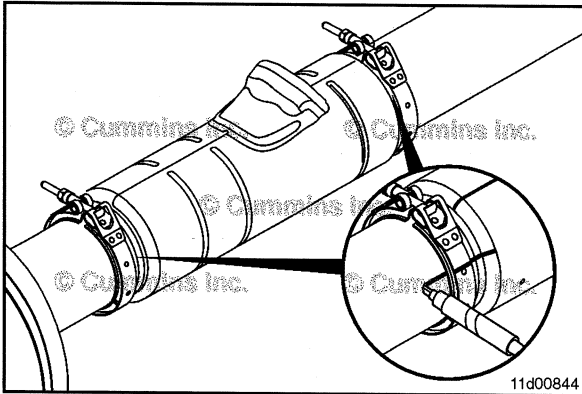
If the aftertreatment decomposition tube has **any** structural defects or material degradation, replace the aftertreatment decomposition tube.

**NOTE:** Surface corrosion such as rust on the inside of the aftertreatment decomposition tube can possibly be observed. Do **not** replace the aftertreatment decomposition tube for this condition.

Check the following areas:

- 1 Aftertreatment dosing valve mount
- 2 Mixer
- 3 Insulation
- 4 Welded joints.





## Install

### ⚠ CAUTION ⚠

Do not use an air tool to tighten the V-band clamp. An air tool will damage the threads.

**NOTE:** The gaskets and clamps on either end of the aftertreatment decomposition tube may **not** be the same. Reference the General Information section of this procedure. Where applicable, install and tighten the full Marman clamps before the spherical Marman to account for misalignment in the aftertreatment system.

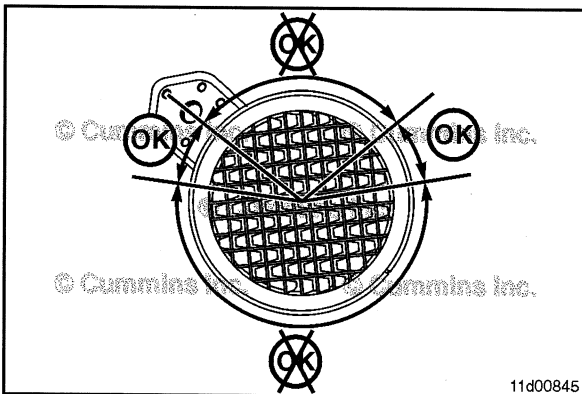
Install the aftertreatment decomposition tube with new gaskets. If other parts of the aftertreatment were adjusted in the removal process of the aftertreatment decomposition tube, slide them back into position.

Align the aftertreatment decomposition tube. Use the identification marks that were made before removal. If marks are **not** available, reference the next step for appropriate orientation of the aftertreatment decomposition tube.

Apply a coat of anti-seize compound on the threads of the V-band clamps.

Install the clamps.

**Torque Value:** 14 N•m [ 124 in-lb ]



Verify the aftertreatment decomposition tube is installed in the same orientation as it was removed.

As viewed from the inlet/outlet of the aftertreatment decomposition tube, the aftertreatment DEF dosing valve mount should be placed between  $\pm 45$  degrees and  $\pm 85$  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.

- Tighten any aftertreatment hangers that could possibly have been loosened in the removal process. See equipment manufacturer service information.
- Install the aftertreatment DEF dosing valve. Refer to Procedure 011-059 in Section 11.
- If applicable, install the aftertreatment DEF dosing valve guard. Refer to Procedure 011-059 in Section 11.
- Connect the batteries. See equipment manufacturer service information.
- Start the engine and check for exhaust leaks.

**NOTE:** If DEF deposits were present, and cleaning of the aftertreatment decomposition tube was required, complete a stationary regeneration to make sure that the remaining DEF deposits have been removed from the aftertreatment system. Continue to monitor for leaks at the exhaust joints.

## Aftertreatment Diesel Exhaust Fluid Dosing Unit Override Test (011-063)

### General Information

The purpose of this test is to perform a dosing cycle to check the:

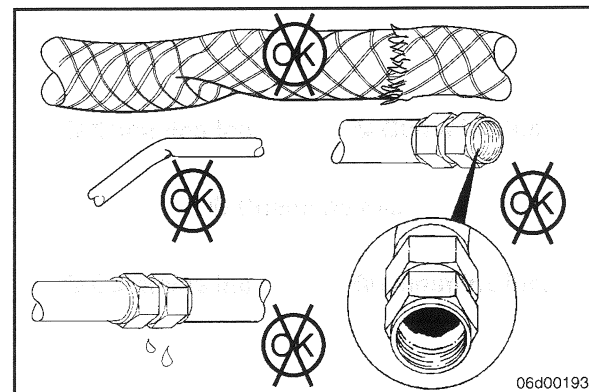
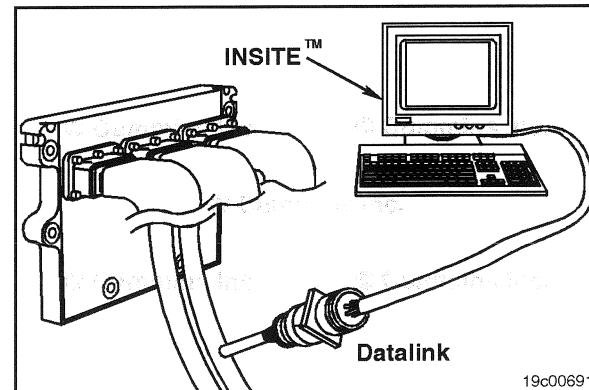
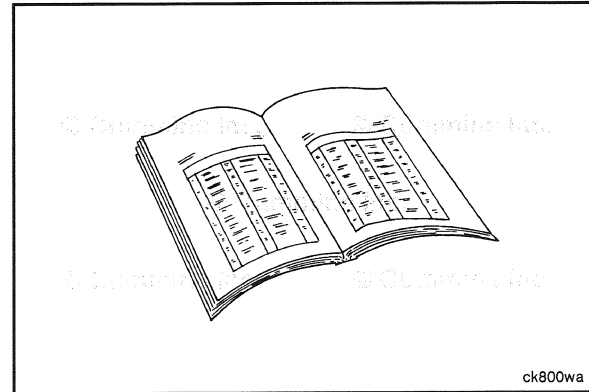
- Aftertreatment diesel exhaust fluid (DEF) dosing valve spray characteristics
- Amount of DEF to be delivered in a specified time (6 minutes).

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.

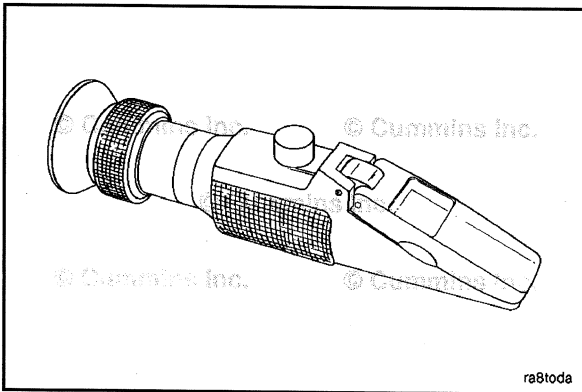
### Initial Check

Inspect for leaks, blockages, and 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.



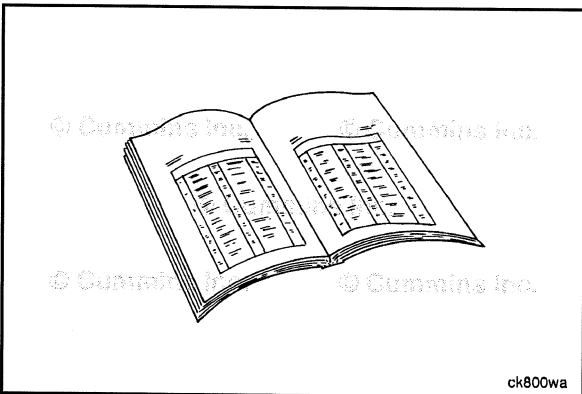




Check that there is an adequate amount of DEF in the DEF tank before starting this test.



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.

## Setup

### ⚠ CAUTION ⚠

Care should be taken when handling and/or disconnecting the DEF line from the aftertreatment DEF dosing valve. The intake of the aftertreatment DEF dosing valve is plastic and can be easily damaged.

### ⚠ CAUTION ⚠

Do not connect a 12-VDC or 24-VDC supply to the aftertreatment DEF dosing valve as this will cause permanent damage.

Connect the electrical and DEF lines. Refer to Procedure 011-059 in Section 11.

**NOTE:** The coolant plumbing does **not** need to be connected for this test.

**NOTE:** There may **not** be enough length for the existing electrical and/or DEF line to allow the aftertreatment DEF dosing valve to be placed in the container. Use service tool kit, Cummins® Part Number 4919573, which contains:

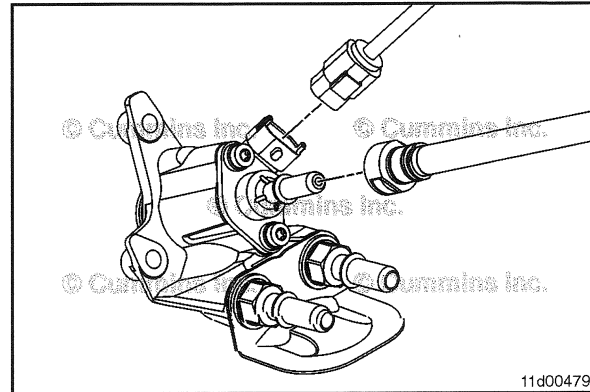
- Wiring harness extension, Cummins® Part Number 4919575
- DEF extension line, Cummins® Part Number 4919574
- Coolant line plug, Cummins® Part Number 4919576.

Obtain a clear plastic container (large enough to hold the aftertreatment DEF dosing valve) and a graduated beaker, Cummins® Part Number 4919139, or equivalent. A measurement cup that is marked in milliliters (ml) or ounces (oz) can also be used.

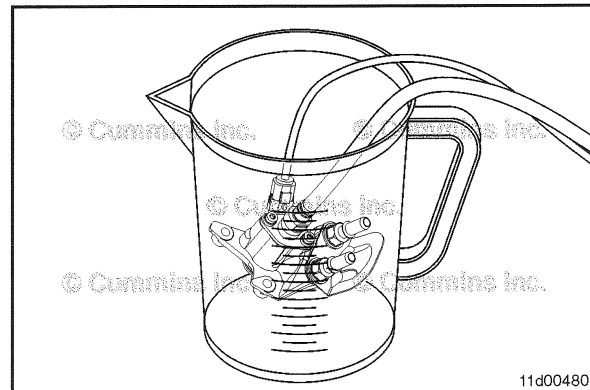
The measuring device **must** be capable of measuring between 0 ml [0.0 oz] and 500 ml [17.0 oz] in 5 ml [0.34 oz] increments

**NOTE:** It is usually easier to capture the DEF in a clean container and transfer the DEF to the measuring device for the final measurement.

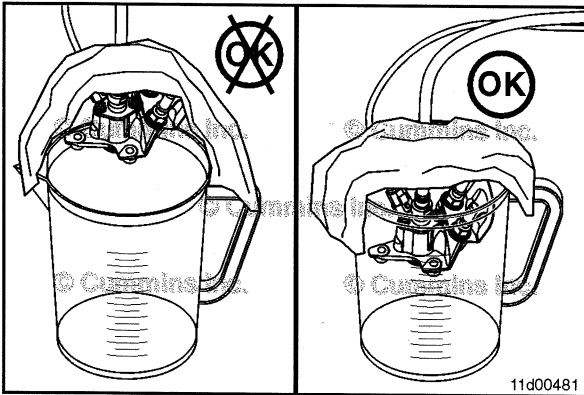
Place the aftertreatment DEF dosing valve into the container.



11d00479



11d00480

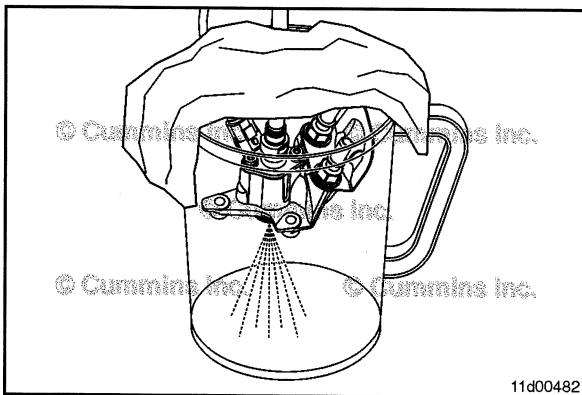


**▲ WARNING ▲**

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 prime. During this process the aftertreatment DEF dosing valve will open intermittently to purge air from the system. As a result, some DEF will be sprayed from the tip. 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 atmosphere, and to make sure the measurement is accurate, place a clean shop towel or cover over the valve and container.



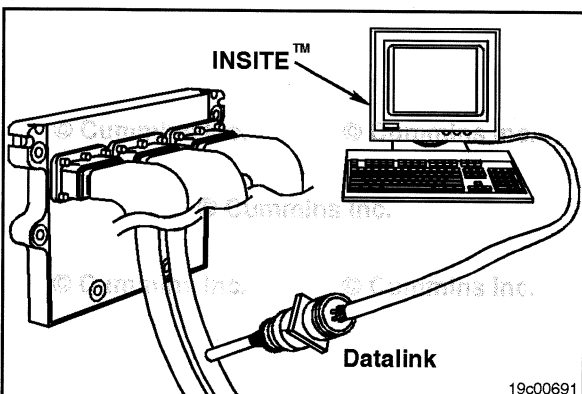
When the test begins, briefly monitor the spray pattern of the DEF exiting the aftertreatment DEF dosing valve. Look for the following:



- Signs of larger drops and/or dripping DEF from the tip
- Spray pattern 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. Reference the Clean and Inspect for Reuse section in the following procedure. Refer to Procedure 011-059 in Section 11.

If necessary, perform 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.



**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. Reference the QSF3.8 CM2350 F107 Fault Code Troubleshooting Manual, Bulletin 4367319.

- Turn the keyswitch ON.
- Connect INSITE™ electronic service tool.
- Locate the DEF 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 6 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.

**QSF3.8 CM2350 F107**  
**Section 11 - Exhaust System - Group 11**

After the test is complete (test runs for 6 minutes), measure the amount of DEF sprayed into the container. Pour the DEF into the graduated beaker, Cummins® Part Number 4919139, or equivalent.

Perform the test three times and average the results of the three tests.

Aftertreatment DEF Dosing Valve Volume Specifications		
ml		fl-oz
85	MIN	2.9
115	MAX	3.9

**NOTE:** Do **not** pour the DEF back into the DEF tank. Dispose of the DEF in accordance with local environmental regulations.

**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. Reference the QSF3.8 CM2350 F107 Fault Code Troubleshooting Manual, Bulletin 4367319.

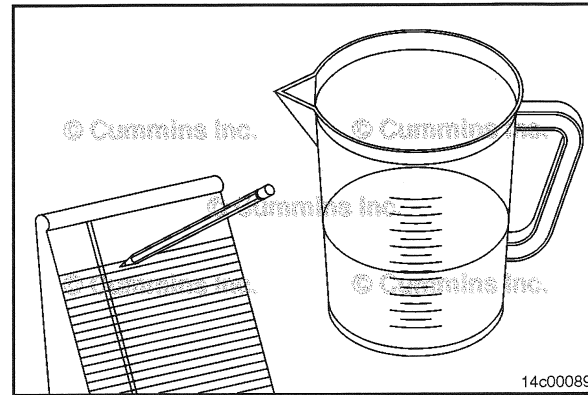
If the amount of DEF is **not** within specification, verify the DEF filter is **not** plugged and check for leaks, blockages, or restrictions in the DEF line between the aftertreatment DEF dosing unit and the aftertreatment DEF dosing valve.

**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.

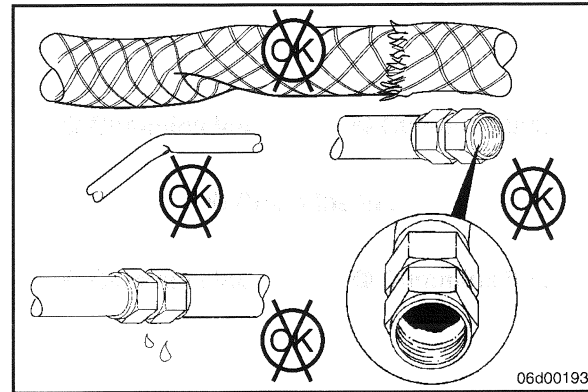
**⚠ CAUTION ⚠**  
**Do not submerge the aftertreatment DEF dosing valve in solvent or water. Damage to the aftertreatment DEF dosing valve will result.**

After the test is complete, a light coating of DEF will cover the aftertreatment DEF dosing valve, DEF line, and electrical line.

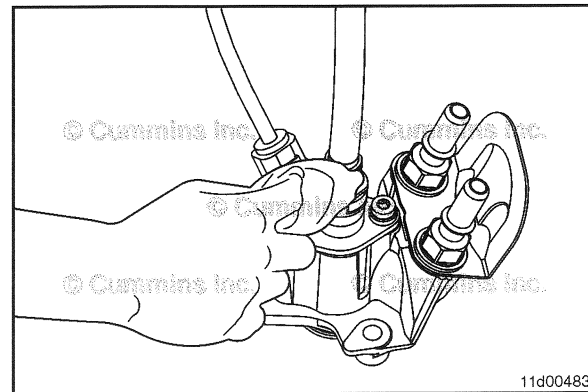
Use a clean shop towel soaked in warm water to wipe the coating of DEF from the components before disconnecting any components.



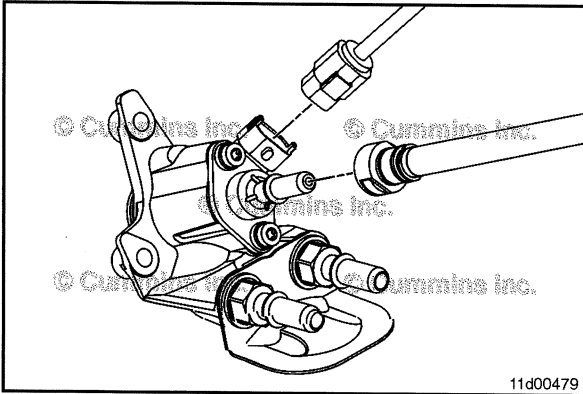
14c00089



06d00193



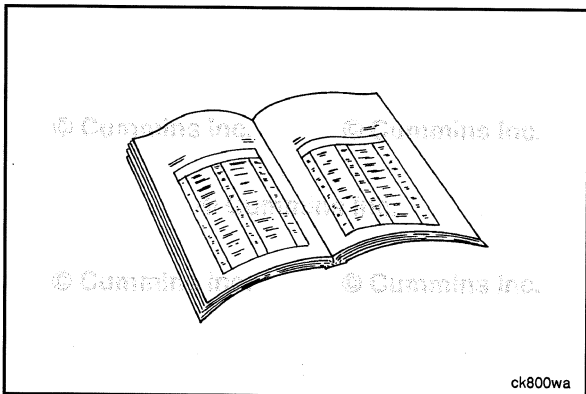
11d00483



Disconnect the electrical and DEF lines. Refer to Procedure 011-059 in Section 11. If used, remove the service tool extensions.



**NOTE:** Clean any service tools used for this test with warm distilled water before storage.



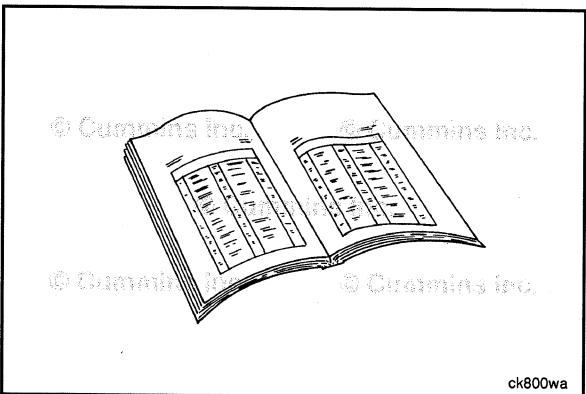
### Finishing Steps



#### **▲ 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 aftertreatment DEF dosing valve. Refer to Procedure 011-059 in Section 11.



## EGR Crossover Tube (011-070)

### General Information

The exhaust gas recirculation (EGR) crossover tube is the tube that connects the EGR cooler to the EGR mass measurement flow assembly.

## 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 EGR temperature sensor connector. Refer to Procedure 019-378 in Section 19.
- Disconnect the harness P-clips from the EGR crossover tube.

**NOTE:** If the EGR crossover tube requires replacement or extensive cleaning, remove the EGR temperature sensor. Refer to Procedure 019-378 in Section 19.

## Remove

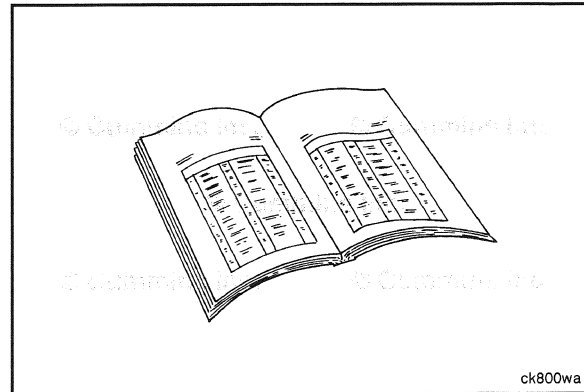
Clean around the flanges of the EGR crossover tube with a clean cloth.

Remove the two capscrews that secure the EGR crossover tube to the EGR cooler.

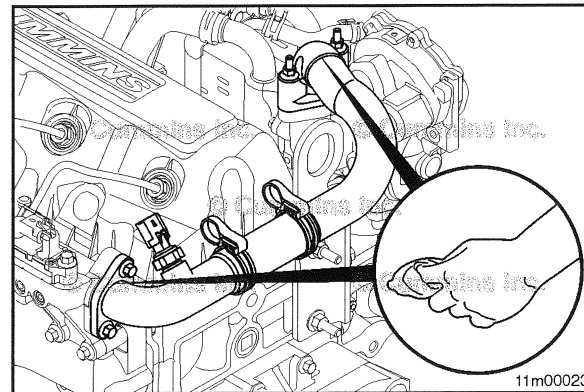
Discard the gasket

Remove the two capscrews that secure the tube to the EGR mass measurement flow assembly.

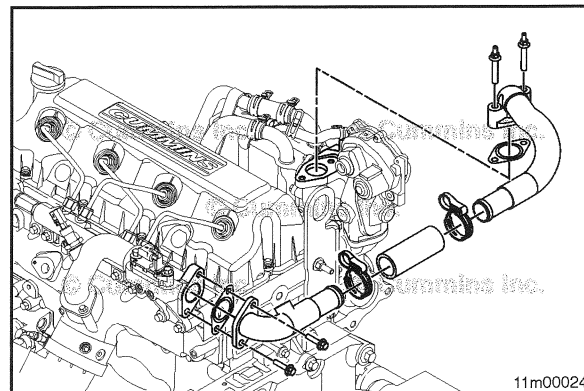
Discard the gasket..



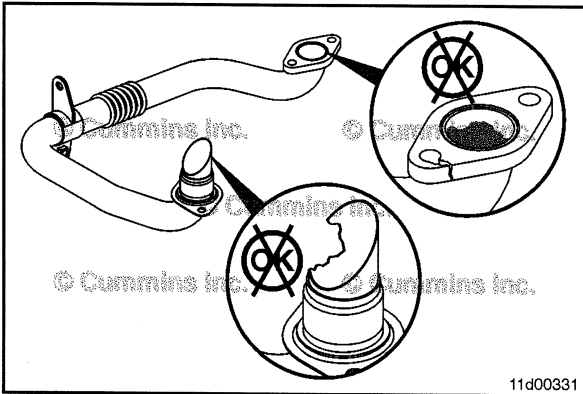
ck800wa



11m00023



11m00024



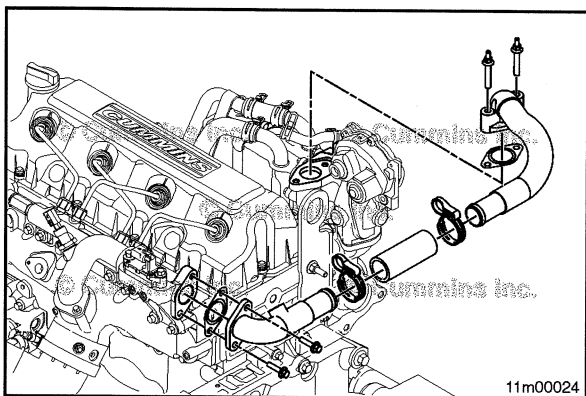
## Clean and Inspect for Reuse

Inspect the tube for cracks, distortion, corrosion, or soot streaking on the outside of the tube, indicating a leaking EGR.

Replace the EGR crossover tube if any cracks or other damage is found.

**NOTE:** It is common for the EGR components to have a buildup of carbon on their inside surface. This buildup is normal and does **not** need to be removed.

**NOTE:** If the EGR crossover tube will be off of the engine for a prolonged period of time, tape over the opening in the EGR cooler to prevent debris from entering the EGR and air intake system.



## Install

### ⚠CAUTION⚠

**Do not use force when installing the crossover tube into the intake manifold or when aligning the tube to the EGR valve. Force fitting the tube will result in undesirable stress in the tube and possible tube damage.**

Place a new gasket onto the tube that connects to the EGR mass measurement flow assembly and a new gasket at the EGR cooler.

Position the tube and check for correct alignment.

Loosely install the capscrews to the EGR mass measurement flow assembly.

Loosely install the capscrews to the EGR cooler.

Loosely install the hose spring clamps.

Tighten the capscrews at the EGR mass measurement flow assemble

**Torque Value:** 18 N•m [ 159 in-lb ]

Tighten the capscrews at the EGR cooler.

**Torque Value:** 43 N•m [ 32 ft-lb ]

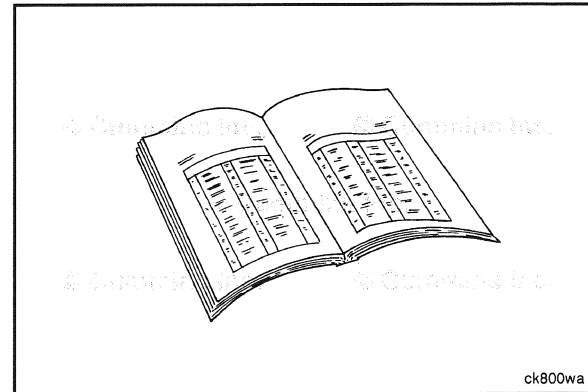
Position the spring clamps on both ends of the EGR crossover tube hose.

## 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 engine harness P-clips.
- Install the EGR temperature sensor, if removed. Refer to Procedure 019-378 in Section 19.
- Connect the harness to the EGR temperature sensor. Refer to Procedure 019-378 in Section 19.
- Connect the batteries. See equipment manufacturer service information.
- Start the engine and check for proper operation.



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## Air in the Diesel Exhaust Fluid (011-075)

### Setup

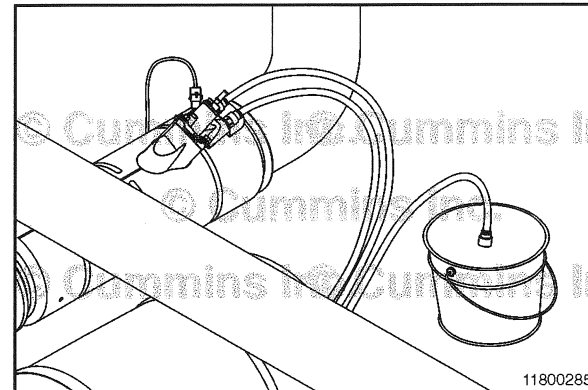
### ▲ CAUTION ▲

Care should be taken when handling and/or disconnecting the diesel exhaust fluid line from the aftertreatment diesel exhaust fluid dosing valve. The intake of the aftertreatment diesel exhaust fluid dosing valve is plastic and can be easily damaged.

Remove the aftertreatment diesel exhaust fluid (DEF) dosing valve supply line from the aftertreatment DEF dosing valve.

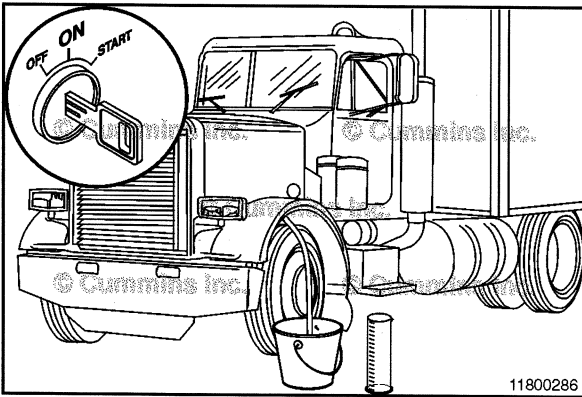
Install the DEF extension line, Cummins® Part Number 4919574, from the Aftertreatment Diesel Exhaust Fluid (DEF) Doser Shutoff Valve Test Kit, Part Number 4919573.

Obtain a container suitable for collection of the DEF that exits the aftertreatment diesel exhaust fluid dosing valve supply line. A 3.8 liter [1 gal] bucket is recommended.



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### Measure

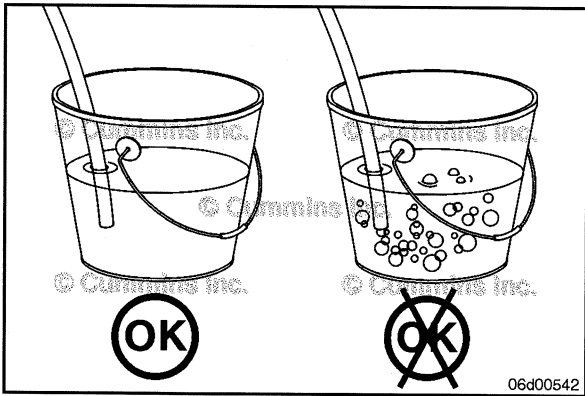
Route the outlet of the diesel exhaust fluid extension line into the collection container.

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, diesel exhaust fluid will be drawn from the tank and pumped through the diesel exhaust fluid extension line.

**NOTE:** Once the test is initiated it will continue to pump diesel exhaust fluid, 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.

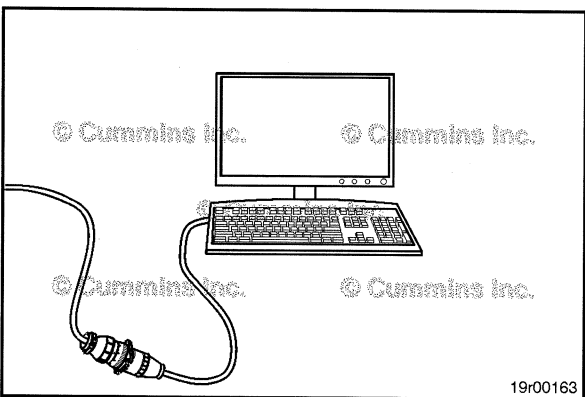


Observe the diesel exhaust fluid flow exiting the diesel exhaust fluid extension line while the Override Test is running.

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 diesel exhaust fluid dosing unit fittings
- Aftertreatment diesel exhaust fluid dosing unit supply line
- Aftertreatment diesel exhaust fluid tank assembly
- Aftertreatment diesel exhaust fluid tank fittings.

Repair or replace any damaged components.

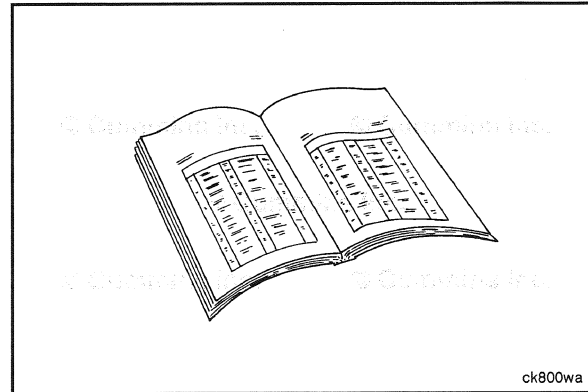


Turn the keyswitch to the OFF position to end the test.

**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 diesel exhaust fluid extension line.
- Connect that aftertreatment diesel exhaust fluid dosing valve supply line.
- Discard the collected diesel exhaust fluid. Dispose of the collected diesel exhaust fluid in accordance with local environmental regulations.
- Operate the engine and check for leaks.



ck800wa

## Aftertreatment SCR Catalyst Temperature Sensor Interface Module Mounting Bracket (011-076)

### General Information

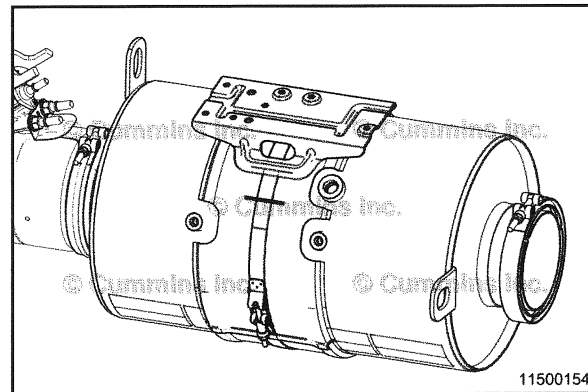
#### ⚠ WARNING ⚠

The exhaust and exhaust components can remain hot after the vehicle has stopped moving. To reduce the risk of fire, property damage, burns, or other serious personal injury, allow the exhaust system to cool before beginning this procedure or repair. Make sure that no combustible materials are located where they are likely to come in contact with hot exhaust or exhaust components.

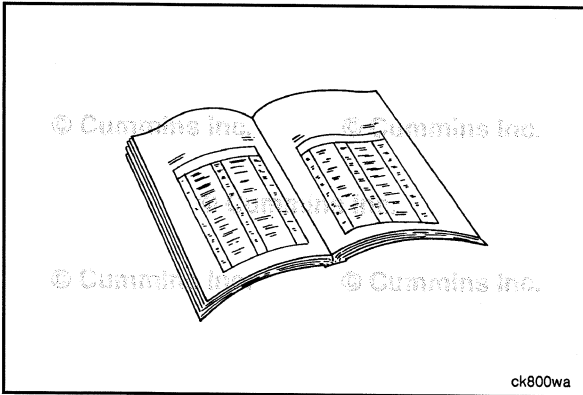
#### ⚠ CAUTION ⚠

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.

**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.



11500154



## Preparatory Steps



### ⚠ WARNING ⚠

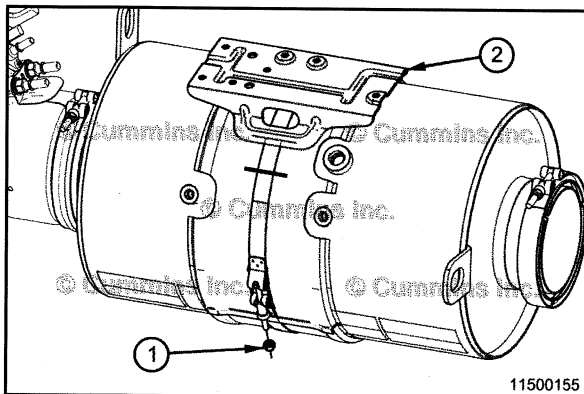
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

### ⚠ CAUTION ⚠

The aftertreatment diesel particulate filter and catalyst can remain hot for long periods of time after the engine has stopped.

- Disconnect the battery cables. See equipment manufacturer service information.
- Mark the orientation and location of the bracket before it is removed to aid installation.
- Disconnect the aftertreatment interface harness from the original equipment manufacturer (OEM) wiring harness connection.
- Remove the mono-nitrogen oxides (NOx) sensor probe from the aftertreatment catalyst body. Refer to Procedure 019-451 in Section 19.
- Remove the aftertreatment temperature sensor probes from the aftertreatment catalyst body. Refer to Procedure 019-449 in Section 19.

**NOTE:** The aftertreatment temperature sensor interface module **must** be oriented in the same location when it is installed. Pay special attention to this orientation.



## Remove

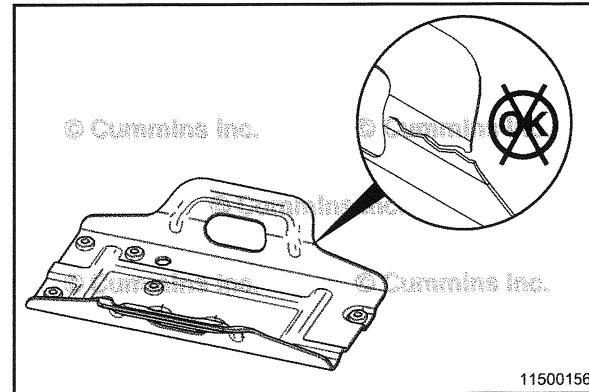
Remove the nut (1) on the aftertreatment temperature sensor interface module mounting bracket strap.

Remove the aftertreatment temperature sensor interface module mounting bracket (2) from the catalyst body.

### Clean and Inspect for Reuse

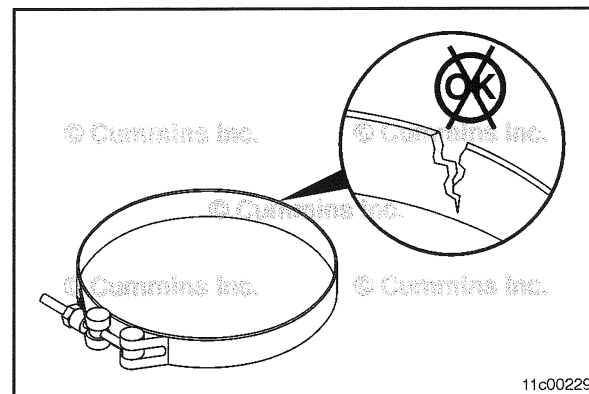
Inspect the aftertreatment temperature sensor interface module mounting bracket for cracks, damaged threads, or broken studs.

Replace the aftertreatment temperature sensor interface module mounting bracket if damaged.



Inspect the aftertreatment temperature sensor interface module mounting bracket strap for cracks, damaged threads, or bends.

Replace the aftertreatment temperature sensor interface module mounting bracket strap if it is damaged.



### Install

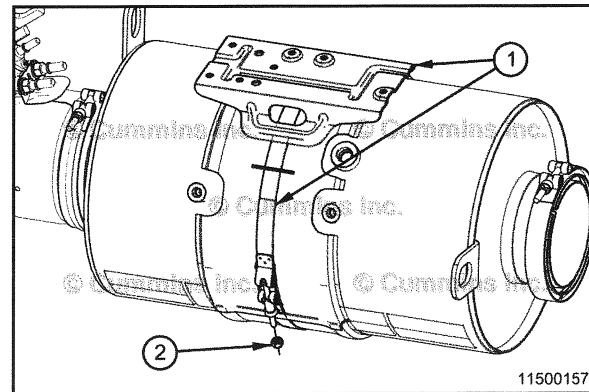
**NOTE:** Make sure the aftertreatment catalyst is oriented so the aftertreatment catalyst temperature sensor interface module mounting bracket is installed in the same orientation noted during removal.

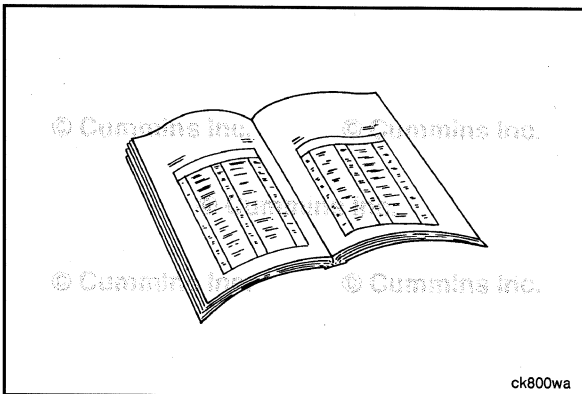
Install the aftertreatment temperature sensor interface module mounting bracket (1) and strap. Be sure to align the mounting bracket using the reference mark that was made during removal.

Apply a coating of anti-seize compound, Cummins® Part Number 3824879 or equivalent, to the threads of the aftertreatment temperature sensor interface module mounting bracket strap.

Tighten the nut (2) on the aftertreatment temperature sensor interface module mounting bracket strap.

**Torque Value:** 7 N•m [ 62 in-lb ]





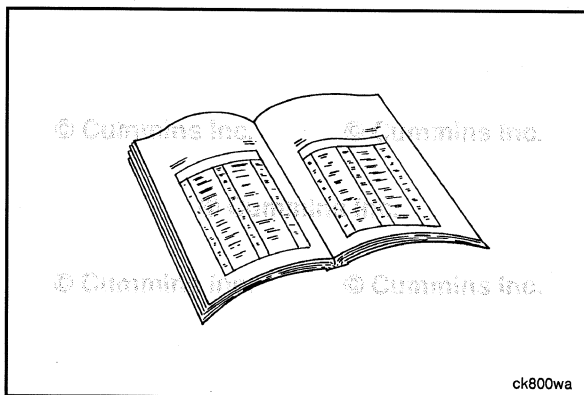
## Finishing Steps



### ▲ 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 temperature sensor probes into the catalyst body. Refer to Procedure 019-449 in Section 19.
- Install the NOx sensor probe. Refer to Procedure 019-451 in Section 19.
- Connect the aftertreatment interface harness to the OEM wiring harness connection.
- Connect the battery cables. 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, in order to check for proper operation.

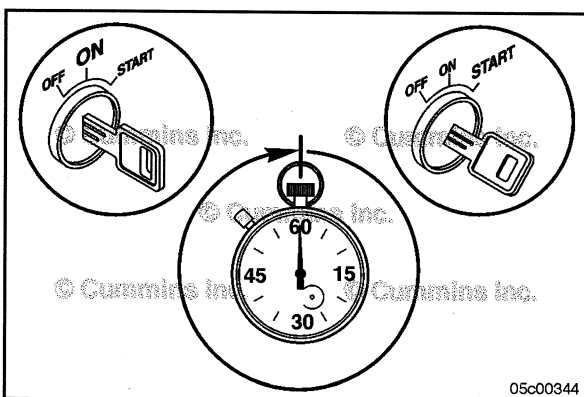


### Setup



**NOTE:** It may 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 diesel exhaust fluid. Refer to the OEM service manual.
- 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.

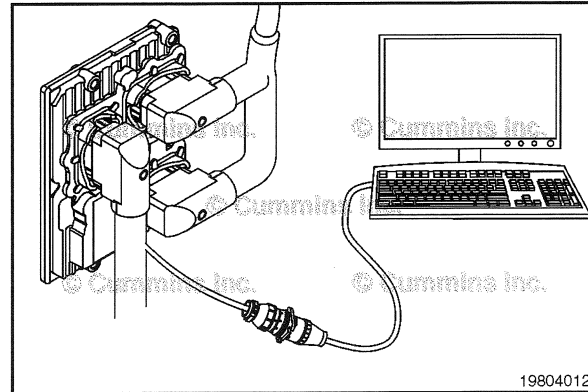


## Prime

With the keyswitch ON and the engine **not** running, select the Aftertreatment Diesel Exhaust Fluid System Leak Test found under the 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 valve supply 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.

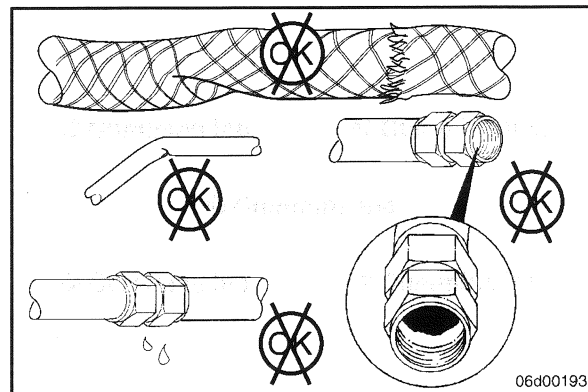


## Inspect

**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. Refer to Procedure 011-058 or Refer to Procedure 011-059 in Section 11 and/or equipment manufacturer service information.

Repair and replace any leaking component(s). Refer to Procedure 011-058 or Refer to Procedure 011-059 in Section 11 and/or equipment manufacturer service information.



**NOTE:** If the system fails to prime a key cycle will be required before attempting to run the aftertreatment DEF system leak test again.

**NOTE:** The aftertreatment DEF system leak test can **only** be attempted twice consecutively. A key cycle will be required before attempting to run the aftertreatment DEF system leak test again after two attempts.

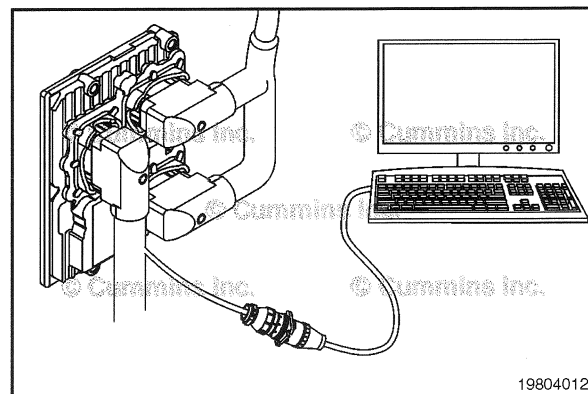
If the system is able to successfully prime, a pop-up message will appear in INSITE™ electronic service tool to notify the technician.

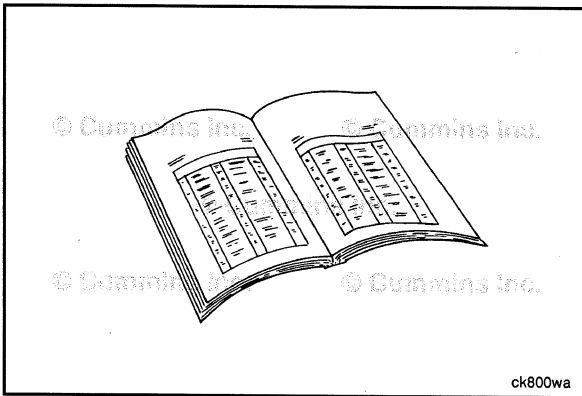
Upon completion of inspecting the lines, fittings, and connections for leaks, press the STOP button in INSITE™ electronic service tool. The dosing unit will then purge the system of DEF. An audible purging noise will be noticeable.

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 diesel exhaust fluid.

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, reference the appropriate fault code troubleshooting tree.

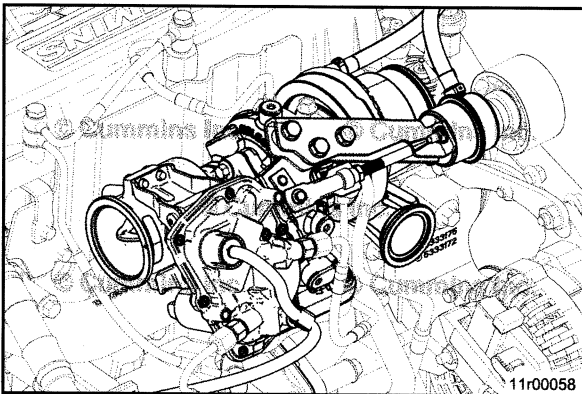




## Finishing Steps



- During the test, a small quantity of DEF is sprayed into the aftertreatment decomposition tube. After completion of the test, it is necessary to run the engine at high idle for 5 minutes in order to prevent DEF deposits from forming in the aftertreatment decomposition tube.
- Check for fault codes.



## Exhaust Pressure Regulator (011-105)

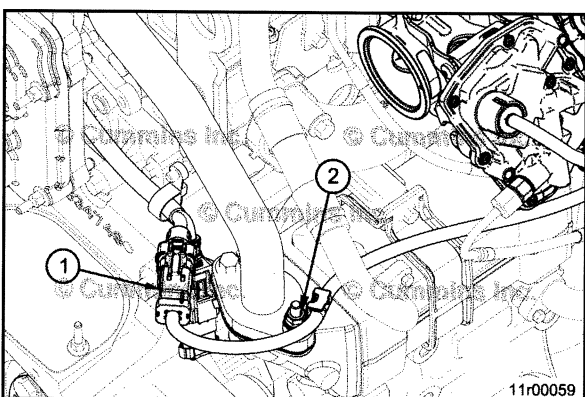
### General Information

The engine control module (ECM) uses the exhaust pressure regulator to regulate air flow at the turbine exhaust outlet to aid in the thermal control of the wastegate turbocharger and exhaust gas recirculation (EGR) valve.

The engine exhaust pressure regulator connects between the following components:

- Turbine outlet adapter by a V-band clamp
- Exhaust outlet pipe connection to aftertreatment component.

An electronic actuator controls the movement of the throttle plate. The position of the engine exhaust pressure regulator moves between fully open (0 percent) and fully closed (100 percent). When the engine is keyed OFF (power off) or keyed ON with zero engine rpm, the exhaust pressure regulator will be fully open.



## 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▲

Electrical operation of the exhaust pressure regulator is only permitted via the ECM. The application of a DC voltage directly to the exhaust pressure regulator will result in serious damage to the actuator.

- Disconnect the batteries. See equipment manufacturer service information.
- Disconnect the electrical connection at the exhaust pressure regulator (1).
- Remove the nut and retaining clip from the stud on the EGR crossover tube (2).

## Remove

### ⚠ CAUTION ⚠

Do not force or strike the actuator housing or clamp with a heavy object. The exhaust pressure regulator could be damaged.

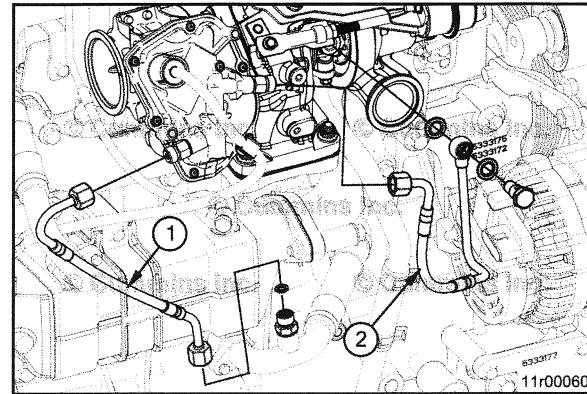
- Partially drain the cooling system. Refer to Procedure 008-018 in Section 8.
- Disconnect the exhaust pressure regulator coolant supply line (1) and coolant return line (2).

**NOTE:** The coolant line fittings have a special coating on the threads and should never be removed from the housing.

- Disconnect the exhaust outlet pipe connection to the aftertreatment component.
- Disconnect the V-band clamp from the turbine outlet adaptor.

**NOTE:** It may be necessary to use a soft hammer to gently tap the V-band clamp for removal.

- Remove the 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 ⚠

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

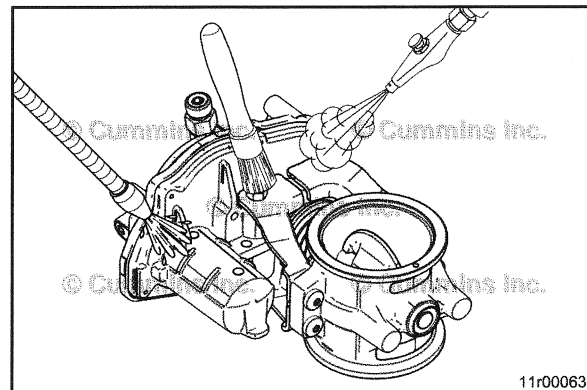
**NOTE:** Quick or forceful movements of the throttle plate by hand can result in damage to the mechanism.

**NOTE:** The exhaust pressure regulator actuator is not repairable and should not be disassembled.

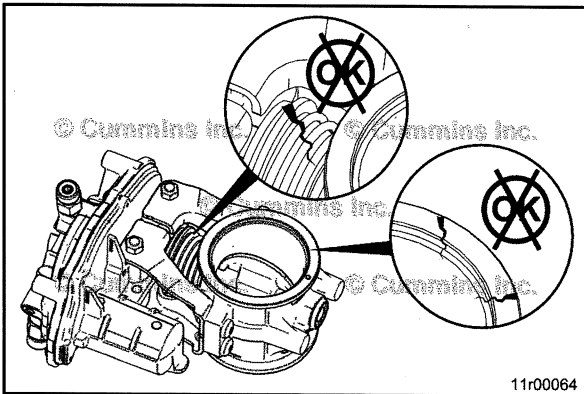
Carefully clean the exhaust pressure regulator with warm soapy water or an acetone free solvent. Do **not** immerse.

Carefully dry with compressed air.

**NOTE:** Solvents containing acetone can damage the seals in the exhaust pressure regulator. Avoid these types of solvents.



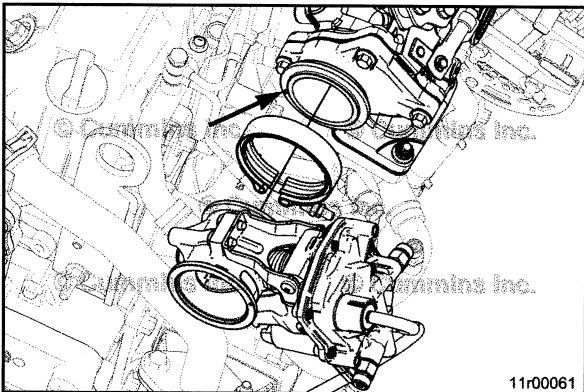




Inspect the exhaust pressure regulator connection sealing surfaces for cracks and other damage.



Inspect valve housing and spring for cracks, breaks, or other damage.



### Install

Install the exhaust pressure regulator to the exhaust outlet adaptor.

**NOTE:** Make sure to align the pin in the outlet adaptor with the hole in the flange of the exhaust pressure regulator.

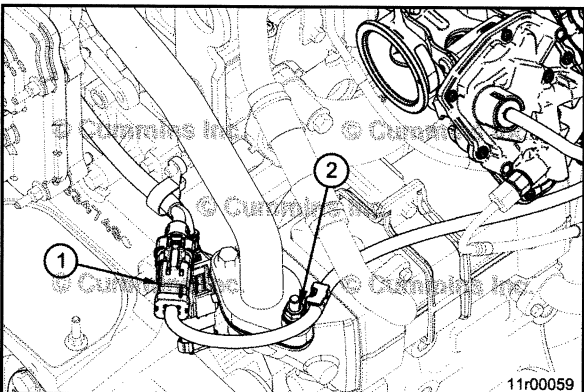
Connect the V-band clamp to the turbine outlet adapter.

**Torque Value:** 10 N•m [ 89 in-lb ]

Connect the exhaust outlet pipe to the aftertreatment component. See equipment manufacturer service information.

Connect coolant supply line and coolant return line to the fittings in the exhaust pressure regulator.

**Torque Value:** 16 N•m [ 142 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 nut and retaining clip on the stud of the EGR crossover tube (2).

**Torque Value:** 10 N•m [ 89 in-lb ]

- Connect the electrical connector at the exhaust pressure regulator (1).
- Fill and vent 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.

# Section 13 - Electrical Equipment - Group 13

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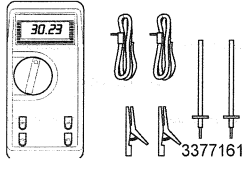
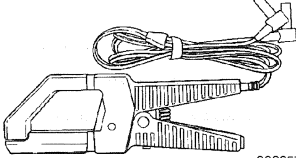
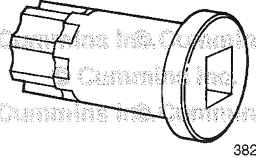
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## Service Tools

### 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
3164489	<p style="text-align: center;"><b>Digital Multimeter</b></p> <p>Used to measure electrical circuits: Voltage (VDC), resistance (ohms), and current (amps). 3164489 - meter with built in temperature adapter and tachometer.</p>	
3164490	<p style="text-align: center;"><b>Clamp-on Current Probe</b></p> <p>Used to measure DC currents from 1 to 1000 amps or AC currents from 1 to 1000 amps.</p>	
3824591	<p style="text-align: center;"><b>Barring Tool</b></p> <p>Used to engage the flywheel ring gear to rotate the crankshaft.</p>	

## Charging System Alternator (013-001)

### General Information

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

#### Typical Delco™ Alternator Wiring System

##### Indicator (I) Terminal

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

##### Lamp (L) Terminal

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

##### Relay (R) Terminal

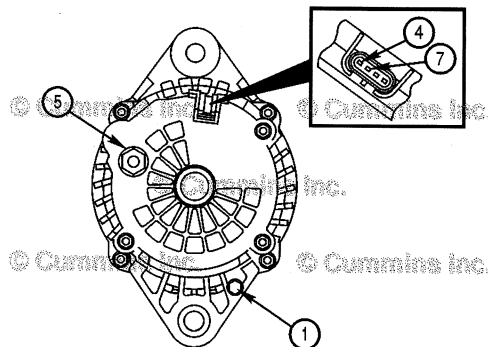
The function of the relay (R) terminal varies. It can supply up to 4 amperes of output at one-half nominal alternator voltage to power items such as a tachometer or an hour meter.

##### One-Wire System

This is the simplest of the wiring systems because the **only** wires connected to the alternator are at the battery (BAT) and ground terminals. (See Table 5.) Connecting to the R terminal, L terminal, and I terminal is optional.

##### Three-Wire System

This system requires more wiring because it has a battery (BAT) terminal, R terminal, two blade terminals identified as number 1 and number 2, and a ground terminal. Typically, in the three-wire system, the number 1 blade terminal serves as the I terminal. (See Table 5.) The advantage of the three-wire system is that it provides the same features as the one-wire system, plus remote sense. By connecting the number 2 blade terminal to the battery's positive (+) terminal, the voltage is both sensed and regulated at the battery, instead of at the alternator. This eliminates the potential for voltage losses in the wiring from the alternator to the battery.



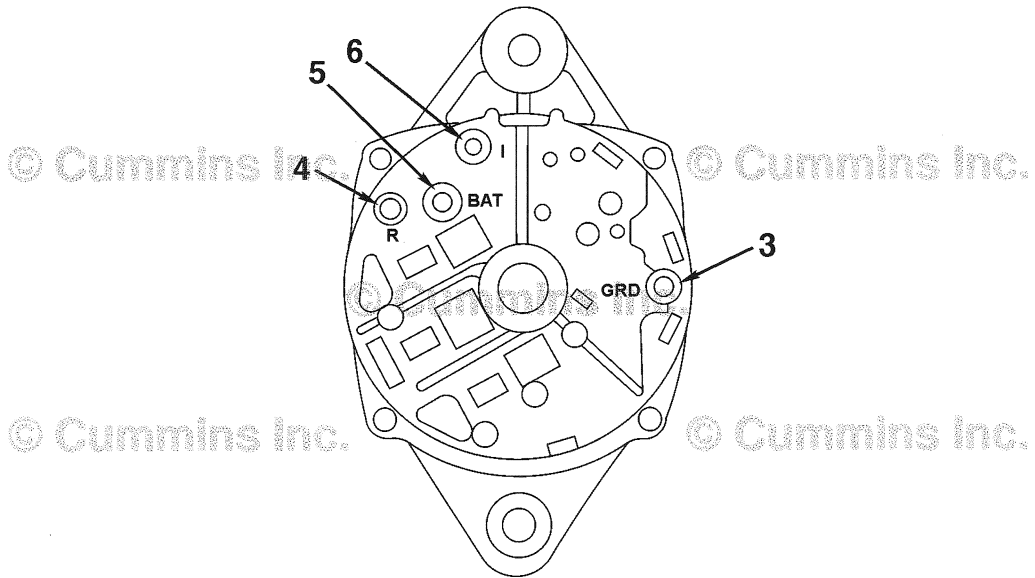
13900200

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

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

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

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



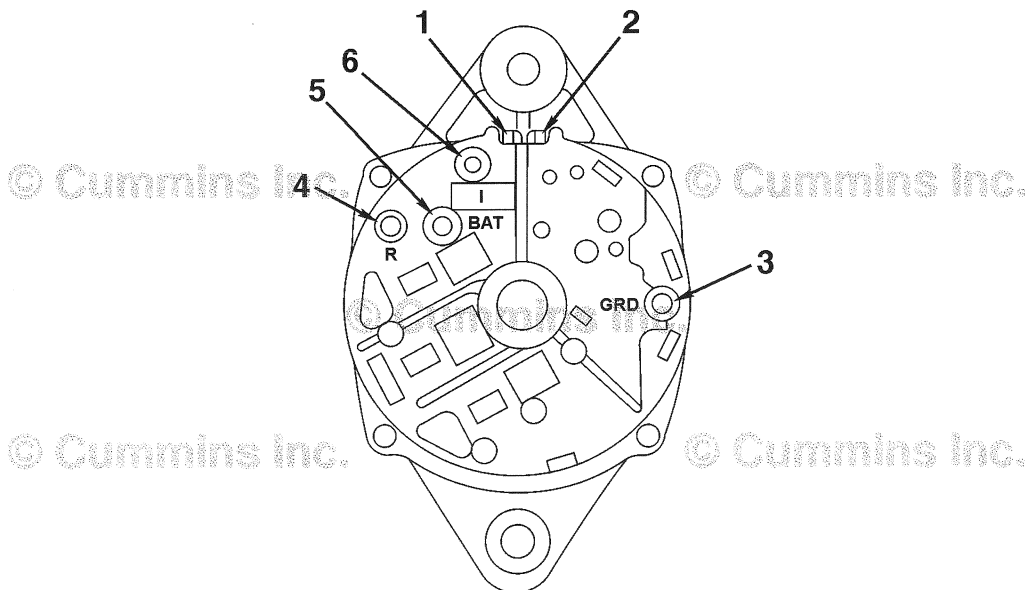
13900134

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

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

\*Not all alternators have this feature.

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



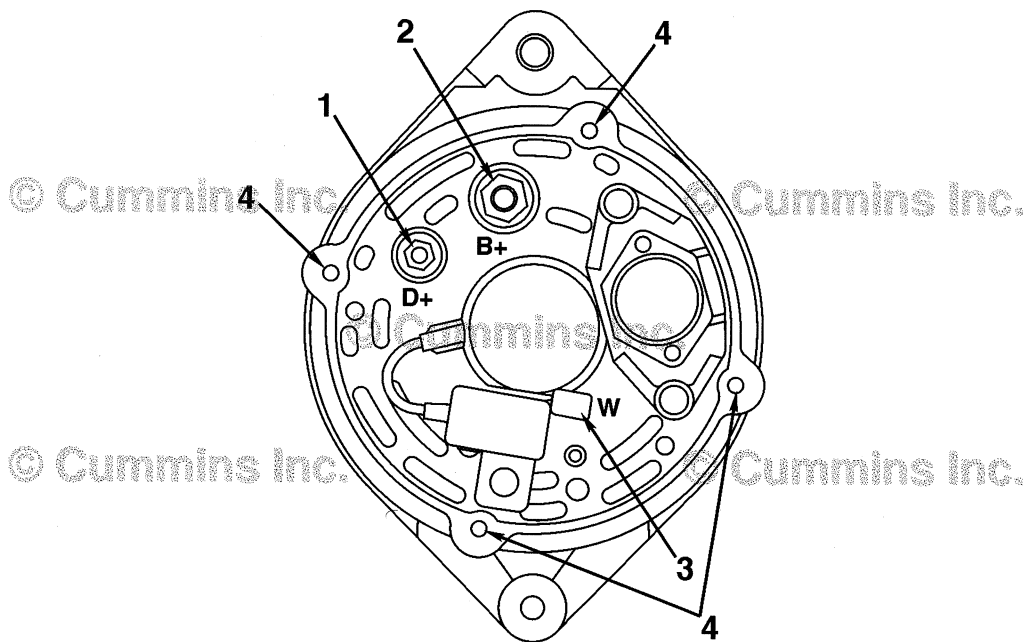
13900135

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

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

\*Not all alternators have this feature.

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



13900133

Table 6, Typical Alternator (Bosch™ K1)

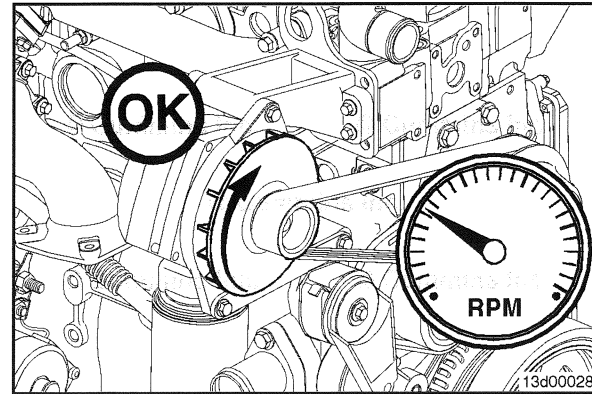
Typical Bosch™ K1 Wiring System		
Key	Terminal	Connected to
1	D+	Electrical charging system status light
2	B+	Positive battery
3	W	Tachometer
4	—	Ground/assembly

### Initial Check

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

If any problems exist, check the following:

- 1 If the drive belt is slipping on the alternator pulley, use the following procedure to inspect the drive belt. Refer to Procedure 008-002 in Section 8. Use the following procedure to inspect the belt tensioner. Refer to Procedure 008-087 in Section 8.
- 2 Remove the drive belt. Refer to Procedure 008-002 in Section 8.
- 3 Check if the alternator pulley is loose on the shaft. If loose, remove the pulley and inspect for damage. Refer to the alternator manufacturer's and/or original equipment manufacturer (OEM) service manual.
- 4 If the alternator will **not** rotate or does **not** rotate freely, the alternator **must** be replaced. See the remove and install section of this procedure.



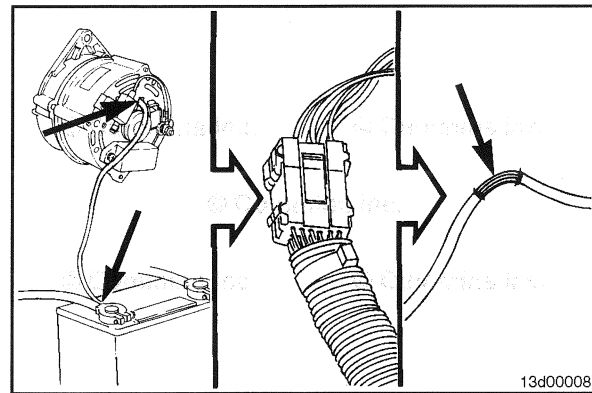
### ⚠ WARNING ⚠

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

Check the battery and all wiring connections.

Inspect the wiring for defects.

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



### Test

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

Check for open circuits.

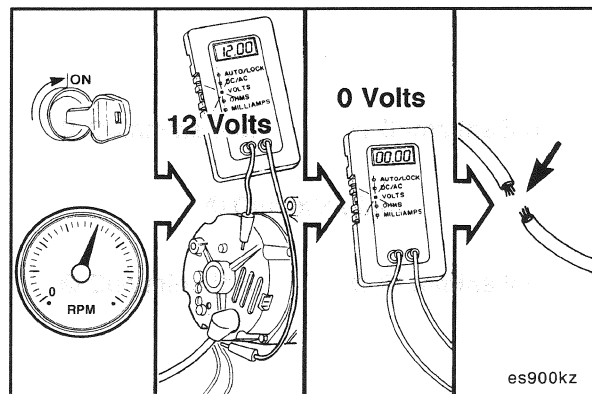
Turn the keyswitch to the ON position.

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

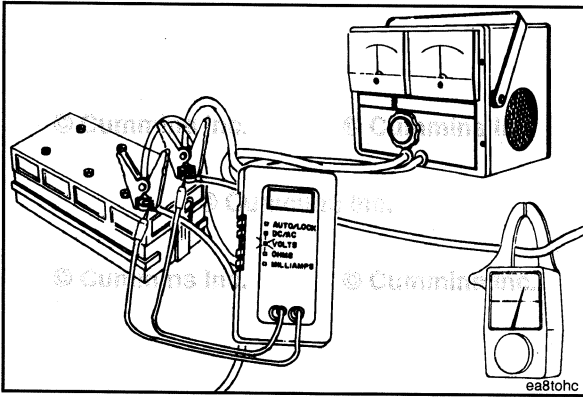
Delco™ Alternators

- 1 Alternator "BAT" terminal to ground
- 2 Alternator blade terminal "number 1" to ground
- 3 Alternator blade terminal "number 2" to ground.

Locate and repair the open circuit.

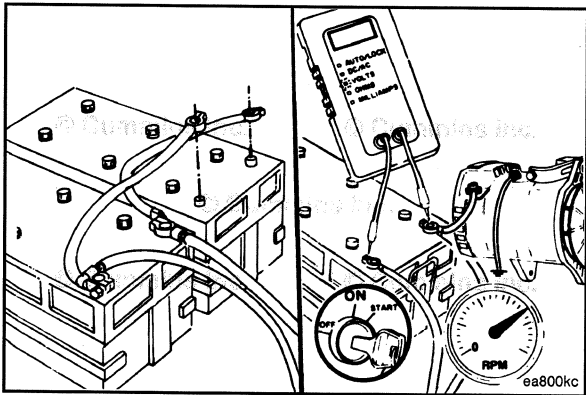






Connect a carbon-pile load (battery/alternator tester) across the batteries in one of the battery boxes.

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



**▲ WARNING ▲**

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

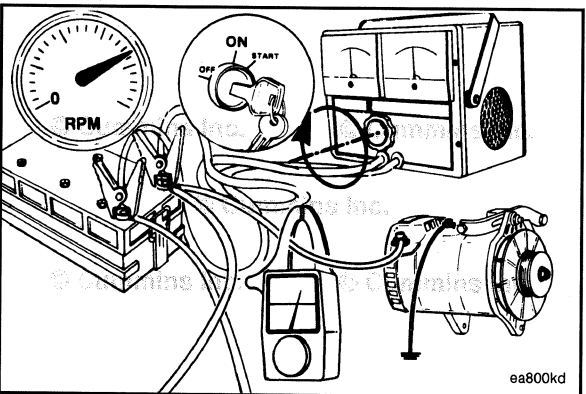


**▲ WARNING ▲**

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

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

Operate the engine at high idle; and measure the alternator voltage output to the batteries with digital multimeter, Cummins® Part Number 3164488 or 3164489. See equipment manufacturer service information.



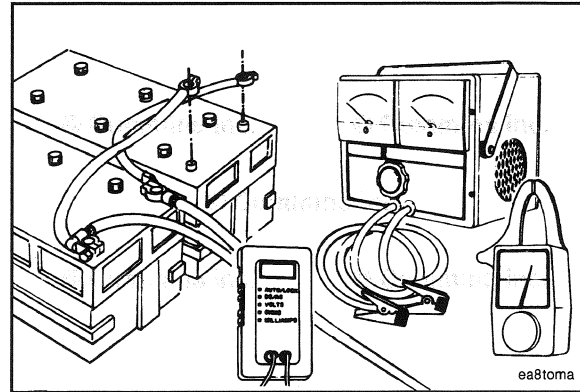
Operate the engine at high idle and adjust the carbon-pile load-testing equipment to apply the maximum rated amperage load to the alternator. Refer to the specifications in the OEM service manual.

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

Measure the alternator amperage output. See equipment manufacturer service information for specifications.

If the alternator output (amps) is **not** within 10 percent of rated output, repair or replace the alternator. See equipment manufacturer service information for repair procedures.

Shut off the engine and remove the test equipment.  
Connect all battery cables, negative (-) cable last.



## Preparatory Steps

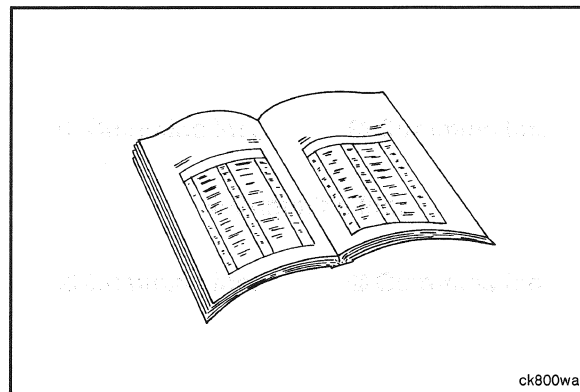
### ▲ WARNING ▲

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

### ▲ WARNING ▲

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

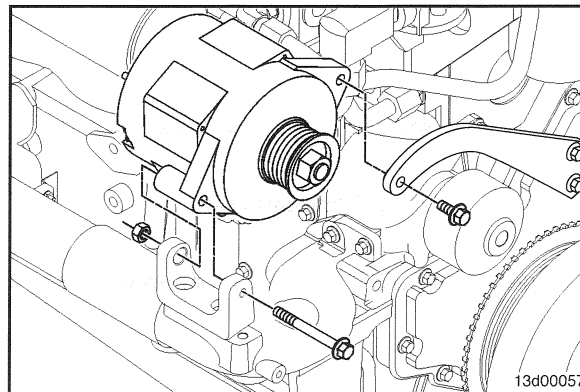
- Disconnect the batteries. See equipment manufacturer service information.
- Remove the drive belt from the alternator pulley. Refer to Procedure 008-002 in Section 8.
- Tag and label all wires on the alternator.
- Disconnect the wires.

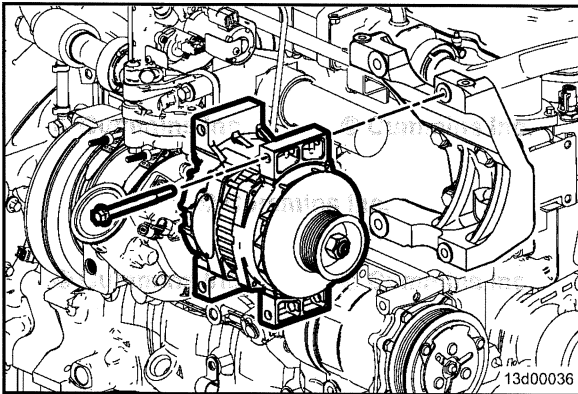


## Remove

### Spool Mount

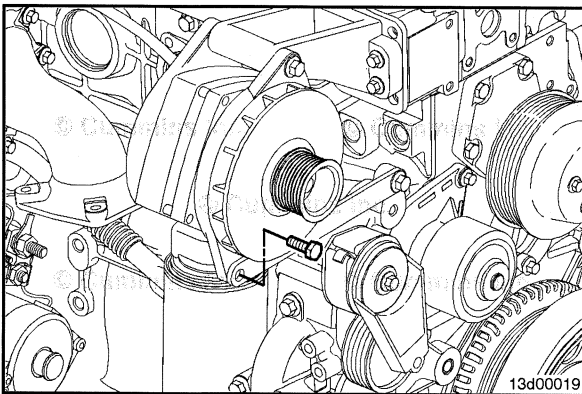
- Remove the upper alternator link capscrew.
- Remove the mounting capscrew and nut at the bottom of the alternator and alternator mounting bracket.
- Remove the alternator.





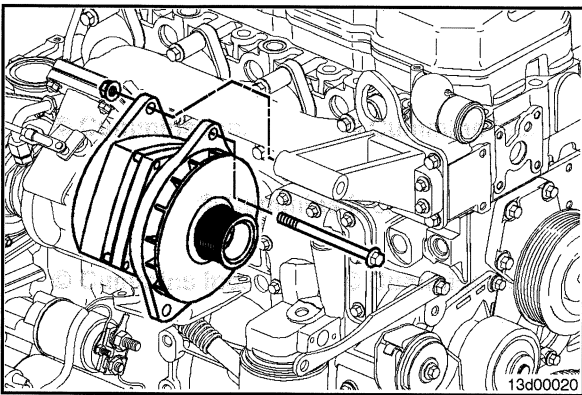
**Pad Mount**

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



**Hinge Mount**

- Remove the alternator link capscrew.



- Remove the alternator mounting capscrew.
- Remove the alternator.

Typical Delco™ Alternator Wiring System

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

Relay (R) Terminal

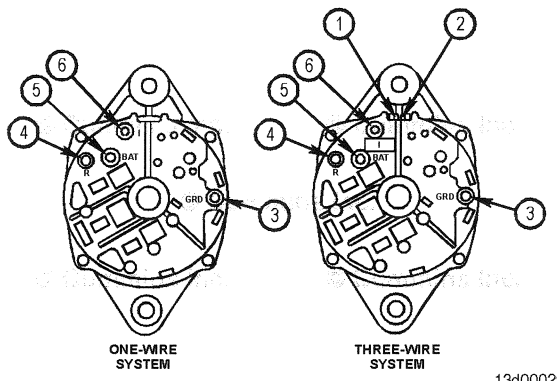
The function of the relay (R) terminal varies. It can supply up to 4 amps of output at one-half nominal alternator voltage to power items such as a tachometer or an hour meter.

One-Wire System

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

Three-Wire System

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



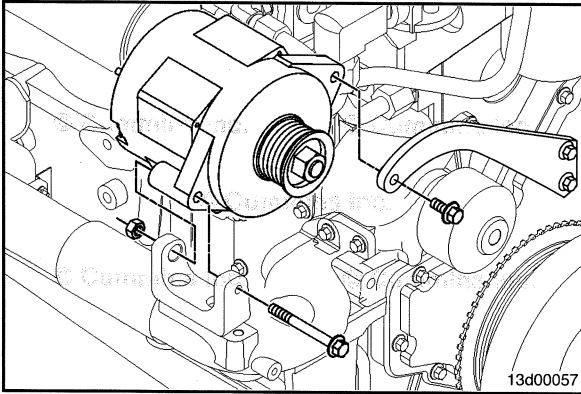
13d00029

Typical Alternator (Delco-Remy™)

Key	Terminal	Connected To
5	BAT	Battery
3	GRD*	Ground
4	R*	Charge indicator, automatic lockout system, tachometer**
1	Blade number 1*	Indicator light
2	Blade number 2	Voltage sense
6	I*	Indicator light

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

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



### Install

#### Spool Mount



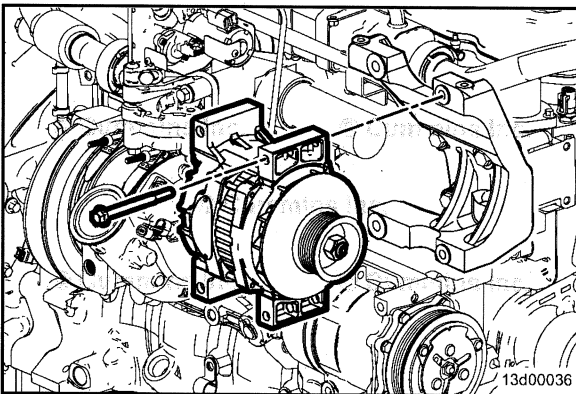
- Install the alternator and the bottom alternator mounting capscrew and nut.
- Install the upper alternator link mounting capscrew at the top of the alternator.
- Tighten the capscrews.

#### Torque Value:

Lower Mounting Capscrew 40 N•m [ 30 ft-lb ]

#### Torque Value:

Upper Link Mounting Capscrew 24 N•m [ 212 in-lb ]



### Pad Mount



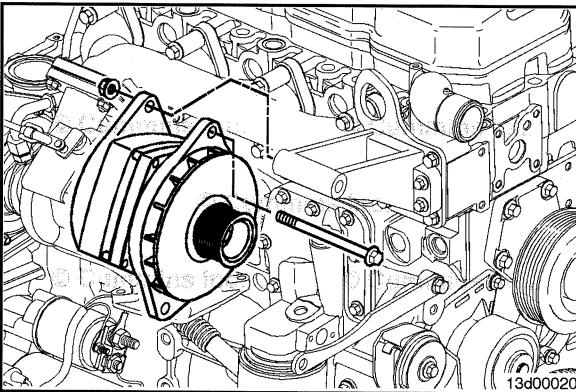
- Install the alternator.
- Install and tighten the alternator mounting capscrews.

#### Torque Value:

M10 Capscrew 36 N•m [ 27 ft-lb ]

#### Torque Value:

M12 Capscrew 64 N•m [ 47 ft-lb ]

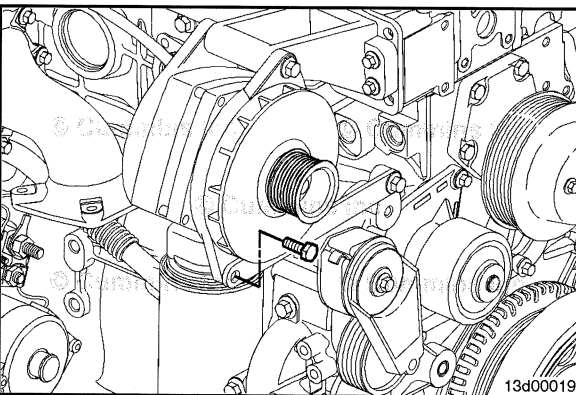


### Hinge Mount



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

**Torque Value:** 40 N•m [ 30 ft-lb ]



- Install the alternator link capscrew.

**Torque Value:** 24 N•m [ 212 in-lb ]



## Finishing Steps

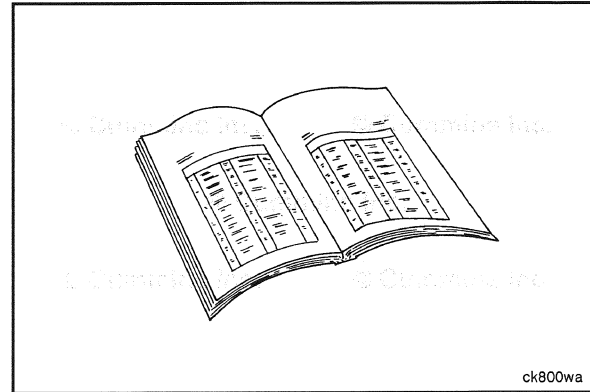
### ⚠ WARNING ⚠

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

### ⚠ WARNING ⚠

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

- Connect all wires to the alternator.
- Install the drive belt. Refer to Procedure 008-002 in Section 8.
- Connect the batteries. Refer to the OEM instructions.
- Operate the engine and check for proper operation.

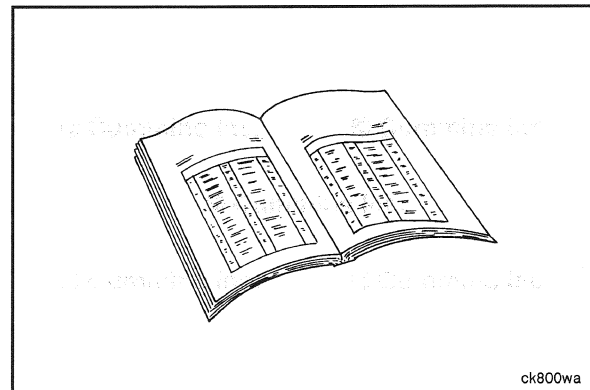


## Charging System Alternator Bracket (013-003)

### General Information

For different applications, there are two kinds of alternator bracket.

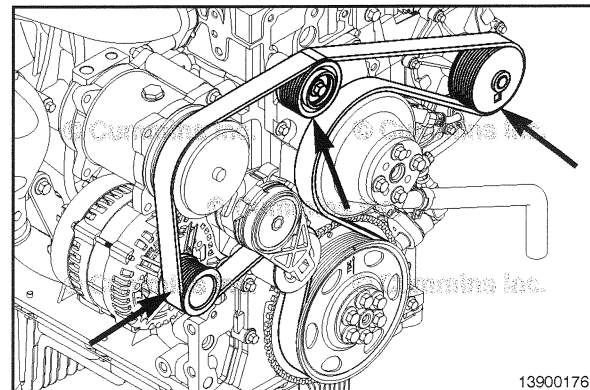
- 1 Alternator bracket without air compressor mounting.
- 2 Alternator bracket with air compressor mounting.

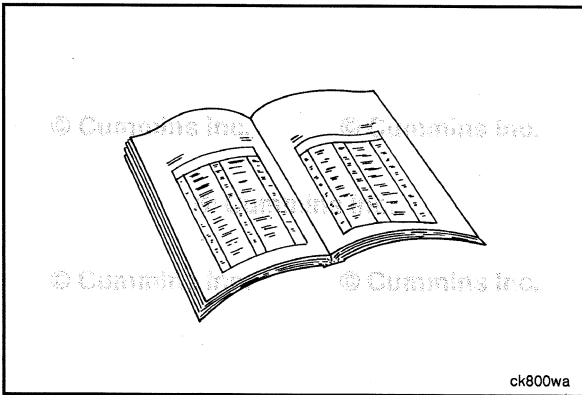


### Initial Check

Check that the alternator pulley is in line with the other belt driven pulleys.

If the alternator pulley is out of alignment, verify the correct alternator brackets have been used and/or have been installed correctly.



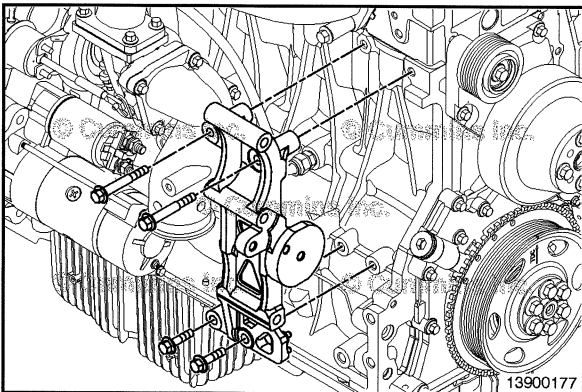


## Preparatory Steps

### ⚠ WARNING ⚠

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

- Disconnect the battery. See equipment manufacturer service information.
- Remove the drive belt. Refer to Procedure 008-002 in Section 8.
- Remove the alternator. Refer to Procedure 013-001 in Section 13.

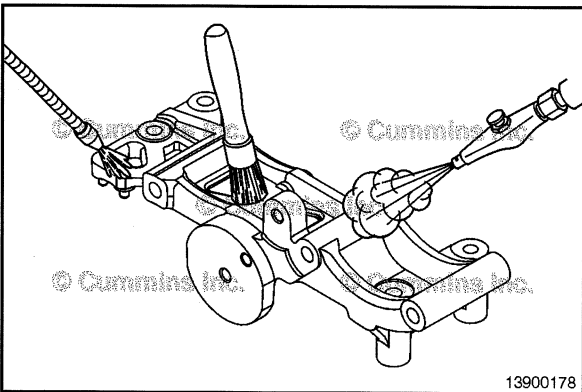


## Remove

Remove the upper alternator bracket mounting capscrews.

Remove the lower alternator bracket mounting capscrews.

Remove the alternator bracket.



## 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, following 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.

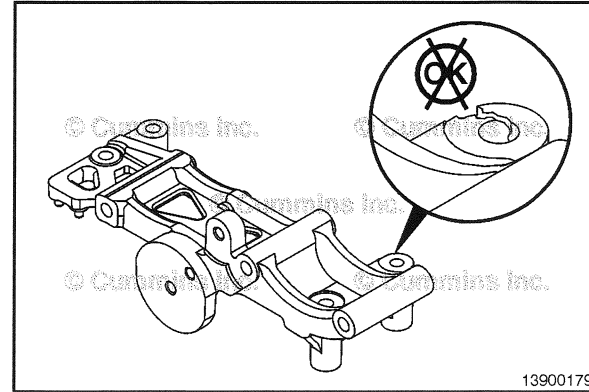
Use steam or solvent to clean the alternator brackets.

Dry with compressed air.

Inspect the alternator brackets for cracks or other damage.



If any cracks or other damage is found on the alternator brackets, they **must** be replaced.



### Install

Install the upper alternator bracket and mounting capscrews.

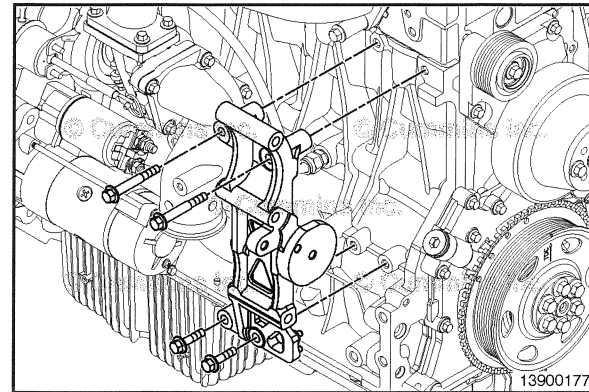


Install the lower alternator bracket and mounting capscrews.



Tighten the upper and lower alternator bracket mounting capscrews.

**Torque Value:** 45 N•m [ 33 ft-lb ]



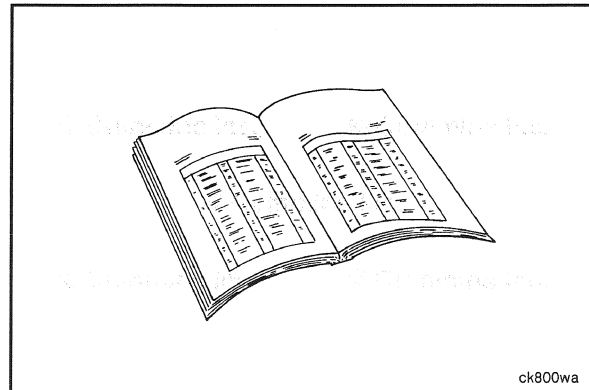
### Finishing Steps

#### **⚠ WARNING ⚠**

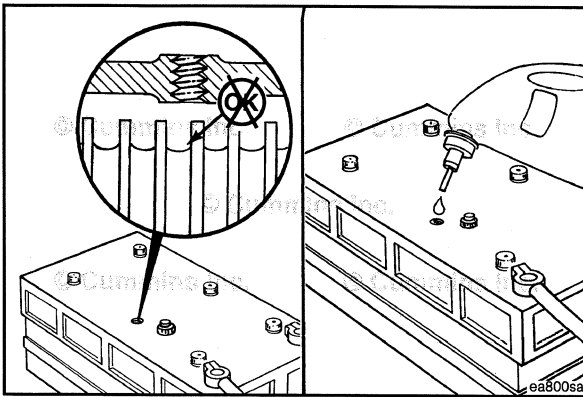
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.



- Install the alternator. Refer to Procedure 013-001 in Section 13.
- Install the drive belt. Refer to Procedure 008-002 in Section 8.
- Connect the battery. See equipment manufacturer service information.
- Operate the engine to check for proper operation.







## Batteries (013-007)

### Initial Check

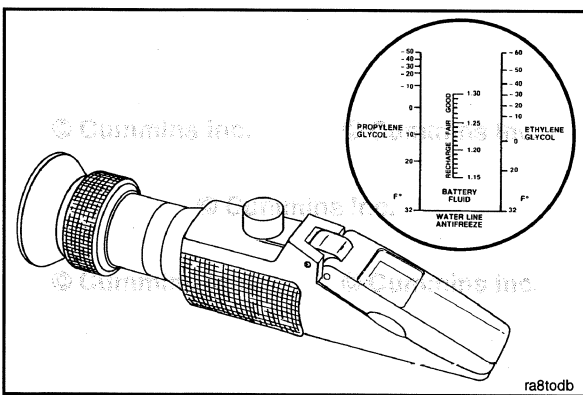


If conventional batteries are used, remove the cell caps or covers, and check the electrolyte level.



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

Fill each battery cell with distilled water. See equipment manufacturer service information.



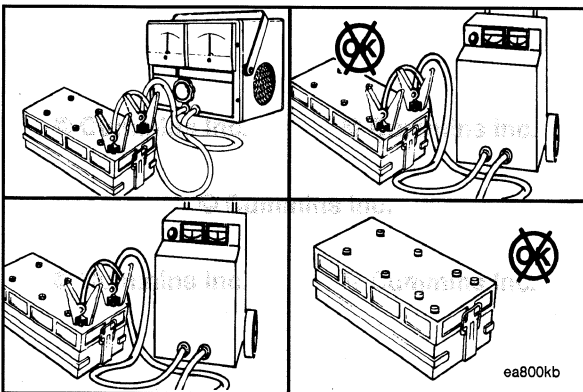
Use a Fleetguard™ refractometer, Part Number CC-2800, to check the specific gravity of the battery electrolyte.



Refer to the battery fluid column in the refractometer to determine the state of charge of each battery cell.



If water has been added to a dry cell, recharge the battery to mix the added water with the existing battery electrolyte, to prevent incorrect readings.



### ⚠ CAUTION ⚠

**Do not connect battery charging cables to any electronic control system part. This can damage the electronic control system parts.**



Use a carbon-pile load (battery/alternator tester) to test the output amperage of maintenance-free or conventional vent cap batteries.



If the output amperage is low, use a battery charger to charge the battery. See equipment manufacturer service information.

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

## Battery Cables and Connections (013-009)

### Initial Check

#### ⚠️ WARNING ⚠️

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

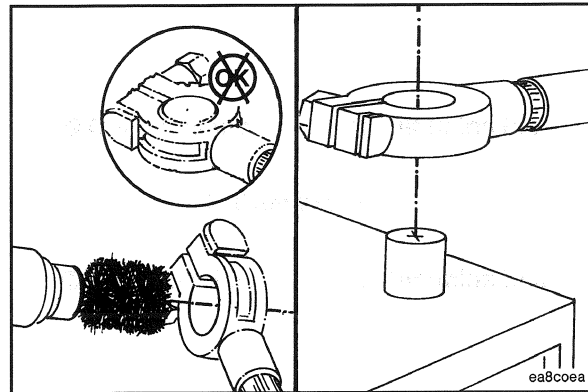
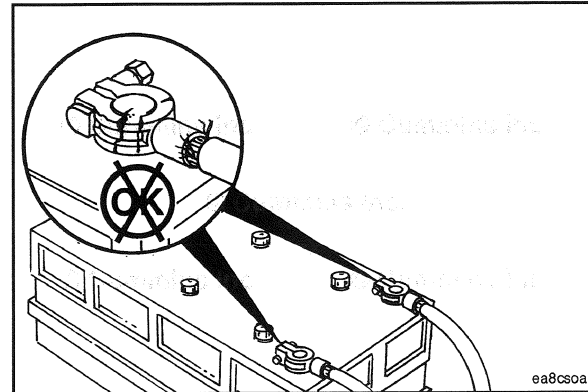
Inspect the battery terminals for loose, broken, or corroded connections.

Repair or replace broken cables or terminals.

If the connections are corroded, remove the cables and use a battery brush to clean the cable and battery terminals.

Install and tighten the battery cables.

Use grease to coat the battery terminals to prevent corrosion.



## Starter Magnetic Switch (013-017)

### Initial Check

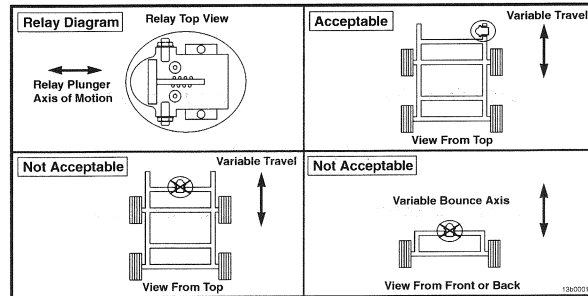
#### ⚠️ CAUTION ⚠️

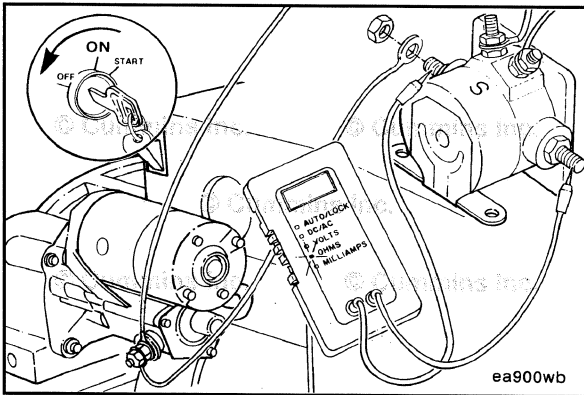
Improper installation of the starter magnetic switch can result in starter over-run damage.

To make sure that the magnetic switch is **not** activated by vehicle movement, the axis of the plunger **must** be horizontal to the ground and perpendicular to vehicle travel.

Do **not** mount an external magnetic switch on the engine or on any metal that can possibly resonate as the result of road or engine vibration.

- See equipment manufacturer service information for proper magnetic switch installation.





### Resistance Check



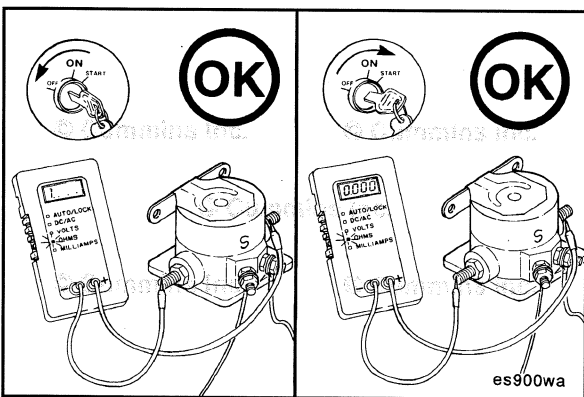
#### ⚠ WARNING ⚠

Be sure the starter motor switch 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 motor solenoid from the magnetic switch terminal.

Connect the leads of the digital multimeter, Cummins® Part Number 3377161, or equivalent, to the two large switch terminals.

Set the digital multimeter, Cummins® Part Number 3377161, to measure resistance (ohms).



Connect the leads to the two large switch terminals.

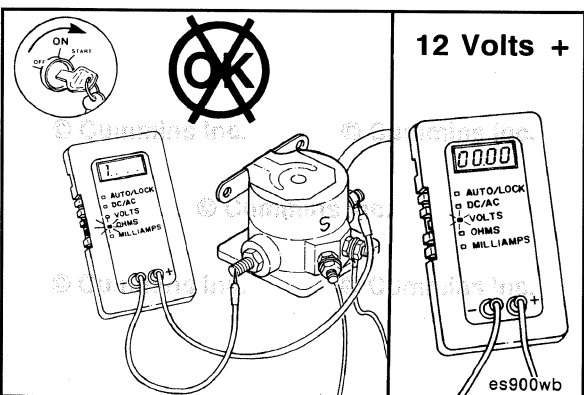
With the keyswitch in the OFF position, the multimeter **must** indicate resistance greater than 100k ohms.



Turn the keyswitch to the START position.



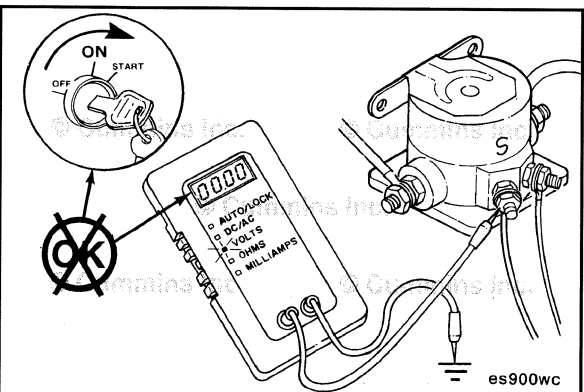
The multimeter **must** indicate less than 10 ohms. If **not** within specifications, replace the starter magnetic switch according to the manufacturer's instructions.



### Voltage Check

If the multimeter indicates resistance greater than 100k ohms with the keyswitch in the START position:

- Turn the keyswitch to the OFF position.
- Set the multimeter scale to read DC voltage.



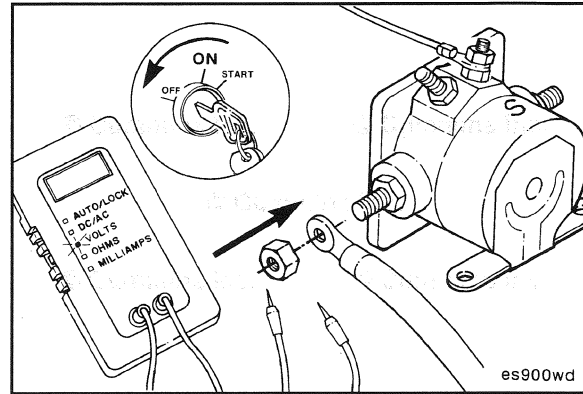
- Connect one multimeter lead to the magnetic switch terminal marked S and the other lead to ground.



- Turn the keyswitch to the START position.

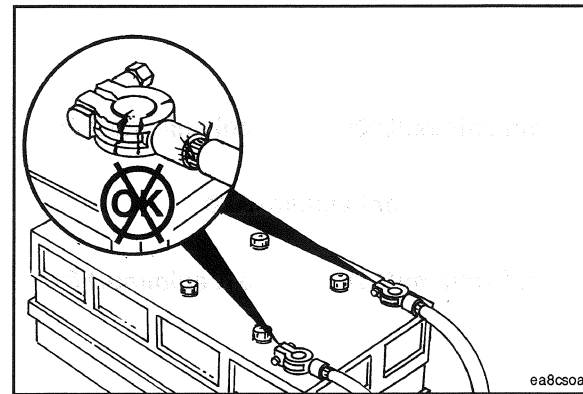
- If the multimeter indicates no voltage, the magnetic switch is **not** the cause of the complaint. If the starter magnetic switch is **not** within specification, replace the switch according to the equipment manufacturer service information.

- Turn the keyswitch to the OFF position.
- Remove the multimeter leads, and connect the magnetic switch to the starter motor solenoid wire.



## Starter Solenoid (013-019) Initial Check

Before troubleshooting the starter motor, make sure the battery terminals are **not** loose or corroded. Refer to Procedure 013-007 in Section 13 and see equipment manufacturer service information.



## Voltage Check

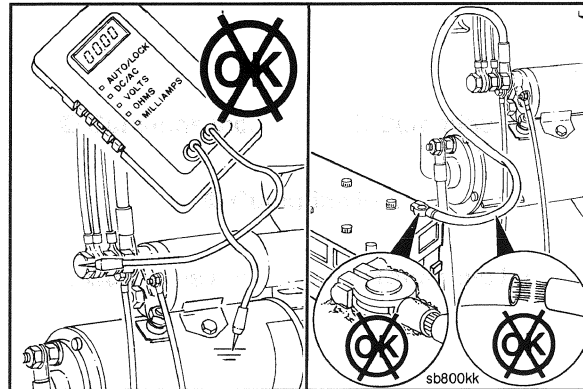
Digital Multimeter, Cummins® Part Number 3377161:

Set the digital multimeter, Cummins® Part Number 3377161, to measure DC volts.

Connect the multimeter positive (+) lead to the starter solenoid positive cable terminal and the negative (-) lead to a chassis or engine ground location.

The multimeter **must** show voltage with the keyswitch in the OFF position to be normal.

If the multimeter does **not** indicate voltage, check the cable connecting the starter solenoid and battery for breaks. Also, check for loose or corroded connections.

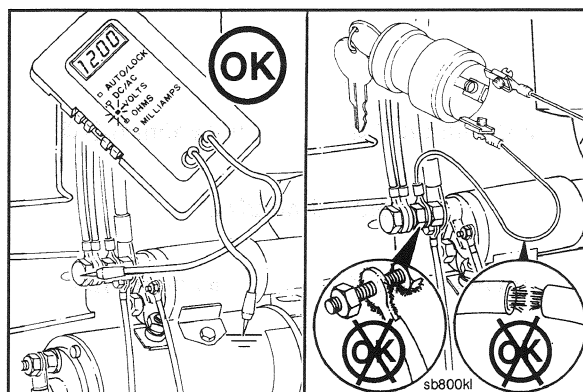


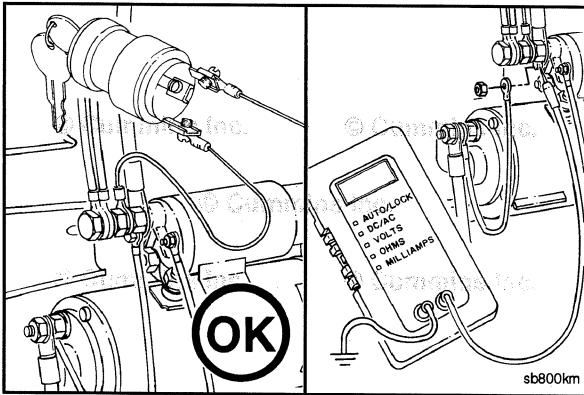
If the multimeter indicates voltage but the starter will **not** operate, check the wire connecting the starter solenoid to the keyswitch for breaks; and also check for loose or corroded connections.



In addition, be sure to check for:

- Fuses.
- Application engine shutoff systems.





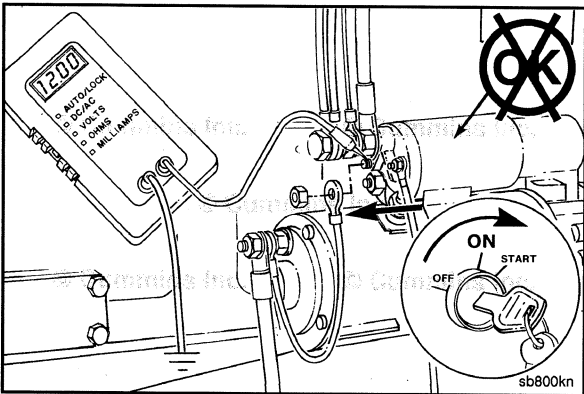
If the wire connecting the starter solenoid and keyswitch is **not** loose or damaged and the starter will **not** operate.



- Remove the cable connecting the starter and starter solenoid from the solenoid terminal.



- Connect the multimeter positive (+) lead to the solenoid "S" or switch terminal and the negative (-) lead to the chassis or an engine ground location.

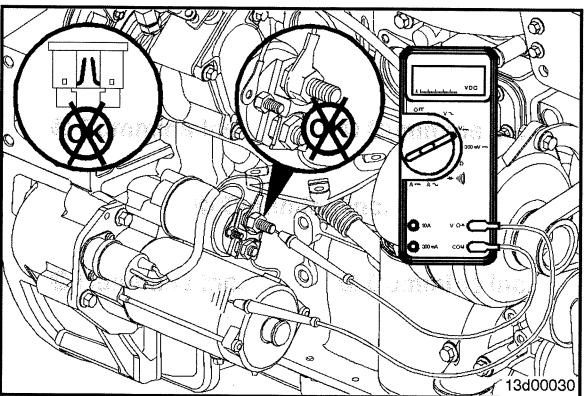


- Turn the keyswitch to the START position.



- If the multimeter indicates voltage and the starter will **not** operate, the starter solenoid is malfunctioning and **must** be replaced.

- Refer to Procedure 013-020 in Section 13.



If the multimeter does **not** indicate system voltage:

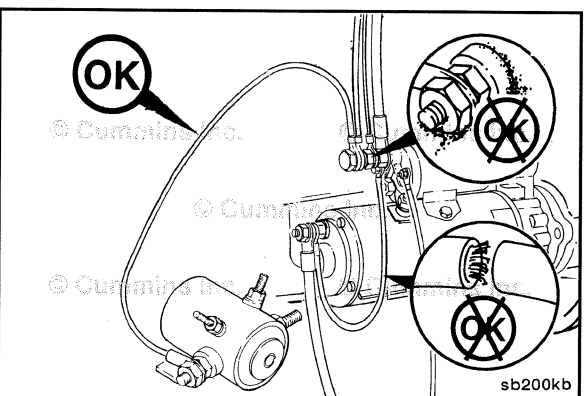


- Check the wire connecting the starter solenoid "S" or switch terminal to the magnetic switch for breaks, and for loose or corroded connections.

- Check that there are no blown fuses.

- Check voltage to the keyswitch and magnetic switch. Refer to Procedure 013-017 in Section 13 and Refer to Procedure 013-030 in Section 13.

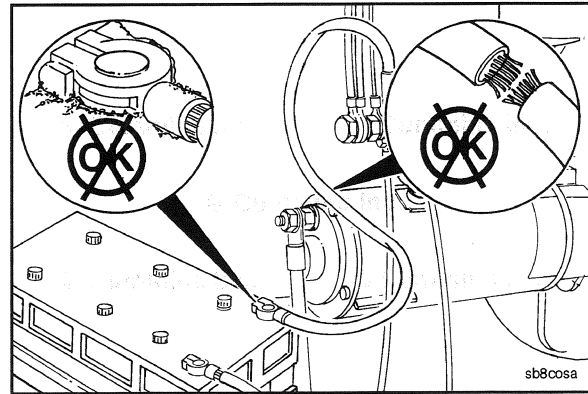
- Check application of the safety shutoff systems.



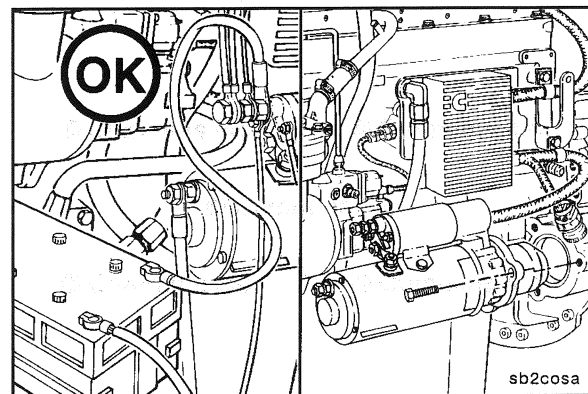
If the wire connecting the starter solenoid to the magnetic switch is **not** loose or damaged and the starter will **not** operate.

- Check the cable connecting the starter solenoid to the starter motor for breaks, and for loose or corroded connections.

- Check the cable connecting the starter motor to the battery for breaks, and for loose or corroded connections.



- If the cables are **not** loose or damaged, the starter motor is malfunctioning and **must** be replaced. Refer to Procedure 013-020 in Section 13.



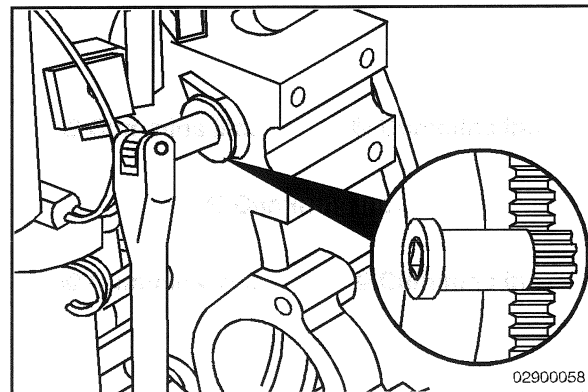
## Starting Motor (013-020) Rotation Check

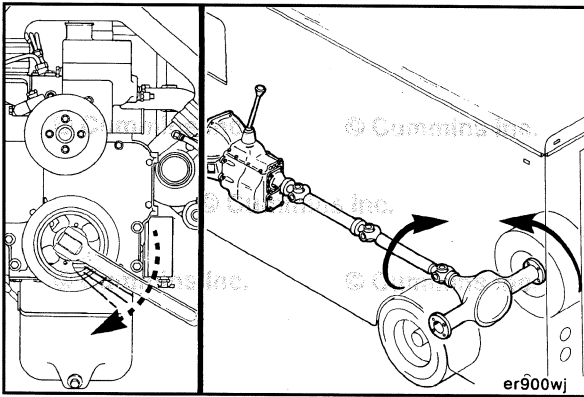
If the starter solenoid is making a sound, but the engine is **not** rotating, turn the keyswitch to the OFF position, and attempt to bar the crankshaft in both directions.

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

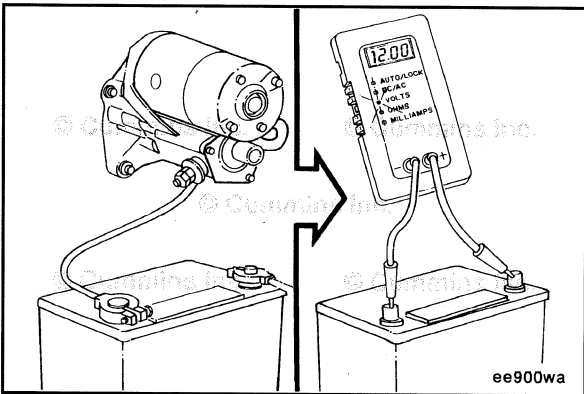
If the crankshaft will bar over, attempt to start the engine. If the starter motor cranks the engine, check the starter motor pinion gear and flywheel ring gear for damage.

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





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

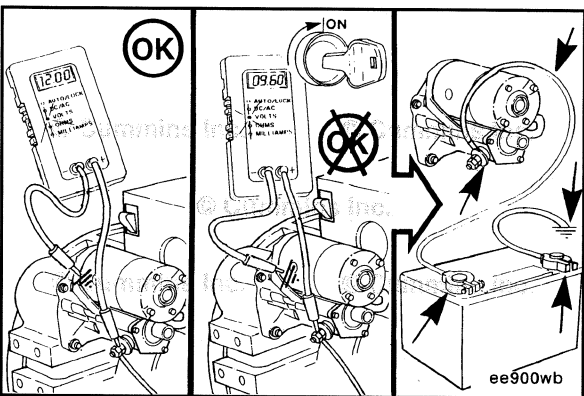


If the engine cranking speed is too slow or will **not** crank at all, and the engine rotates freely:



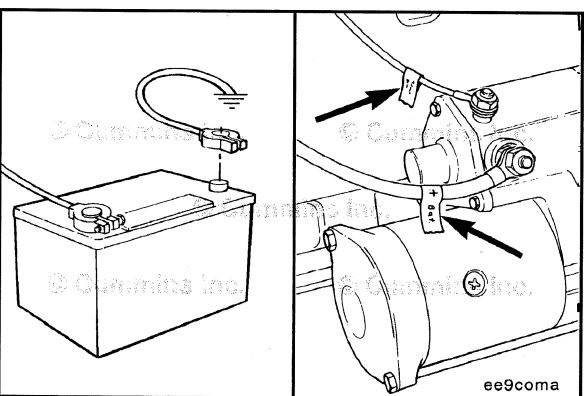
Make sure the wiring connections are clean, tight, and **not** damaged.

Check the battery voltage. See equipment manufacturer service information and/or manufacturer for specifications.



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

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



### Preparatory Steps

#### ▲ WARNING ▲

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

- Disconnect the batteries. See equipment manufacturer service information.
- Identify each wire with a tag indicating location on the starting motor.
- Remove the electrical connections from the starting motor.

**⚠ WARNING ⚠**

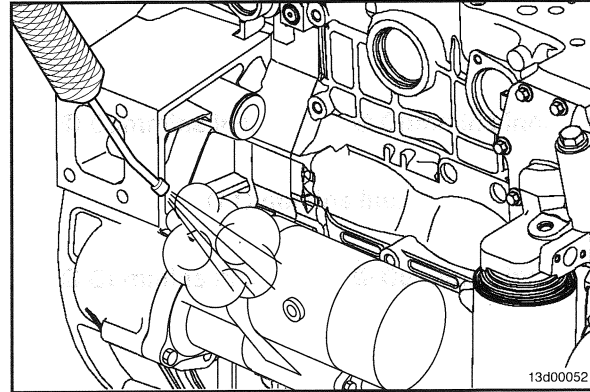
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

**⚠ WARNING ⚠**

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

Prior to removing the starter, use steam to clean the area around the starting motor to prevent debris from entering the flywheel housing.

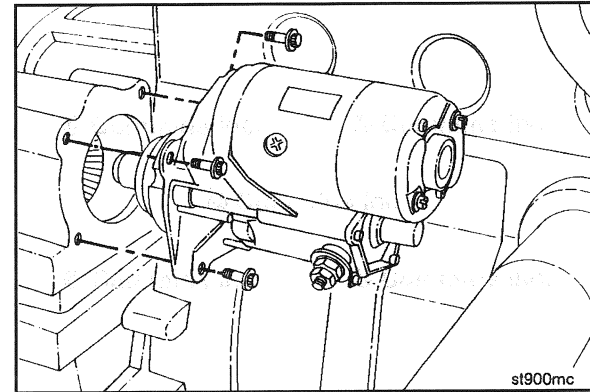
Dry with compressed air.



### Remove

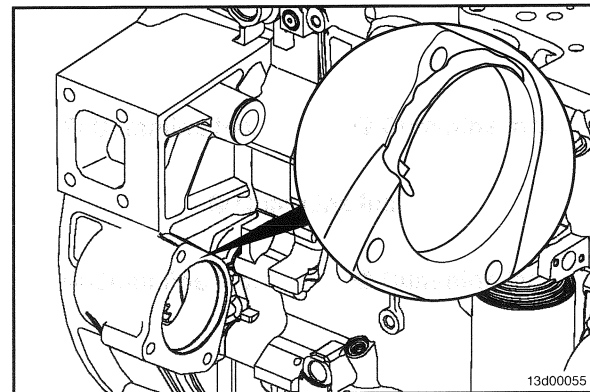
Remove the three capscrews and the starting motor.

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



### Clean and Inspect for Reuse

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

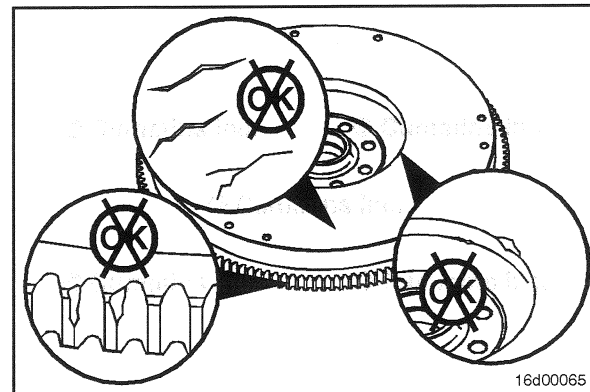


Inspect the starter motor pinion gear and/or flywheel ring gear for chipping or uneven wear.

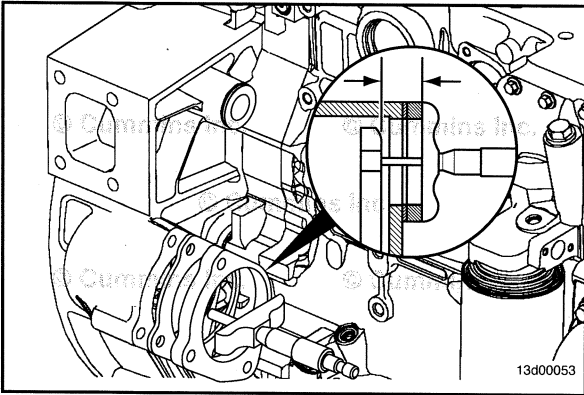
**NOTE:** If the starter motor pinion gear and/or flywheel ring gear teeth are damaged, they **must** be replaced.

Use the following procedure if equipped with a flywheel. Refer to Procedure 016-005 in Section 16.

Use the following procedure if equipped with a flexplate. Refer to Procedure 016-004 in Section 16.







### Measure

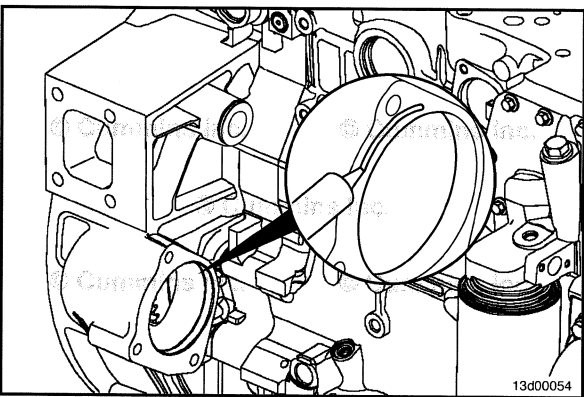
Use an inside micrometer or a vernier caliper to measure the distance from the starting motor mounting flange to the forward face of the front side of the flywheel ring gear.

**NOTE:** Include any spacers previously removed when completing the measurement.

### Starting Motor Spacing

mm		in
49.28	MIN	1.94
52.32	MAX	2.06

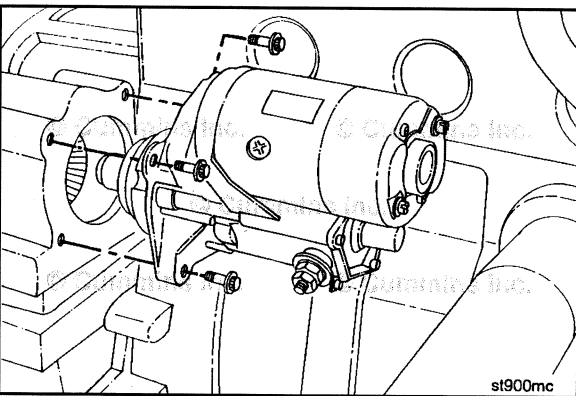
Add or remove spacers as necessary to achieve the correct starting motor spacing.



### Install

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

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



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

**Torque Value:** 43 N•m [ 32 ft-lb ]



### Cummins® Branded Starters

#### ⚠ WARNING ⚠

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

#### ⚠ CAUTION ⚠

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

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

Connect the electrical connections to the starter motor.

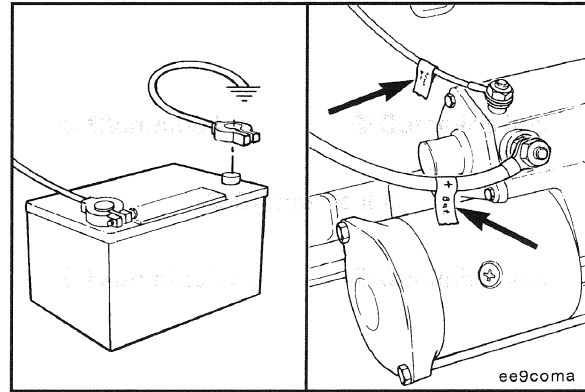
#### Torque Value:

M5 4 N•m [ 35 in-lb ]

#### Torque Value:

M10 21 N•m [ 186 in-lb ]

Connect the ground cable to the battery terminal.



### Non-Cummins® Branded Starters

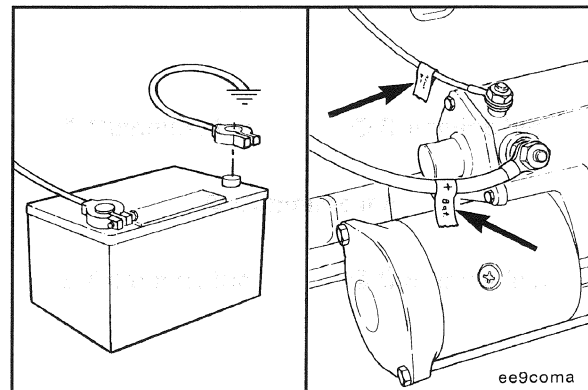
#### ⚠ CAUTION ⚠

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

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

Install the starter motor electrical connections.

For Non-Cummins® branded starters, see equipment manufacturer service information for torque specifications.

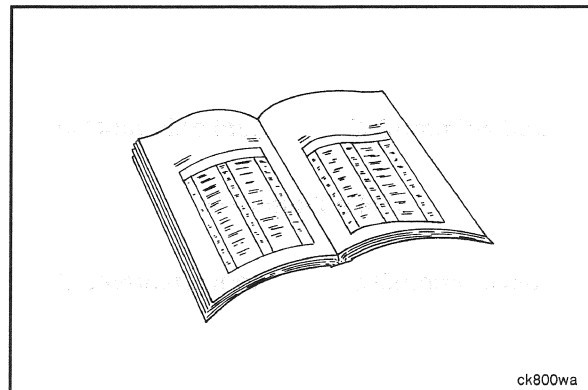


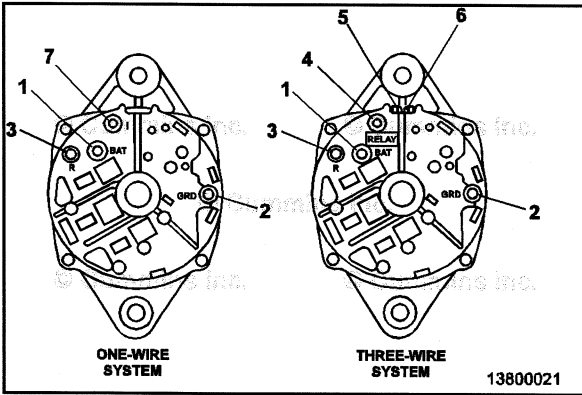
### Finishing Steps

#### ⚠ WARNING ⚠

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

- Connect the batteries. See equipment manufacturer service information.
- Operate the starter to check for proper function.



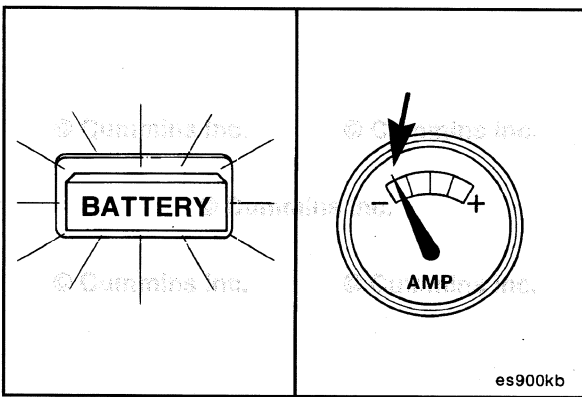


## Charging System Indicator (013-023)

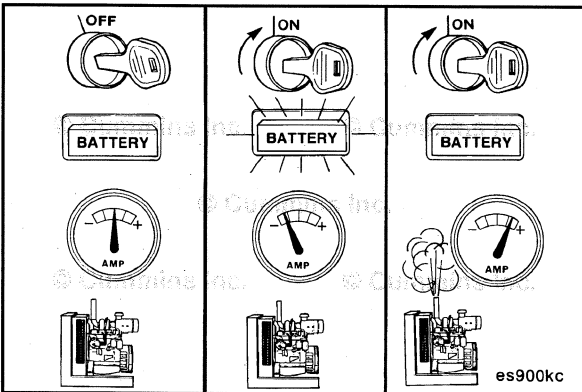
### Initial Check

**NOTE:** Be positive that the correct terminals are used on the alternator.

Reference the alternator manufacturer's instructions.



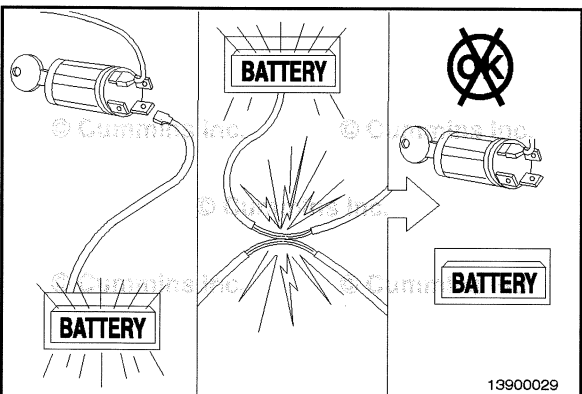
Trouble with the charging system can be indicated by the indicator lamp or ammeter.



Check the indicator lamp for normal operation as shown below.



Stopped	Off	Off
Stopped	On	On
Running	On	Off



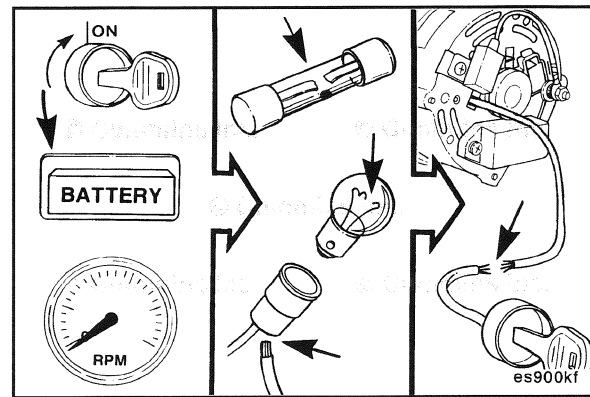
If the lamp is on when the switch is in the OFF position and the engine is **not** running, disconnect the lamp lead at the keyswitch.



- 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.

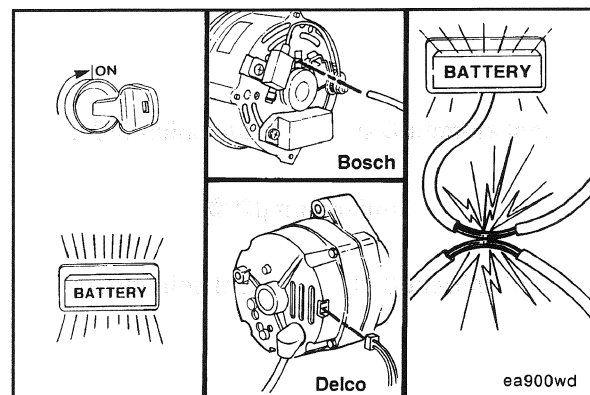
If the lamp is OFF when the switch is in the ON position and the engine is **not** running, there can be an open circuit.

Check for a blown fuse, a burned out bulb, damaged 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

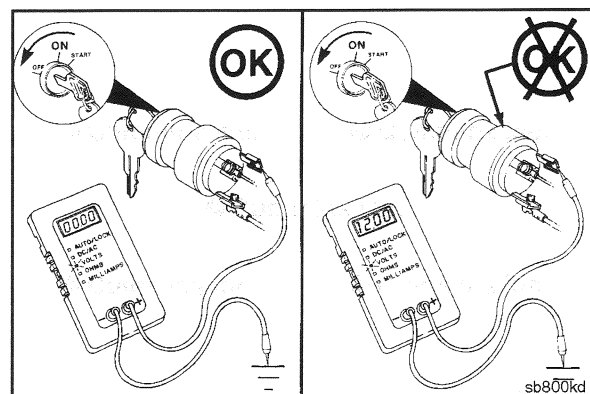
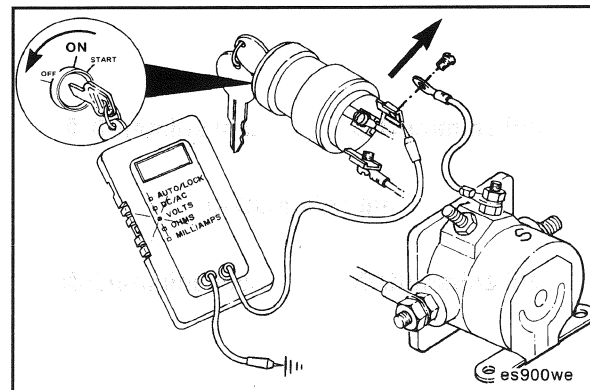
#### ⚠ WARNING ⚠

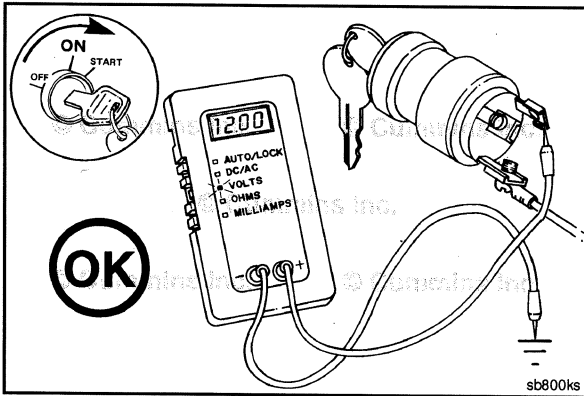
Be sure the keyswitch is in the OFF position to reduce the possibility of electrical shock and personal injury.

Remove the wire connecting the keyswitch to the magnetic switch (marked S or Start) from the keyswitch terminal.

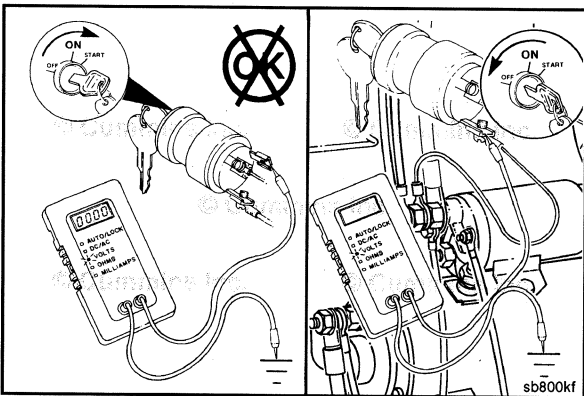
Connect the positive (+) lead of digital multimeter, Cummins® Part Number 3377163, or equivalent, to the keyswitch terminal and the negative (-) lead to a chassis or engine ground location.

**NOTE:** Set the multimeter to indicate DC volts with the keyswitch in the OFF position. There **must** be no voltage at the keyswitch terminal. If the meter indicates voltage, the keyswitch is malfunctioning and **must** be replaced.



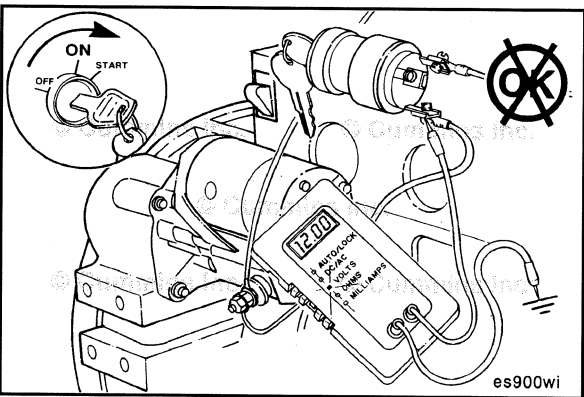


Turn the keyswitch to the START position.  
The multimeter **must** indicate system voltage.



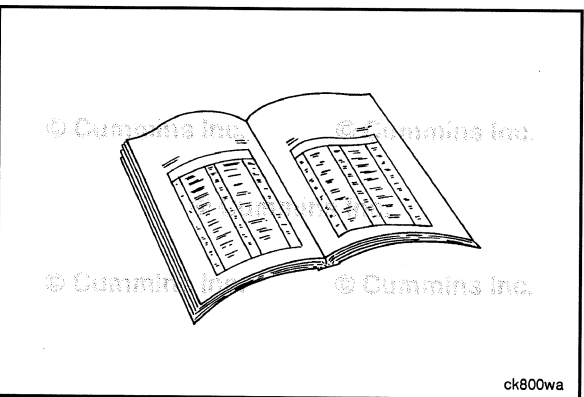
If there is no voltage:

- Turn the keyswitch to the OFF position.
- Check for supply voltage to the keyswitch by connecting the multimeter positive (+) lead to the keyswitch terminal having a wire connecting the keyswitch to the starter motor solenoid "B" terminal.



Turn the keyswitch to the START position.

If the meter indicates system voltage at the keyswitch input terminal, the keyswitch is defective and **must** be replaced. See equipment manufacturer service information for replacement.



If the meter indicates no voltage, the keyswitch is **not** the cause of the complaint.

Check the wiring from the keyswitch to the starter motor solenoid "B" terminal, and from the starter motor solenoid to the battery, for broken or damaged wires.

# Section 14 - Engine Testing - Group 14

## Section Contents

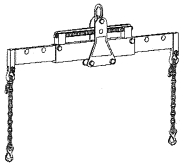
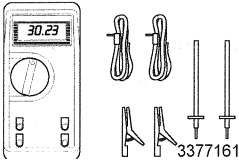
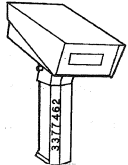
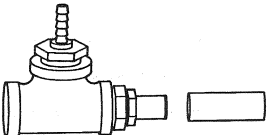
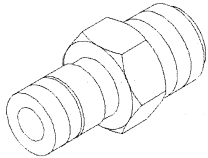
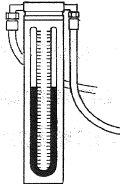
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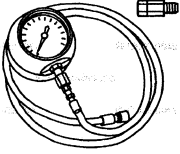
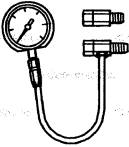
## Service Tools

### 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
3162871	<p><b>Engine Lifting Fixture</b></p> <p>Used to remove and install the engine.</p>	 <p>3162871</p>
3164489	<p><b>Multimeter</b></p> <p>Used to measure electrical circuits: Voltage (volts), resistance (ohms), and current (amps), 3164489 - meter with built in temperature adapter and tachometer.</p>	 <p>3377161</p>
3377462	<p><b>Digital Optical Tachometer</b></p> <p>Used to measure engine speed (rpm).</p>	 <p>3377462</p>
3822476	<p><b>Blowby Checking Tool</b></p> <p>Used to check engine crankcase blowby (0.221 inch orifice)</p>	 <p>eg8toge</p>
3824842	<p><b>Compuchek™ Fitting</b></p> <p>Used to check fuel filter restriction. With 10 mm O-ring connection.</p>	 <p>3824813</p>
ST-1111-3	<p><b>Manometer</b></p> <p>Used to measure pressure and restriction 0 to 2.5 kPa [0 to 36 in H<sub>2</sub>O] pressure differential with more accuracy.</p>	 <p>eg190ja</p>



Tool No.	Tool Description	Tool Illustration
<p><b>ST-1273</b></p>	<p align="center"><b>Pressure Gauge Assembly</b></p> <p>Used to measure pressures from 0 to 75 in-Hg.</p>	 <p align="right">eg8togi</p>
<p><b>ST-434</b></p>	<p align="center"><b>Vacuum Gauge</b></p> <p>Used to inspect the fuel filter restriction during the engine performance test. Hose adapter, Part Number ST-434-2, and vacuum gauge, Part Number ST-434-12, are used to perform the test.</p>	 <p align="right">eg8togc</p>

## Engine Run-in (Without Dynamometer) (014-004)



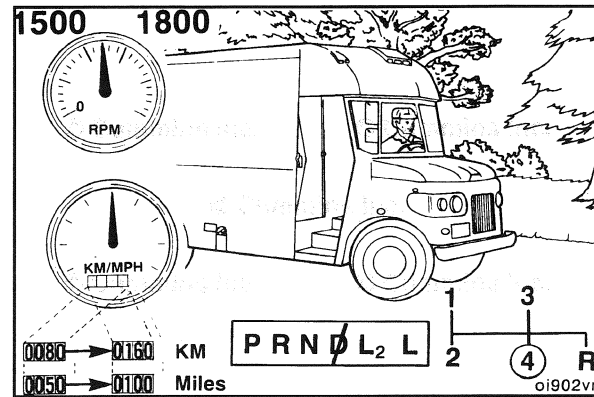
### Test

#### ⚠ CAUTION ⚠

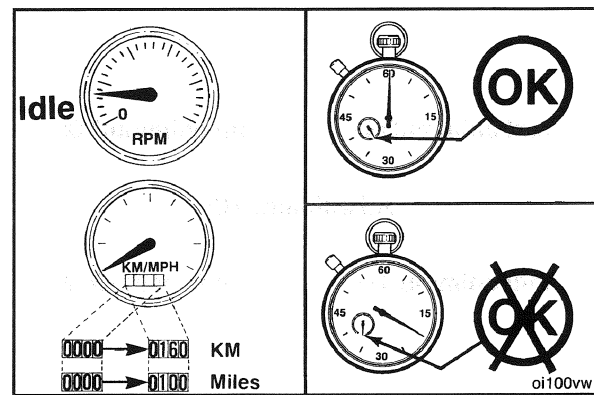
Refer to Procedure 014-005 in Section 14 before operating the engine to avoid engine component damage.

#### On-Highway

- Operate the engine at 1500 to 1800 rpm in high gear for the first 80 to 160 km [50 to 99 mi] after a rebuild.



**NOTE:** Do **not** idle the engine for more than 5 minutes at any one time during the first 160 km [99 mi] of operation.



## Engine Testing (Engine Dynamometer) (014-005)



### Setup

Use engine lifting fixture, Cummins® Part Number 3822512, to remove the engine from the chassis. Refer to Procedure 000-001 in Section 0.



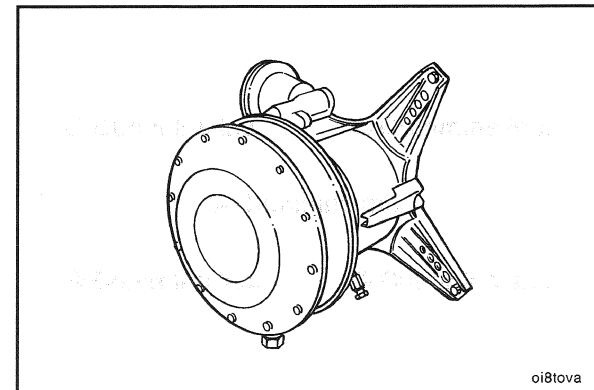
Install the engine to the test stand.

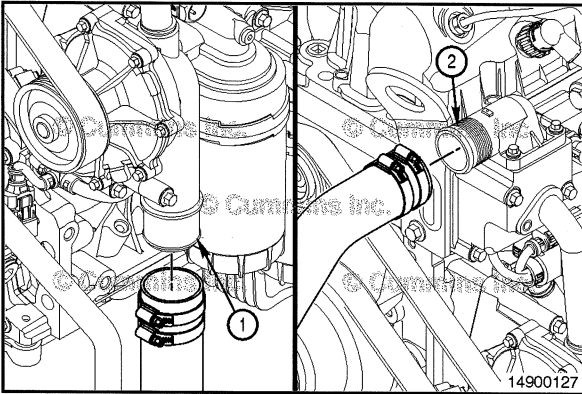


Align and connect the dynamometer. Refer to the manufacturer's instructions for aligning and testing the engine.



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.



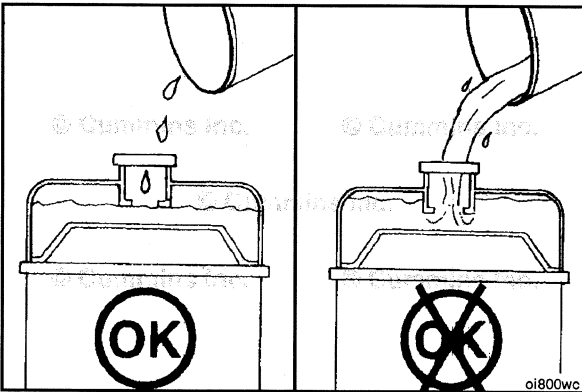


Connect the coolant supply to the coolant inlet connection (1).

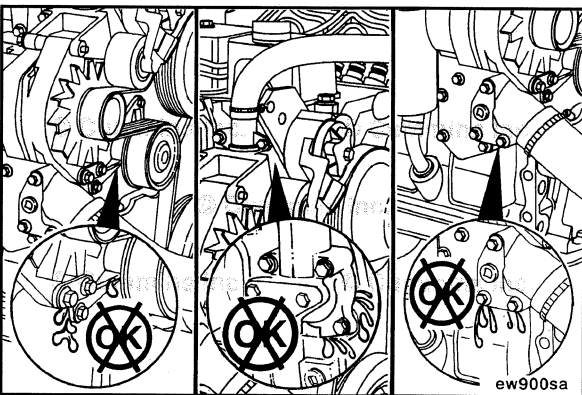
Connect the coolant return to the coolant outlet connection (2).

Install the drain plugs; close all the coolant draincocks.

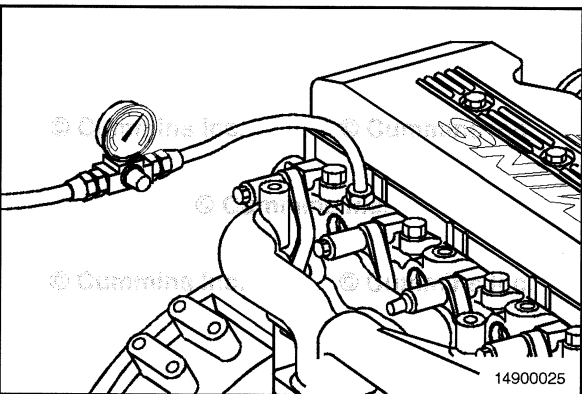
Make sure all the clamps and fittings are tight.



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 a coolant tap on the exhaust side of the cylinder head.

**Minimum Gauge Capacity:** 415 kPa [ 60 psi ]

Open Thermostat	
rpm	Location on Engine
2000	Water outlet
2000	1/2-NPT head port
2000	3/4-NPT head port
2500	Water outlet
2500	1/2-NPT head port
2500	3/4-NPT head port

**⚠ CAUTION ⚠**

Do not attempt to install pipe thread fittings in plastic or rubber intake piping. Damage to the components can occur.

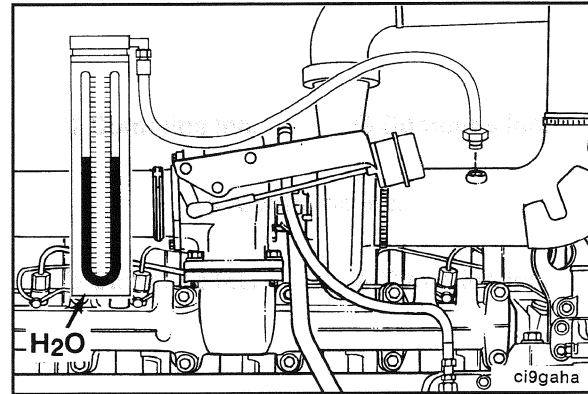
**Air Inlet Restriction**

Connect a water manometer, Cummins® Part Number ST-1111-3, to the turbocharger air inlet pipe to test air restriction.

**NOTE:** The manometer connection **must** be installed at a 90-degree angle to the airflow in a straight section of pipe, one pipe diameter before the turbocharger.

**NOTE:** A vacuum gauge, Cummins® Part Number ST-434, can be used in place of the water manometer.

Minimum Gauge Capacity: 760 mm H<sub>2</sub>O [30 in H<sub>2</sub>O]

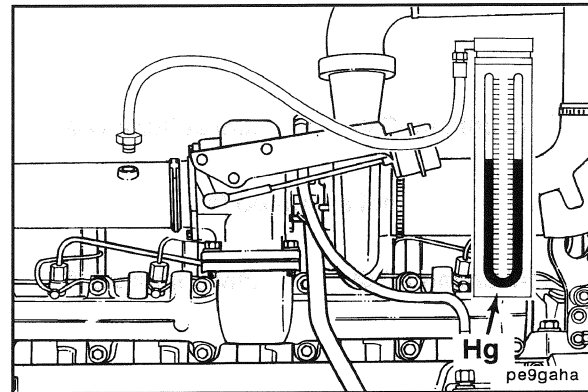


**Exhaust Restriction**

Connect a mercury manometer to a straight section of the exhaust piping near the turbocharger outlet to check the exhaust restriction.

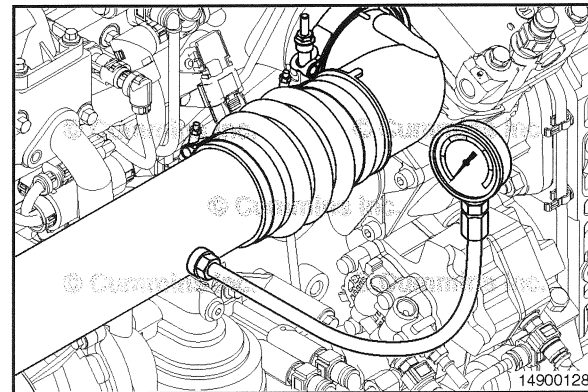
**NOTE:** A pressure gauge, Cummins® Part Number ST-1273, can be used in place of the mercury manometer.

Minimum Gauge Capacity: 254 mm Hg [10 in Hg]



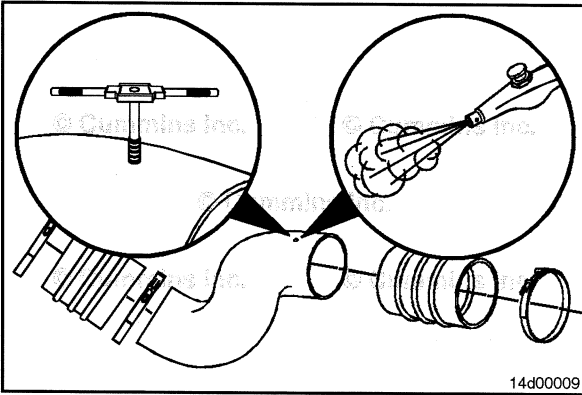
To determine the amount of turbocharger boost, remove the pipe plug in the charge-air cooler tube.

Install an intake manifold pressure sensor or pressure gauge, Cummins® Part Number ST-1273.



**Pressure Gauge Capacity**

kPa	MIN	psi
276		40



**⚠ CAUTION ⚠**

Do not attempt to install pipe thread fittings in plastic or rubber intake piping. Damage to the piping can result.



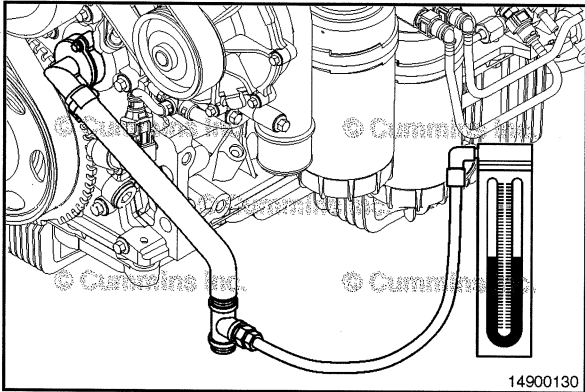
If INSITE™ electronic service tool is available, use it to monitor intake manifold pressure during the test. This eliminates the need to install a gauge as shown below.



If the charge-air cooler outlet tube does **not** have a pipe plug and tapped hole, perform the following procedure:



- 1 Remove the charge-air cooler outlet tube from the engine. Refer to Procedure 010-019 in Section 10.
- 2 Drill and tap a 1/8-inch pipe thread hole in the crossover tube in the location shown.
- 3 Clean all metal shavings from the air crossover tube.
- 4 Install the crossover tube. Refer to Procedure 010-019 in Section 10.



**Blowby**

For accurate engine crankcase blowby measurement, insert a blowby checking tool, Cummins® Part Number 3822566, in the crankcase breather vent.



Connect a water manometer, Cummins® Part Number ST-1111-3, to the blowby tool. A pressure gauge can be used in place of the manometer.

**BLOWBY CONVERSION TABLE**

**(7.67-mm [0.302-in] orifice)**

Inches of Water	Liters
1	50
2	84
3	103
4	119
5	133
6	145
7	155
8	164
9	172
10	180
11	187
12	193
13	200
14	206
15	211
16	217
17	222
18	226
19	229
20	232

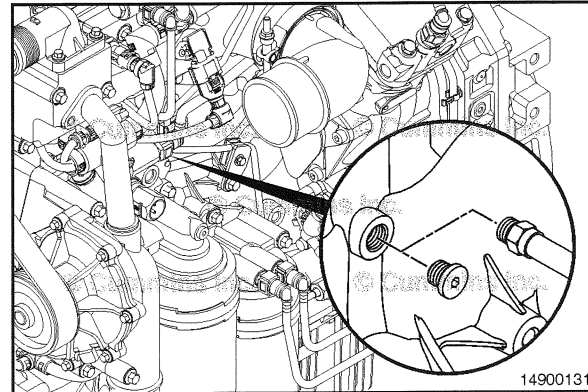
**⚠CAUTION⚠**

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 plug.

To prime the system, use external pressure, connect the supply to a tapped hole in the main oil rifle.



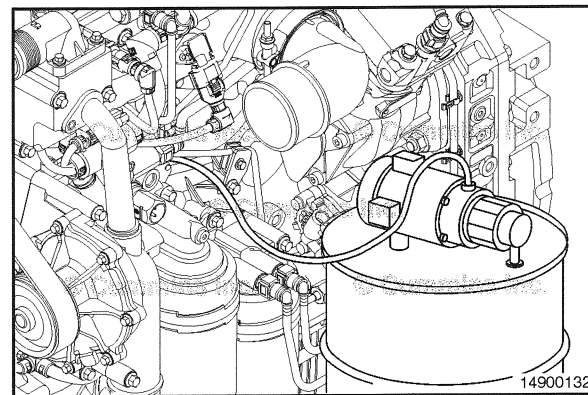
Use a pump capable of supplying 210 kPa [30 psi] of continuous pressure. Connect the pump to the port on the main oil rifle as shown.

Use clean 15W-40 oil to prime the system until the oil pressure registers on the gauge.

Remove the oil supply tube, and install the plug.

Tighten the plug.

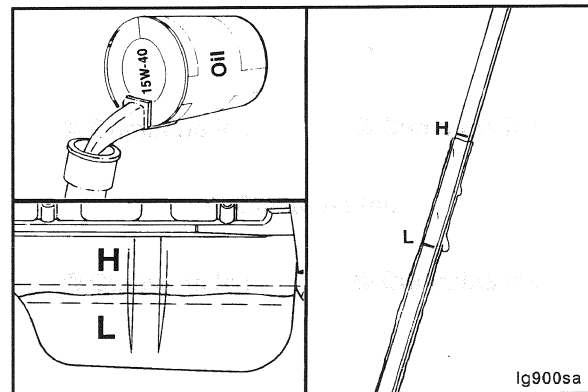
**Torque Value:** 6 N•m [ 53 in-lb ]



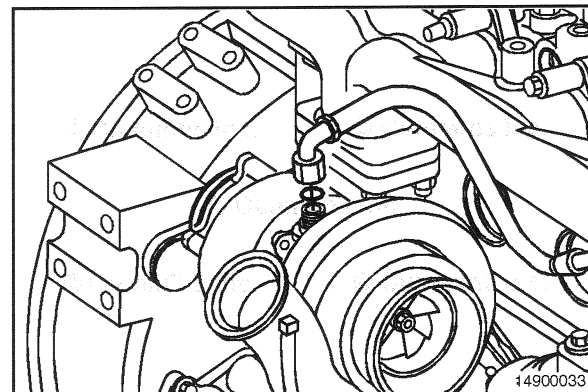
Make sure the lubricating oil has had time to drain to the oil pan and fill the engine to the high mark as measured on the dipstick.

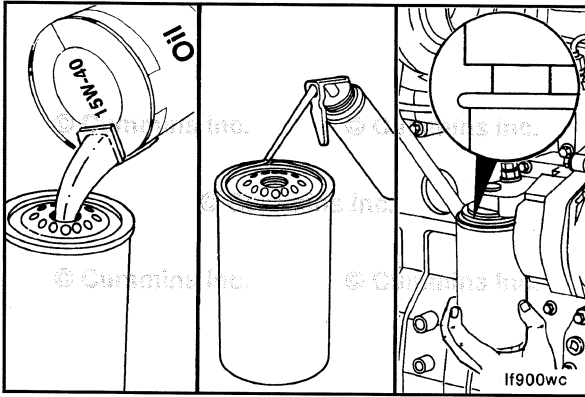
If an external pressure pump is **not** available, prime the lubricating system according to the following procedure:

- Fill the engine with clean 15W-40 oil to the high mark on the dipstick.



- Disconnect the turbocharger lubricating oil supply tube.
- Pour 50 to 60 cc [2 to 3 fl oz] of clean 15W-40 oil into the turbocharger oil supply hole.
- Connect the oil supply tube to the turbocharger.



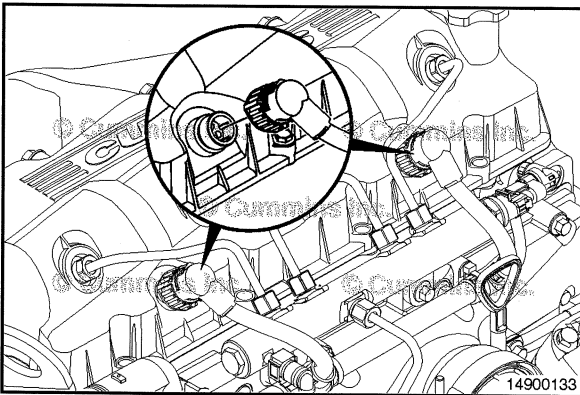


**CAUTION**

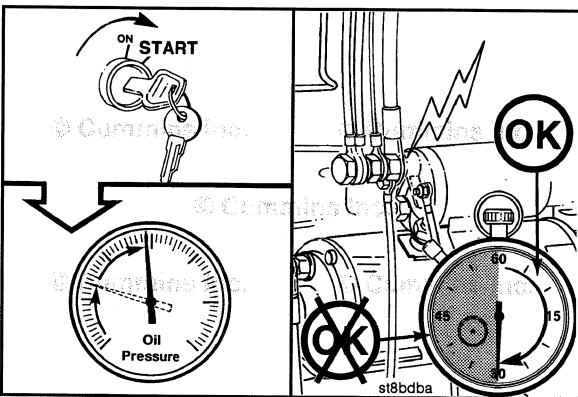
Mechanical overtightening can distort the threads or damage the filter element seal.



- Fill the lubricating oil filters with clean 15W-40 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.



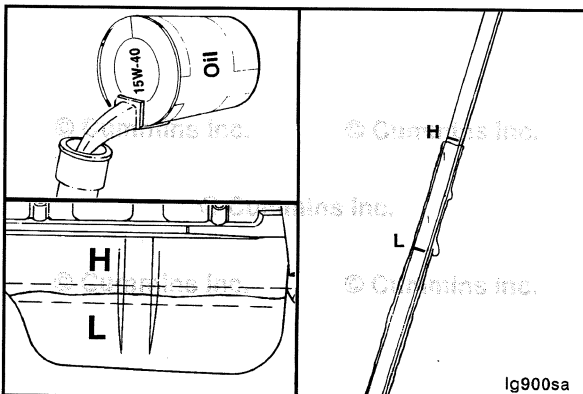
**CAUTION**

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.

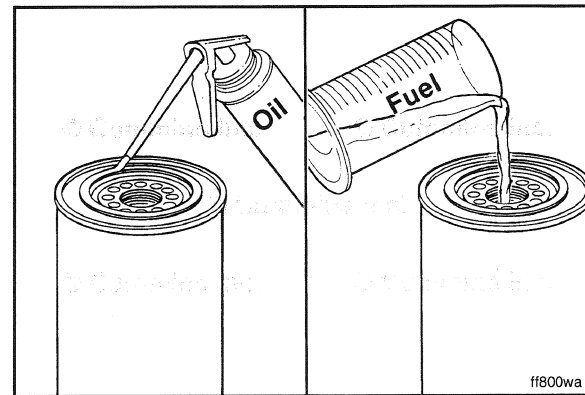
Add oil, as necessary, to bring the level to the high level mark on the dipstick.

**QSF3.8 CM2350 F107**  
**Section 14 - Engine Testing - Group 14**

Lubricate the gasket on the fuel filter with clean 15W-40 oil.



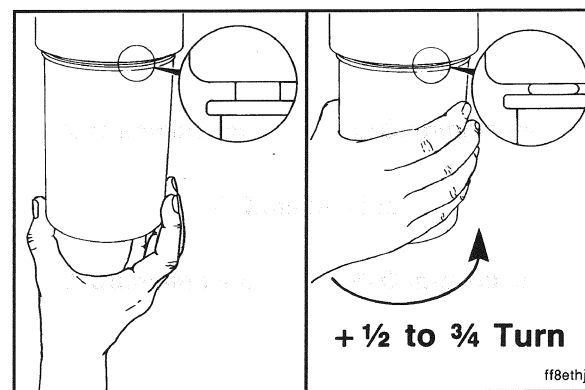
Fill the fuel filter with clean fuel.



Screw the fuel filter onto the fuel filter head until the gasket contacts the fuel filter head surface.



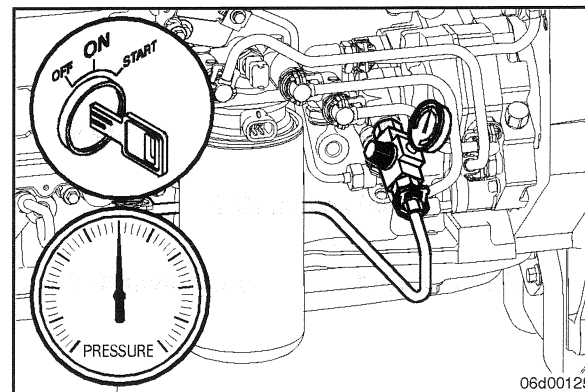
Tighten the filter as specified by the manufacturer.



Measure fuel filter restriction. Refer to Procedure 006-020 in Section 6.



Fuel Filter Restriction Pressure Gauge Capacity		
kPa		psi
1379	MIN	200



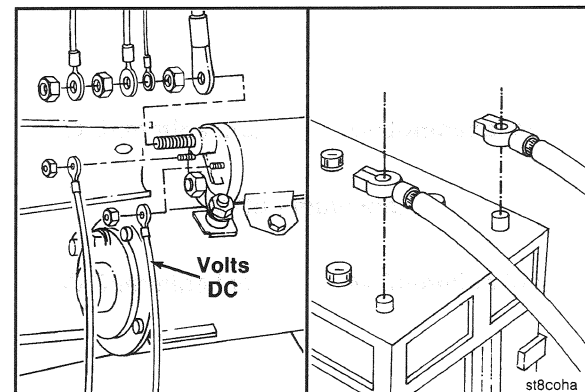
Inspect the voltage rating on the starter motor before installing the electrical wiring.



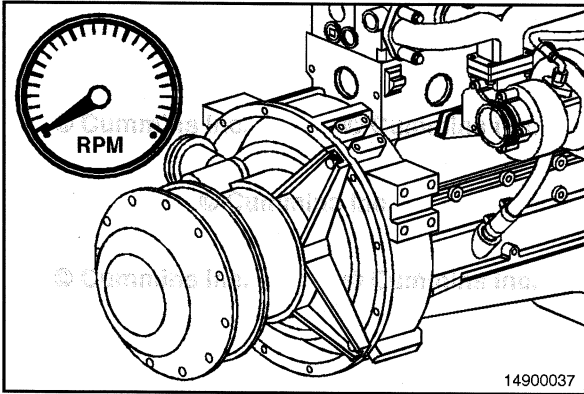
Attach electrical wires to the starter motor and the batteries, if used, negative (-) cable last.



**NOTE:** If another method of starting the engine is used, follow the equipment manufacturer service information to make the necessary connections.





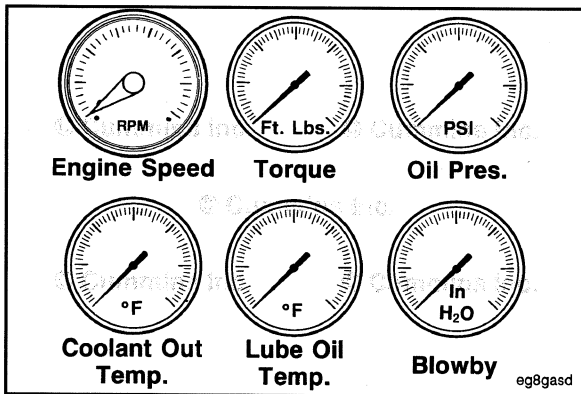


## Engine Run-in (Engine Dynamometer) (014-006)

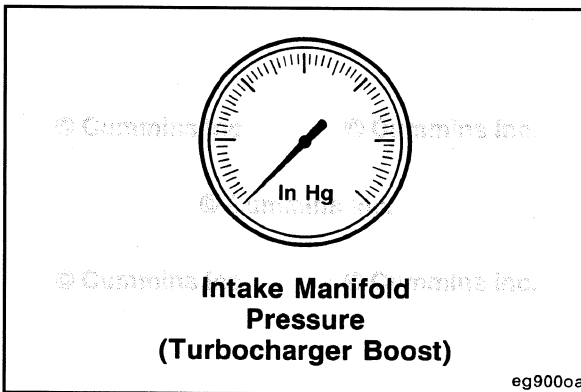
### Run-In Instructions

The engine run-in period allows the tester to detect assembly errors and to make final adjustments needed for performance that meets specifications.

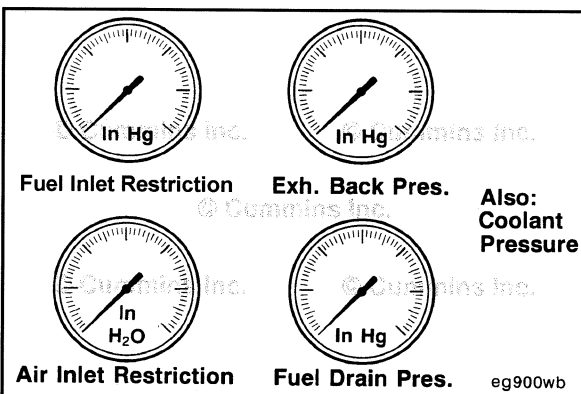
**NOTE:** The amount of time specified for the following engine run-in phases are minimums. Additional time can be used, if desired, at each phase except engine idle periods.



Measurements from these indicators and gauges **must** be observed closely during all phases of the engine run-in period. Refer to Procedure 014-005 in Section 14 for specifications and acceptable readings.



To evaluate the engine's performance correctly, this additional measurement **must** be observed during engine run-in phases.

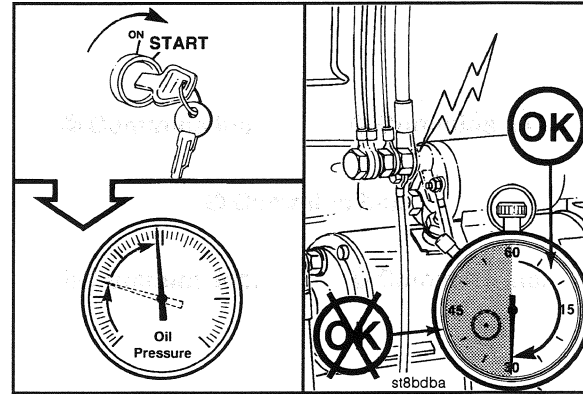


It is good practice to observe these measurements even if engine performance meets specifications. If engine performance does **not** meet specifications, these measurements can indicate possible reasons for under-performance.

**⚠ CAUTION ⚠**

**Do not crank the engine for more than 30 seconds. Excessive heat will damage the starter motor.**

Crank the engine and observe the lubricating oil pressure when the engine starts. If the engine fails to start within 30 seconds, allow the starter motor to cool for 2 minutes before cranking the engine again.

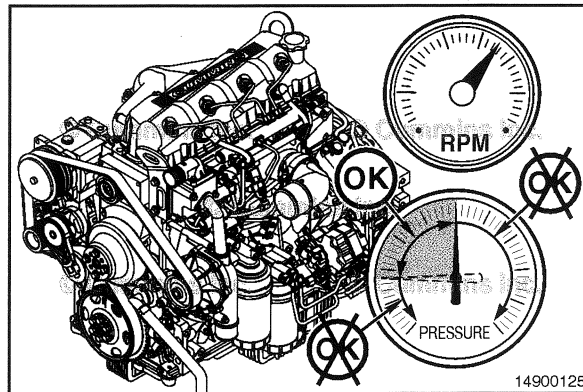


**⚠ CAUTION ⚠**

**If the lubricating oil pressure is not within specifications, shut off the engine immediately. Low lubricating oil pressure will cause engine damage.**

Engine lubricating oil pressure **must** be at least 69 kPa [10 psi] at 700 rpm.

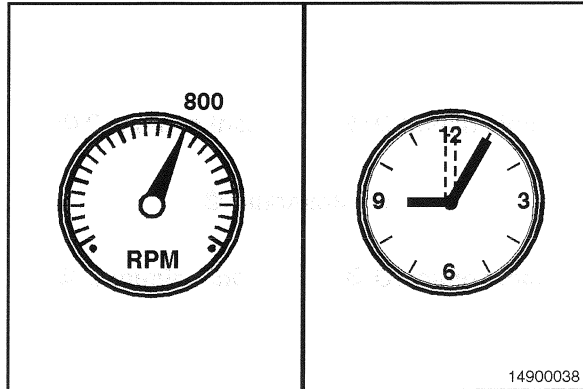
Correct the problem if the lubricating oil pressure is **not** within specifications.



**⚠ CAUTION ⚠**

**Do not operate the engine at idle speed longer than specified during engine run-in. Excessive carbon formation will cause damage to the engine.**

Operate the engine at approximately 800 rpm for 3 to 5 minutes.

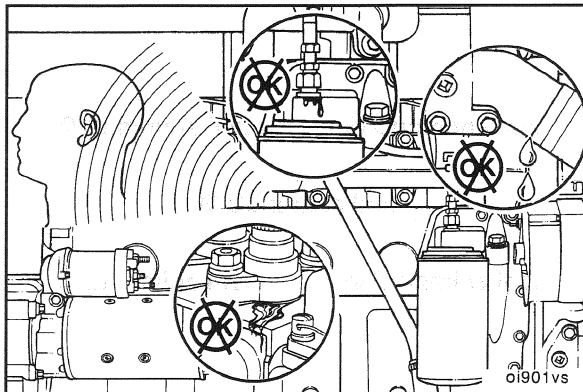


**NOTE:** Repair all leaks or component problems before continuing the engine run-in.

Listen for unusual noises.

Watch for coolant, fuel, and lubricating oil leaks.

Check for correct engine operation in general.



**1200**

**Test Load**

**70°C [160°F]**

oi802vr



Move the throttle to obtain 1200 rpm engine speed, and set the test load to 25 percent of the rated load.

Operate the engine at this speed and load level until the coolant temperature is 70°C [158°F].

Check all gauges, and record the data.

**NOTE:** Do **not** proceed to the next step until a steady blowby reading is obtained.

**Torque Peak**

**2x (Test Load)  
(50% Rated Load)**

**2 Minutes**

oi804vh



Adjust the throttle to obtain peak torque rpm, and adjust the dynamometer load to 50 percent of torque peak load. Operate the engine at this speed and load level for 2 minutes.

Check all gauges, and record the data.

**NOTE:** Do **not** proceed to the next step until blowby is stable within specifications.

**Torque Peak**

**3x (Test Load)  
(75% Rated Load)**

**2 Minutes**

oi804vi



With the engine speed remaining at torque peak rpm, increase the dynamometer load to 75 percent of torque peak load. Operate the engine at this speed and load level for 2 minutes.

Check all gauges and record the data.

**NOTE:** Do **not** proceed to the next step until blowby is stable within specifications.

**Full Throttle  
Torque Peak  
Maximum Load**

**10 Minutes**

oi804vj



Move the throttle lever to its fully opened position, and increase the dynamometer load until the engine speed is at torque peak rpm. Operate the engine at this speed and load level for 10 minutes or until the blowby becomes stable within specifications.

Check all gauges, and record the data.

**QSF3.8 CM2350 F107**  
**Section 14 - Engine Testing - Group 14**

Reduce the dynamometer load until the engine speed increases to the engine's rated rpm.

Operate the engine at rated rpm for 5 minutes.

Check all gauges, and record the data.



**Full Throttle Rated**

**Maximum Load at Rated Speed**

**5 Minutes**

oi804vk

**⚠ CAUTION ⚠**

Shutting off the engine immediately after operating at full load will damage the turbocharger and internal components. Always allow the engine to cool before shutting it off.

Remove the dynamometer load completely, and operate the engine at 800 rpm for 3 to 5 minutes. This period will allow the turbocharger and other components to cool.



800

RPM

TORQUE %

14900039

Shut the engine off.

OFF

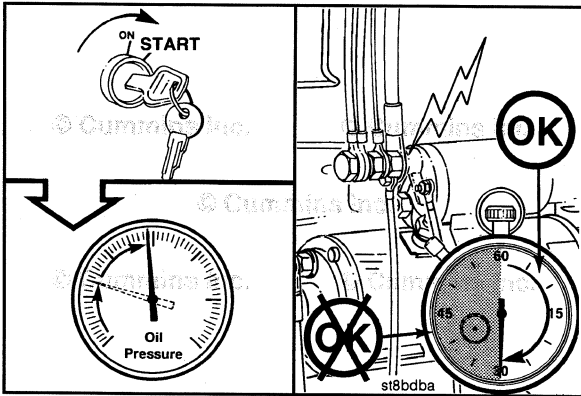
RPM

oi802vx

**Engine Dynamometer Test - Performance Check**

- Make sure the air compressor will be unloaded during the performance check.

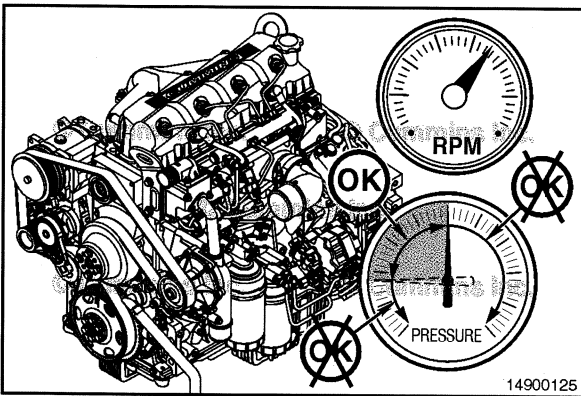




**⚠ CAUTION ⚠**

Do not crank the engine for more than 30 seconds. Excessive heat will damage the starter motor.

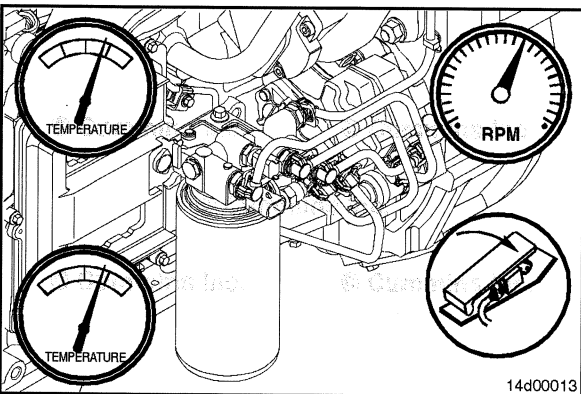
Crank the engine and observe the oil pressure when the engine starts. If the engine fails to start within 30 seconds, allow the starter motor to cool for 2 minutes before cranking the engine again.



**⚠ CAUTION ⚠**

If the lubricating oil pressure is not within specifications, shut off the engine immediately. Low lubricating oil pressure will cause engine damage. Correct the problem if lubricating oil pressure is not within specifications.

Engine lubricating oil pressure **must** be at least 69 kPa [10 psi] at approximately 700 rpm.



Make sure the engine is at operating temperature (71.1°C [160°F] minimum coolant temperature).

Move the throttle pedal to 100 percent throttle. Adjust the dynamometer load until the engine maintains the rated rpm.

Allow the readings to stabilize. Read the horsepower.

**NOTE:** The horsepower reading will **not** be accurate if the lubricating oil temperature and fuel temperature are **not** within specifications.

**Lubricating Oil Temperature**

°C		°F
90	MIN	194

**Fuel Temperature**

°C		°F
32	MAX	90

Check all gauges, and record the data.

**⚠ CAUTION ⚠**

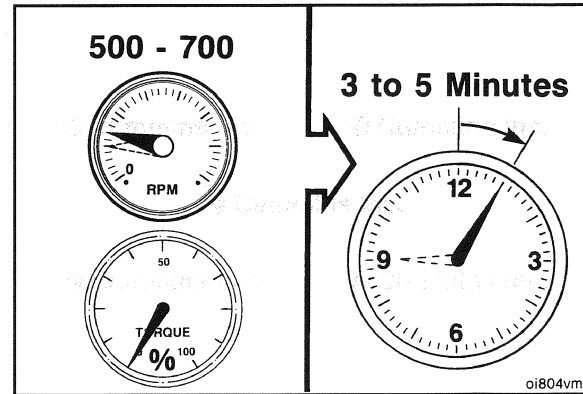
Do not shut off the engine immediately after it has been loaded. It must be allowed to cool sufficiently.

Move the throttle lever to its fully opened position, and increase the dynamometer load until the engine speed is at torque peak rpm. Allow the readings to stabilize. Read the torque. Check all of the gauges and record the readings.

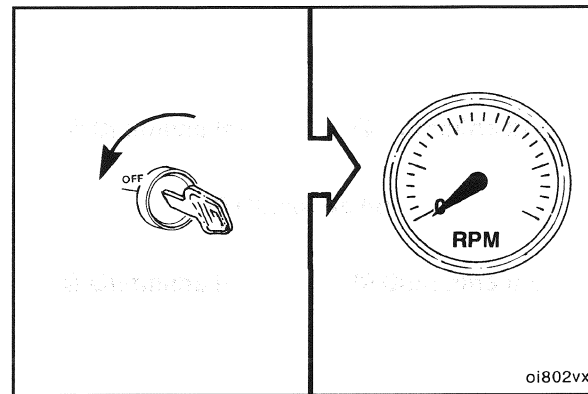
Remove the dynamometer load completely.

Operate the engine at idle speed for 3 to 5 minutes. This will allow the turbocharger and other components to cool.

**NOTE:** Idle periods longer than 5 minutes are to be avoided.



Shut off the engine after the cooldown period.

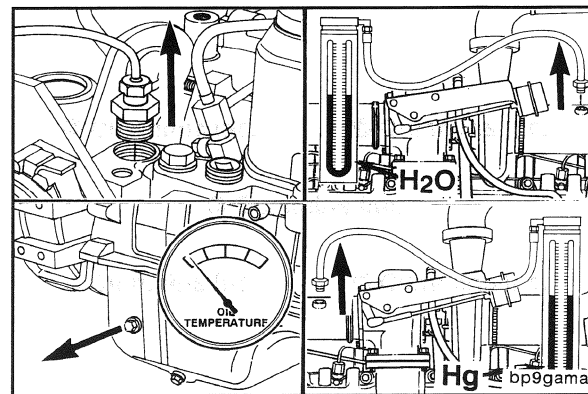


Remove all test instrumentation.

Remove the engine from the dynamometer.

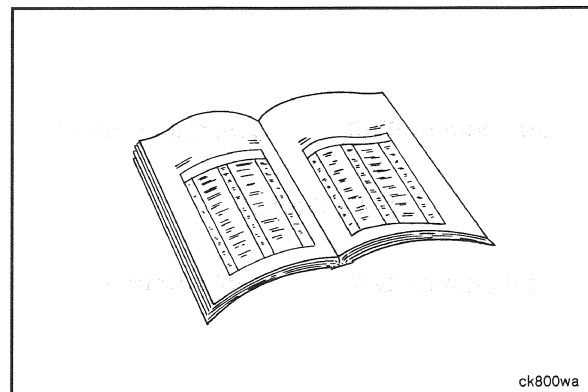
**NOTE:** If the engine is to be stored temporarily and does not have permanent-type antifreeze, it is necessary to drain all coolant.

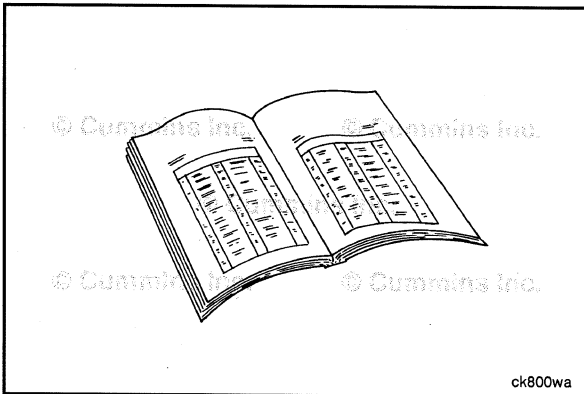
Prepare the engine for engine painting. Refer to Procedure 000-007 in Section 0.



**Engine Testing (In Chassis) (014-008)  
 Setup**

The setup for dynamometer function is used to prepare the attached engine control module (ECM) for advanced diagnostic tests that are run on the 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. All of these values are automatically reset to their previous values when the engine keyswitch is in the OFF position.





### Settings

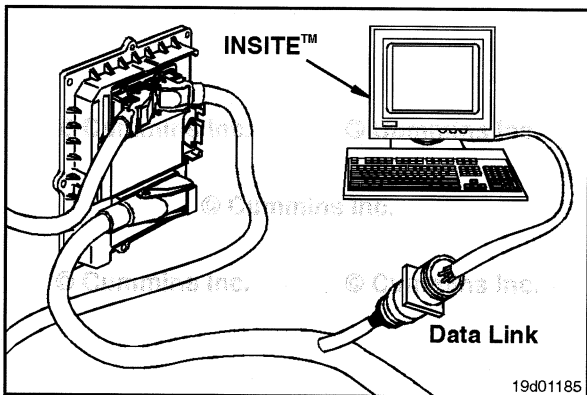
**Maximum Engine Speed without VSS:** For testing purposes, this speed is temporarily set to the maximum value allowed. 3000 rpm

**Maximum Vehicle Speed in Top Gear:** For testing purposes, this speed is temporarily set to the maximum value allowed. Maximum Vehicle Speed in Top Gear: 120 mph

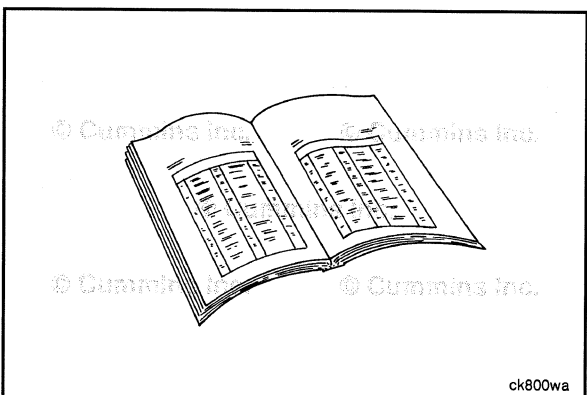
**Maximum Vehicle Speed in Lower Gear:** For testing purposes, this speed is temporarily set to the maximum value allowed. Gear-Down Protection (heavy engine load): 120, Gear-down Protection (light engine load): 120

**Idle Shutdown:** This feature is temporarily disabled for testing purposes.

Some J1939 electronic subsystems **must** be disabled. The user has the ability to enable or disable the J1939 data link with the service tool.



Refer to INSITE™ electronic service tool user's manual for detailed setup for dynamometer instructions.



### Automated Cylinder Performance Test

The automated cylinder performance test is the most thorough test of cylinder performance (versus the single-cylinder cutout test, which tests the performance of individual cylinders **only**). The service tool **must** be attached to an ECM to perform this test. Follow the steps outlined in preparing to run the automated cylinder performance test to make sure the best possible outcome is achieved.

This test is automated in the sense that once the test is started the service tool controls what cylinders are disabled or enabled, what ECM values are recorded, and what information displays as a result of the test. Once the test is finished, follow the steps outlined in After Running the Automated Cylinder Performance Test to make sure the engine returns to its original state.

This test will produce a pass-or-fail message for each cylinder. Its percent contribution value is also displayed.

**Preparing to Run the Automated Cylinder Performance Test**

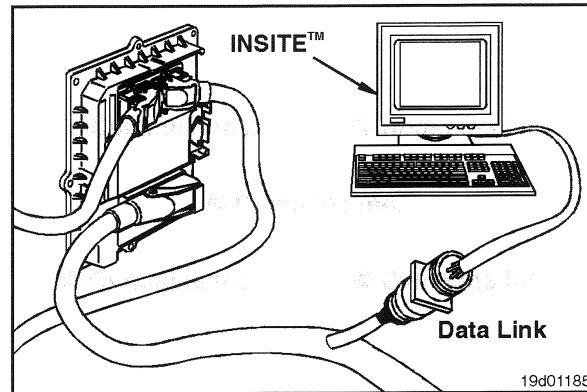
Before performing this test, make sure you:

- 1 Clear the areas around the engine and the fan, and make sure the exhaust is vented correctly.
- 2 Operate the engine until the coolant temperature is a minimum of 76.7°C [170°F].
- 3 Shut the engine OFF.
- 4 Lock the fan clutch in the ON position for continuous operation.
- 5 Shut off the air conditioning.
- 6 Disengage any devices that can cause the load on the engine to vary.
- 7 With the vehicle stationary, start the engine and let it idle.
- 8 Start the test using INSITE™ electronic service tool.

Cylinder % Contribution		
1	66	Is Not OK
2	101	Is OK
3	98	Is OK
4	101	Is OK
5	101	Is OK
6	101	Is OK

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Refer to INSITE™ electronic service tool user's manual for detailed automated cylinder performance test instructions.



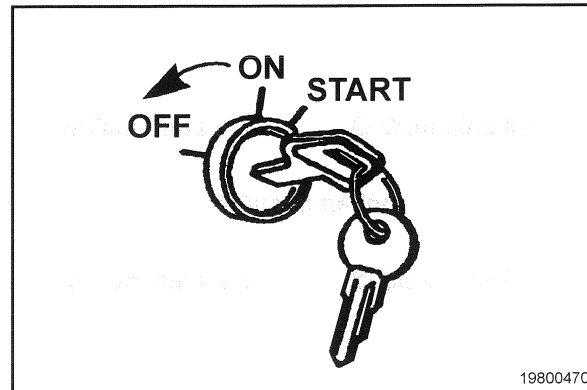
19d01185

**After Running the Automated Cylinder Performance Test**

It is normal for the engine rpm to vary during the test, but if the engine rpm goes to high idle for more than 5 seconds at a time, shut the engine OFF.

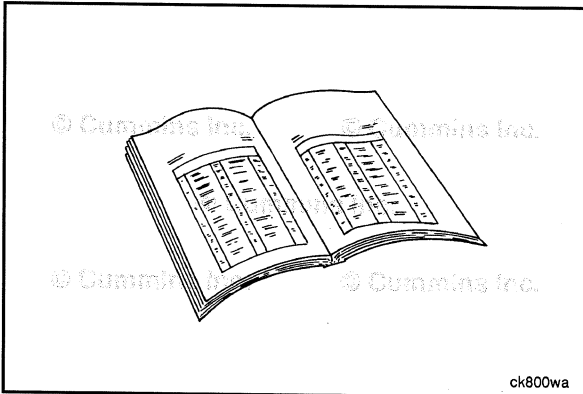
Once the test is complete, make sure to:

- 1 Shut the engine OFF.
- 2 Return the fan to normal operation, if necessary.
- 3 Perform the suggested repairs that resulted from the test.
- 4 Return any disengaged devices to their normal mode of operation.



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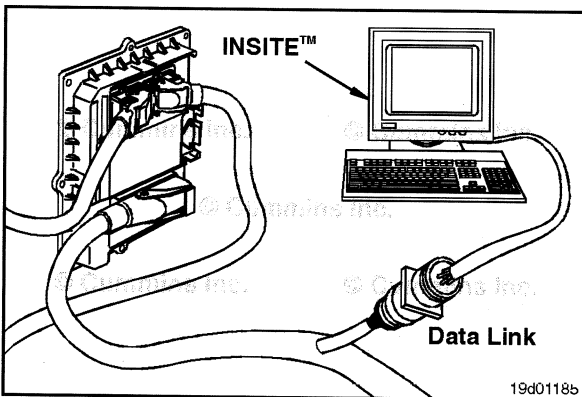




## Cylinder Cutout Test

Use the single-cylinder cutout test to remove individual cylinders from the engine firing cycle and to monitor a running engine while the selected cylinder is disabled. The system displays the percent load and rpm values while the cylinder is disabled.

The service tool **must** be attached to a running engine in a nonmoving vehicle to perform this test.



### Cylinder to Be Cut Out

None: Select this option to run all cylinders.

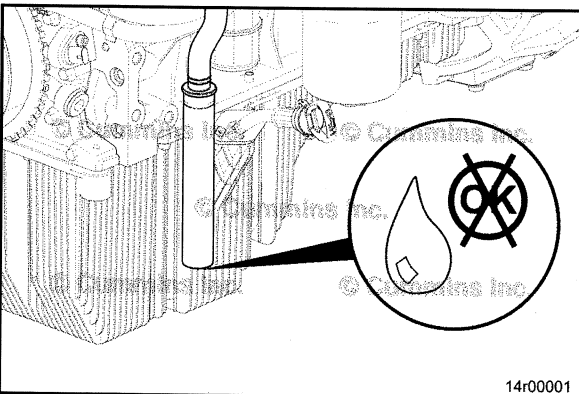
1 to 6: Select one of these options to shut OFF cylinder number 1 through number 6, respectively. **Only** one cylinder can be shut OFF at a time.

Monitor

Percent Load: Is the percent of load that the engine is carrying.

rpm: Is the engine's revolutions per minute.

Refer to INSITE™ electronic service tool user's manual for detailed cylinder cutout test instructions.



## Crankcase Blowby, Measure (014-010) General Information

Excessive crankcase gases (blowby) can indicate an engine or engine-related component malfunction that allows combustion gases or air to enter the crankcase. This results in the buildup of higher than normal crankcase pressure, which results in increased levels of blowby.

Measuring blowby is typically done to confirm engine break-in after an engine rebuild. Other symptoms include:

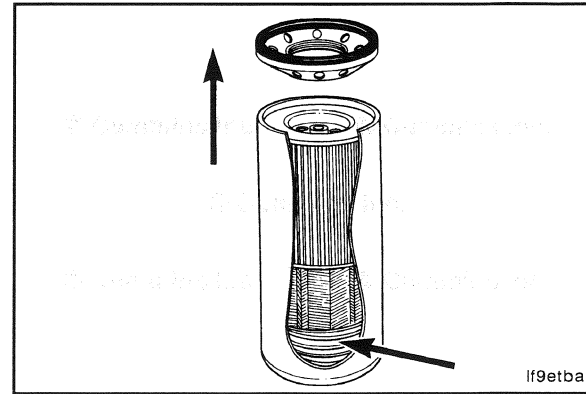
- Determine reason for excessive oil exiting crankcase breather tube.
- Determine reason for excessive oil consumption.
- Determine if internal engine components are damaged or worn (piston rings, valve stem seals or guides, and turbocharger seals etc.).

If no other symptom is present, there is no need to take a blowby measurement.

**NOTE:** If internal engine damage is suspected to be the cause of the excessive blowby condition, other steps can be taken to confirm. The steps include:

- Confirm engine maintenance practices
- Cut the oil filter open and check for debris
- Take an oil sample and inspect for contamination.

**NOTE:** For specific crankcase gases (blowby) symptom and information, reference the Crankcase Gases Blowby Excessive troubleshooting symptom tree in Section TS.



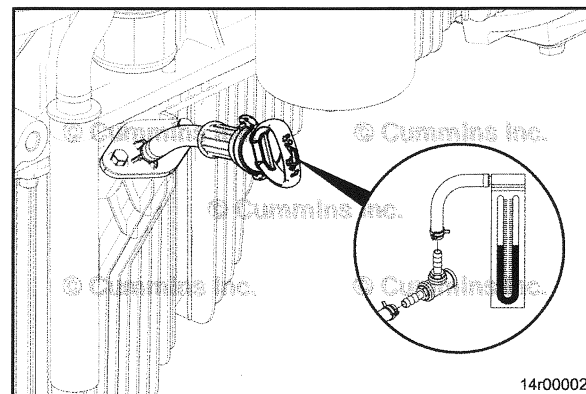
**NOTE:** The terms blowby and carryover (oil out of the breather tube) are used interchangeably.

The quantity of oil coming out of the breather tube 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.

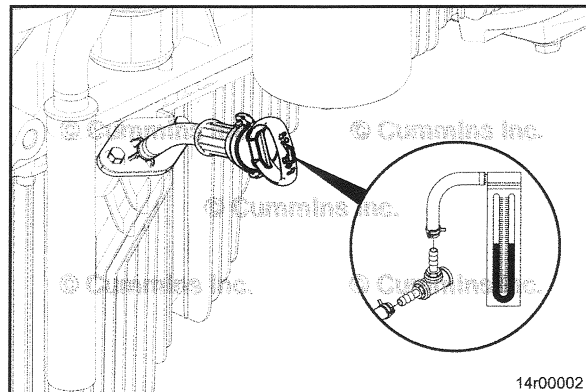
If this occurs, it will be necessary to:

- Find a different location on the engine to measure blowby (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 deflecting oil toward the breather cavity (piston cooling nozzles, accessory oil drains, etc.)



Crankcase blowby is dependent on the volume of intake air flow. Different blowby measurement tools are available to accommodate the wide variety of engine configurations and ratings.

The following chart contains general blowby specifications. These specifications are intended to **only** be used as a guide to help identify if a problem exists. These specifications are **not** intended to be used as engine condemning limits.



<b>Blowby Conversion Table (5.61 mm [0.221 in orifice, Blowby Tool, Cummins® Part Number 3822476])</b>	
<b>mm [in] of H<sub>2</sub>O</b>	<b>liter [cfm] per minute</b>
25.4 [1]	27 [0.953]
50.8 [2]	40 [1.413]
76.2 [3]	48 [1.695]
101.6 [4]	58 [2.048]
127 [5]	64 [2.260]
152.4 [6]	71 [2.507]
177.8 [7]	76 [2.684]
203.2 [8]	81 [2.860]
228.6 [9]	86 [3.037]
254 [10]	90 [3.178]
279.4 [11]	94 [3.320]
304.8 [12]	98 [3.461]
330.2 [13]	102 [3.602]
355.6 [14]	105 [3.708]
381 [15]	109 [3.849]
406.4 [16]	112 [3.955]
431.8 [17]	115 [4.061]
457.2 [18]	118 [4.167]
482.6 [19]	121 [4.723]
508 [20]	124 [4.379]
533.4 [21]	128 [4.520]
558.2 [22]	131 [4.626]
584.2 [23]	135 [4.767]
609.6 [24]	137 [4.838]
635 [25]	140 [4.944]
660.4 [26]	144 [5.085]
685.8 [27]	147 [5.191]
711.2 [28]	150 [5.297]
736.6 [29]	154 [5.438]
762 [30]	157 [5.544]
787.4 [31]	160 [5.650]
812.8 [32]	163 [5.756]
838.2 [33]	166 [5.862]
863.6 [34]	169 [5.968]
889 [35]	172 [6.074]

<b>Blowby Specifications Chart</b>		
	<b>Blowby Specification For New or Rebuild - mm H<sub>2</sub>O [in] H<sub>2</sub>O</b>	<b>Blowby Specification For Troubleshooting - mm H<sub>2</sub>O [in] H<sub>2</sub>O</b>
Engine Model	Blowby Tool 3822476 - 5.61 mm [0.221 in] Orifice	Blowby Tool 3822476 - 5.61 mm [0.221 in] Orifice
QSF3.8	101.6 [4]	431.8 [17]

### Initial Check

Prior to measuring blowby pressure, reference Section 3 to check for cracks, obstructions, and other damage to the crankcase breather system that can obstruct the blowby flow.

- 1 Crankcase breather tube
- 2 Open Crankcase Ventilation (OCV) filter hose
- 3 Crankcase breather oil drain-back hose
- 4 Crankcase breather adaptor.

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.

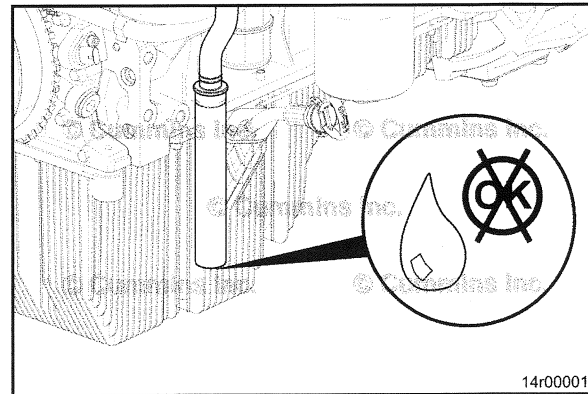
Check the engine oil level and, if necessary, proper calibration of the dipstick. If the level is too high, it can cause a higher than normal blowby pressure and/or excessive carryover. Refer to Procedure 007-009 in Section 7.

### Measure

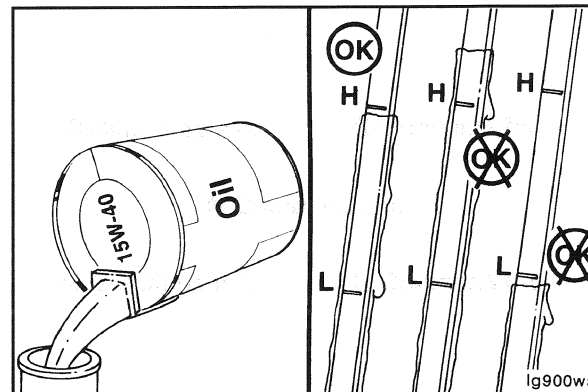
Use the following service tool to measure the crankcase blowby pressure.

Blowby Tool Part Number	Orifice Size mm [in]
3822476	5.61 mm [0.221 in]

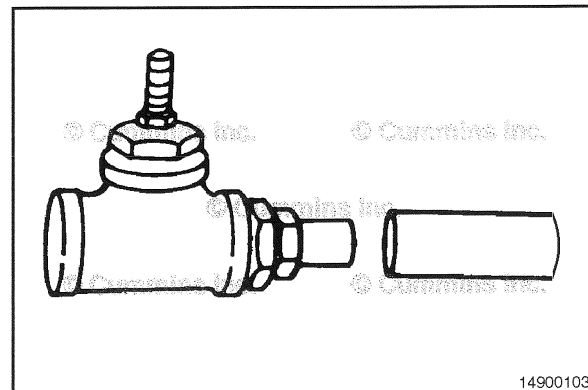
To measure the crankcase blowby pressure, connect a water manometer, Cummins® Part Number ST1111-3, pressure gauge, or transducer to the blowby measurement service tool and to the end of the crankcase breather tube.



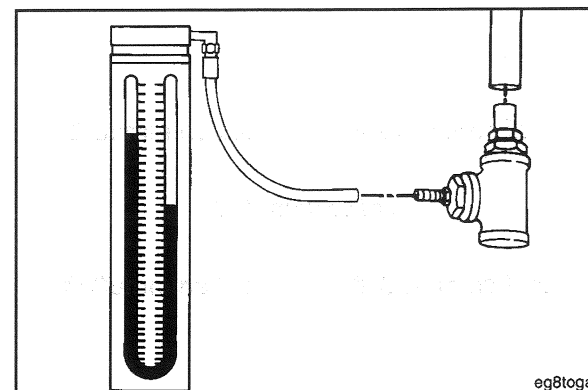
14r00001



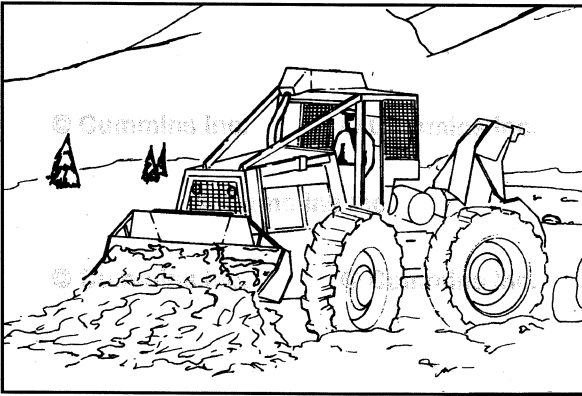
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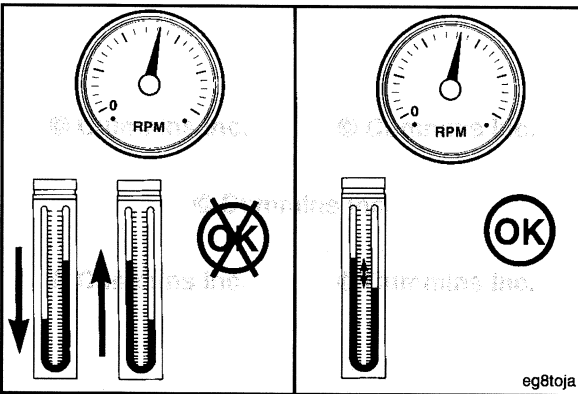
eg8toga



#### Engine Blowby Contribution:

Operate the engine at rated speed and under load:

- For engine run-in, use engine dynamometer.
- For engine testing, use engine dynamometer.
- For engines equipped with automatic transmissions **only**, use a stall speed test.



#### ⚠ 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.

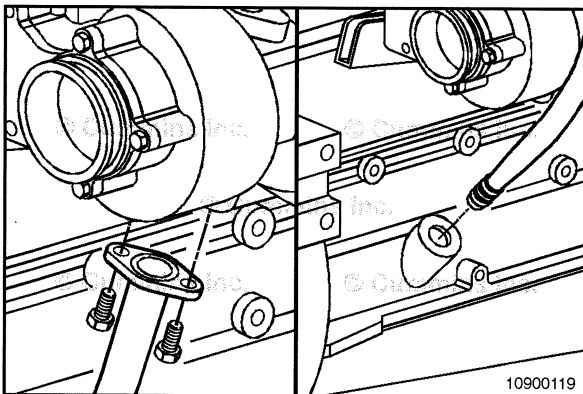
Operate the engine at rated rpm and full load until a steady reading is obtained.

**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.



#### 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.

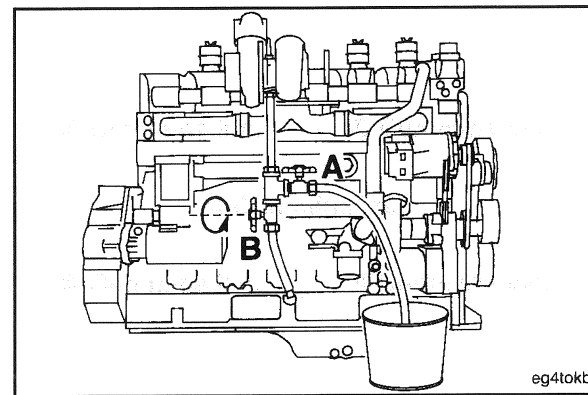
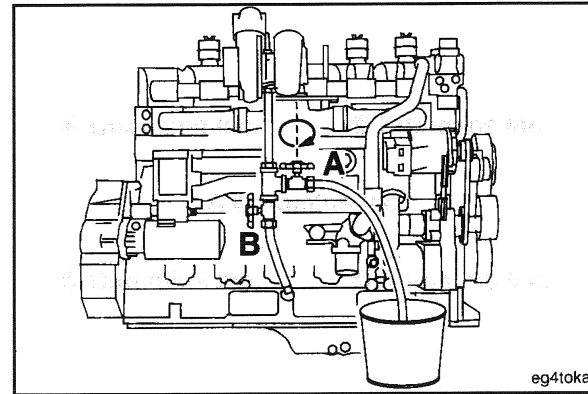
Preferred Turbocharger Isolation Method:

Install a hose assembly with two shutoff valves (A and B), installed as shown in the illustration, between the turbocharger and turbocharger drain line location in the cylinder block. The valves **must** have a minimum inside diameter of 19 mm [0.75 in]. Place the other hose in an 8 to 9 liter [2 to 3 gal] container.

**NOTE:** Some turbocharger oil drain tubes are a single one piece tube. It can be necessary to create a turbocharger isolation tool. Use a new or used turbocharger drain line and cut a middle section out of the turbocharger drain line to fit the check valves and hoses.

Close the valve (A) that allows oil to drain into the bucket.

Open the valve (B) that allows oil to drain into the engine.

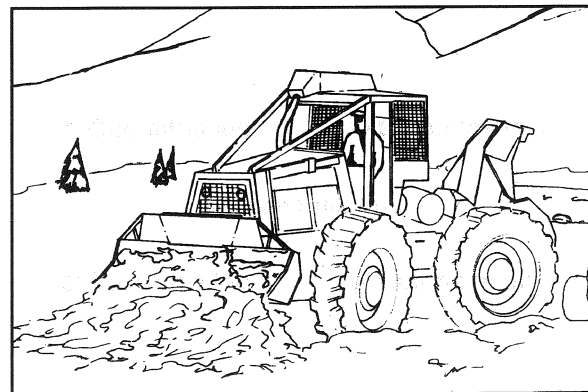


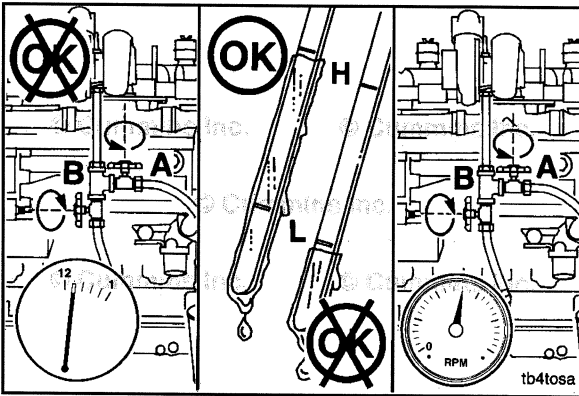
Operate the engine at rated speed and under load:

- For engine testing, use engine dynamometer
- For engines equipped with automatic transmissions **only** use a stall speed test.

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.





**⚠ 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.

**⚠ WARNING ⚠**

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

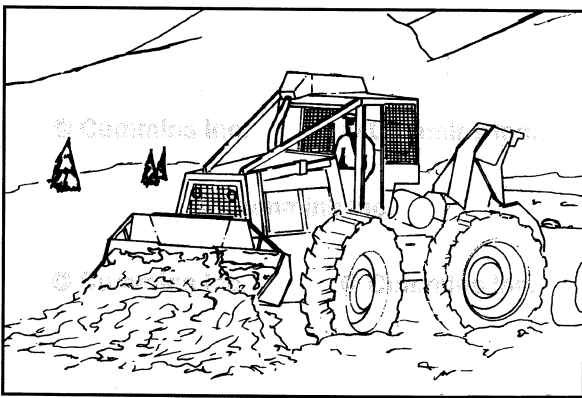
**⚠ CAUTION ⚠**

Do not operate the engine with valve (A) open and valve (B) closed for more than 1 minute. Monitor the amount of oil accumulating in the bucket. The engine can run out of lubricating engine oil and severe engine damage will occur.

Continue operating at rated speed and load.

Open valve (A) and close valve (B).

Record the blowby pressure reading.



**⚠ 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.

Alternate Turbocharger Isolation Method:

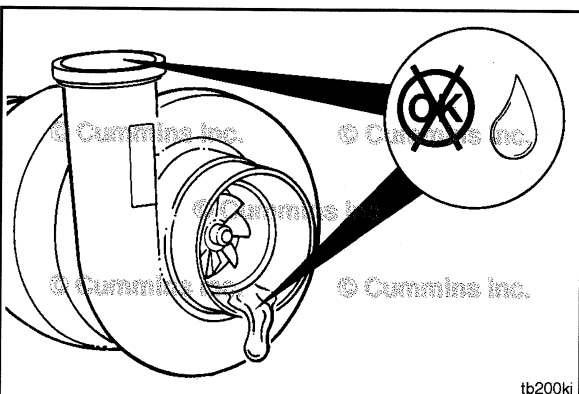
With the turbocharger oil drain line disconnected from the cylinder block, run the turbocharger drain line into a large container.

Plug the turbocharger oil drain port in the cylinder block.

Operate the engine at rated speed and under load by:

- For engine testing, use engine dynamometer
- For engines equipped with automatic transmissions **only** use a stall speed test.

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, valve (A) open, and turbocharger drain **not** isolated, valve (A) closed.

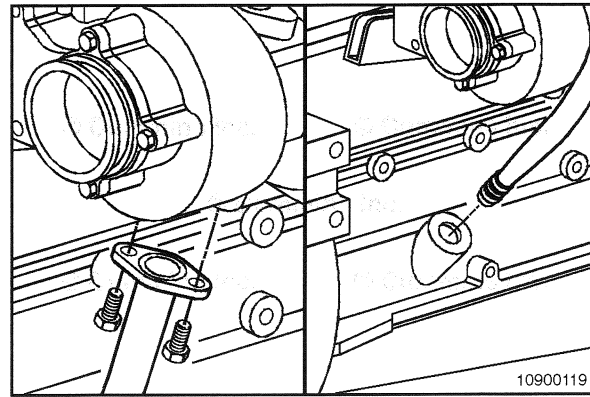
Blowby Pressure Differential	
Turbocharger Blowby Contribution	Maximum: 30 percent

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. Refer to Procedure 010-139 in Section 10.

If installed, remove the turbocharger isolation hose 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.

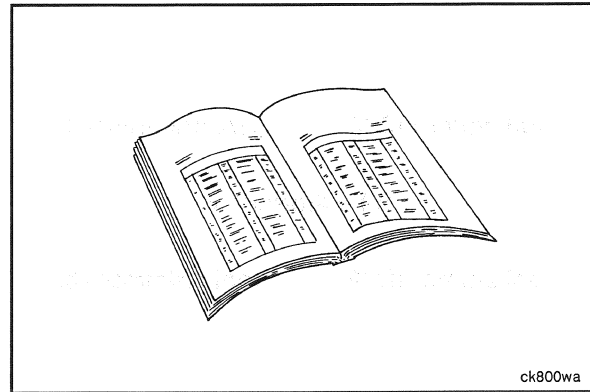


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#### Base Engine Component Blowby Contribution:

Base engine components can also be contributing factors of increased crankcase blowby and higher than normal crankcase pressure. Use Troubleshooting Symptom Tree t027 (Crankcase Gases (Blowby) Excessive) in Section TS to evaluate the remaining possible causes for increased blowby and higher than normal crankcase pressure. The following are listed as possible Base Engine Component causes:

- The valve stems or seals are damaged. Refer to Procedure 002-004 in Section 2.
- The cylinder head valve guides are excessively worn. Refer to Procedure 002-004 in Section 2.
- Piston or piston rings are worn or damaged. Refer to Procedure 001-043 in Section 1.



ck800wa

## Aftertreatment Testing (014-013)

### General Information

#### ⚠ CAUTION ⚠

The use of high sulfur fuel will shorten the life of certain components in the exhaust system, including the selective catalytic reduction catalyst. This damage could cause the engine to become inoperable and affect the warranty coverage on the engine system.

#### Stationary (Parked) De-Sulfur Regeneration of Aftertreatment Catalyst

Under some operating conditions, such as low speed, low load, or stop and go duty cycles, the engine aftertreatment catalyst may **not** be operating at very high temperatures, and if non-approved high sulfur content fuel is used, there is a probability that ammonium sulfate will accumulate on the catalyst, which will consequently reduce the effectiveness of NOx conversion in the selective catalytic reduction (SCR) system.

To rectify this problem, an authorized Cummins® repair location will need to perform Stationary (parked) De-Sulfur regeneration of the aftertreatment catalyst.

**NOTE:** Contact a Cummins® Authorized Repair Location.

A stationary regeneration can **only** be performed with the use of the INSITE™ electronic service tool, which is initiated by selecting the feature option "Aftertreatment SCR Catalyst DeSulfurization". INSITE™ electronic service tool will then perform a timed engine warm-up and will then raise the engine speed to between 2380 to 2450 RPM for a defined period. The length of a stationary (parked) regeneration will typically take approximately 2 hours to complete, and the vehicle **must not** be left unattended during this period.



**▲ 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:** When the stationary regeneration process has been completed, and before the vehicle is returned to service, the lubrication oil **must** be drained and replenished with clean oil, along with installing a new oil filter.

To perform a stationary (parked) regeneration, follow the steps as listed:

- 1 Prepare the vehicle.
  - Make sure that the fuel tank is full and that the oil quantity is sufficient.
  - Inspect the exhaust piping and components for leaks, cracks and loose connections. Refer to Procedure 010-024 in Section 10. Tighten exhaust clamps, if necessary. See equipment manufacturer service information for torque value specifications.
  - No gas or vapors nearby that could burn, explode, or contribute to a fire (such as LP gas, gasoline vapors, oxygen, nitrous oxide).
- 2 Select an appropriate external location to park the vehicle.
  - Preferably on a surface that will **not** burn or melt under high exhaust temperatures (such as clean concrete or gravel, not grass or asphalt). Make sure there are not items within two feet of the exhaust outlet. Any items that can burn, melt or explode (such as gasoline, paper plastics, fabrics, compressed gas containers, hydraulic lines) **must** be placed at least 3 meters [10 feet] from the exhaust outlet.
- 3 Park the vehicle securely and make sure that the parking brake is applied.
  - Set the transmission in PARK, if provided. Otherwise, in NEUTRAL.
  - Place the heavy duty wheel chocks at the front and rear of at least two tires.
- 4 Set up a safe area around the vehicle exhaust, and use barriers to prevent any bystanders from entering within 1.5 meters [5 ft] of the exhaust outlet.
  - Make sure that a serviceable fire extinguisher is nearby.
  - Check the exhaust system components, and confirm that there is nothing on or near the exhaust system surfaces (such as tools, rags, grease, debris, or organic material).
- 5 Connect INSITE™ electronic service tool and make sure that it is placed on a stable surface. Check that any additional fault codes have been resolved and cleared. Initiate the stationary regeneration by selecting the "Aftertreatment SCR Catalyst Desulfurization" and follow the on-screen instructions to perform the process.
  - Once the regeneration commences, the engine speed will initially remain at idle to allow the engine to warm-up. This will be followed by a slow controlled acceleration to attain the appropriate elevated speed for regeneration. At this point, the fuel injection sequencing is adjusted, and it will be noted that the engine running tone will change. This is normal during the regeneration process. At the end of this elevated speed period, the engine will decelerate to idle for a short cooling phase, whereby the regeneration process will be completed.
  - Select the stop button on the INSITE™ electronic service tool monitor screen
  - Depress the clutch, if equipped
  - Depress the brake
  - Depress the acceleration pedal
  - Switch the engine OFF.
- 6 Monitor the area
  - Make sure that the vehicle and surrounding area is monitored during regeneration. If any unsafe condition occurs, shut down the engine immediately.

When the stationary regeneration process is completed, the temperature of the exhaust aftertreatment components will remain elevated for at least 5 minutes.

Take the vehicle for a short test drive, and operate the vehicle as instructed by INSITE™ electronic service tool, so that the Aftertreatment High NOx fault code can be reset. Reference the QSF3.8 CM2350 Fault Code Troubleshooting Manual, Bulletin 4367319.

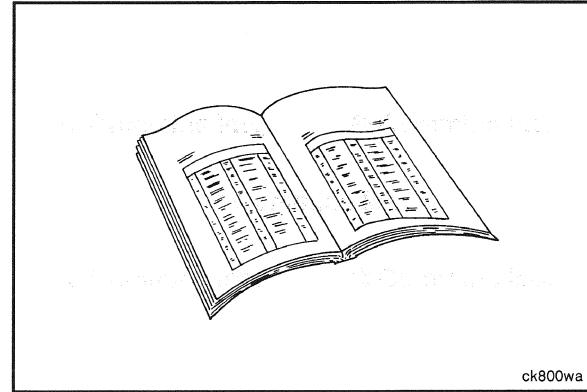
Drain and replenish the lubrication oil and replace the oil filter **before** the vehicle is returned to service.

Use the following procedure in the QSF3.8 CM2350 F107 Operation and Maintenance Manual, Bulletin 4367317 Refer to Procedure 007-002 in Section 4.

## Aftertreatment Selective Catalytic Reduction (SCR) Performance Test (014-015)

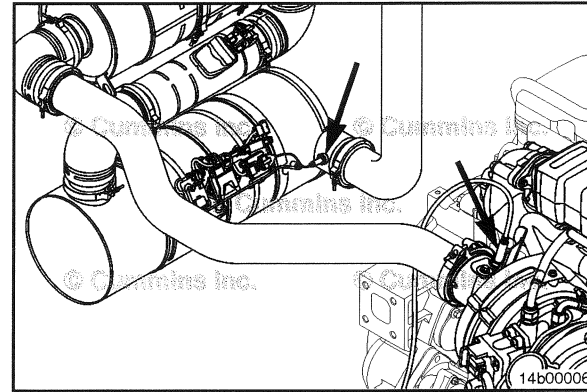
### General Information

Use the following procedure 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.

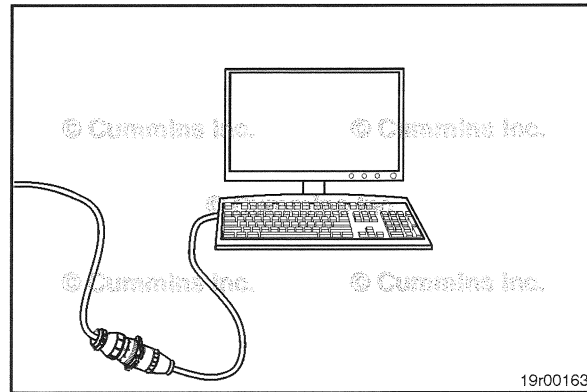
The INSITE™ electronic service tool SCR Performance Test uses the Aftertreatment Intake NOx sensor and Aftertreatment Outlet NOx sensor readings to test the efficiency of the SCR catalyst.



### 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 testing, exhaust gas temperature could 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 stops 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.

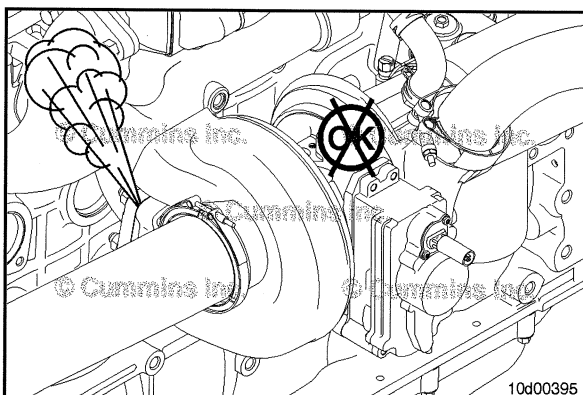
Before performing an SCR Performance Test, follow the steps listed below:

- 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
2 Park the truck securely.
3 Set up a safe exhaust area.
4 Check exhaust system surfaces.
5 Prepare for engine speed changes during regeneration.
6 Begin the SCR Performance Test.
7 Monitor the area.

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.



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.

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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.

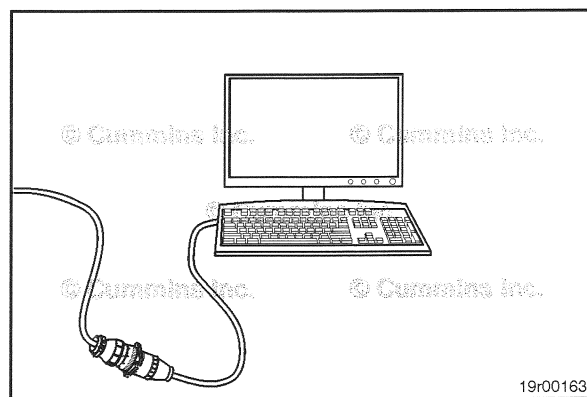
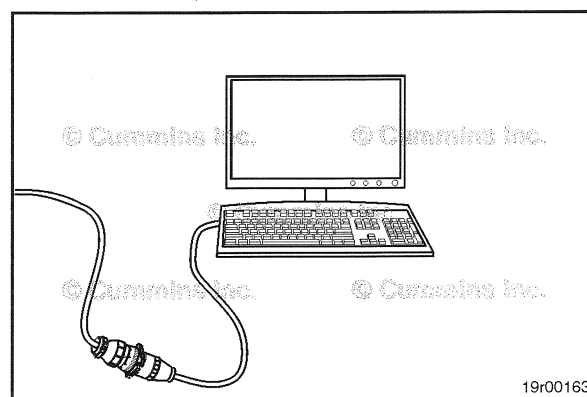
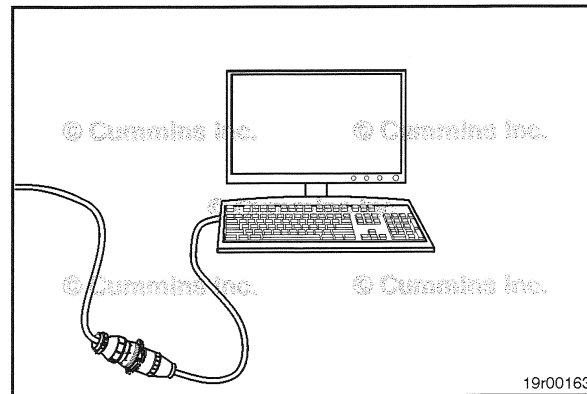
- The Aftertreatment Intake NOx sensor and Aftertreatment Outlet NOx sensor readings will be compared to determine if they are working properly.
- If one, or both, of the NOx sensors fail the rationality test, the test will stop and a pop-up message will be displayed, stating that the NOx sensor has failed and troubleshooting is required.

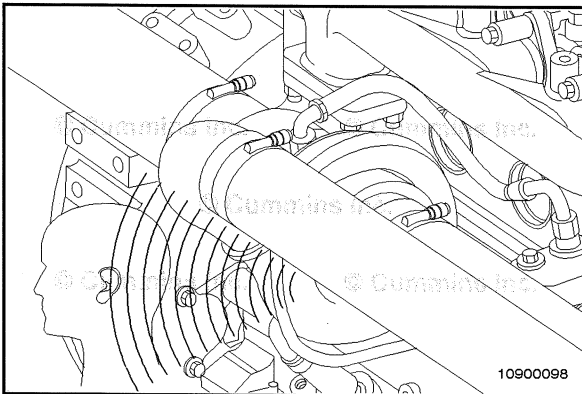
Check the SCR catalyst efficiency.

- 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 Efficiency Test, the following will be monitored:

- SCR catalyst inlet temperature
- SCR catalyst outlet temperature
- Aftertreatment intake NOx sensor reading
- Aftertreatment outlet NOx sensor reading.

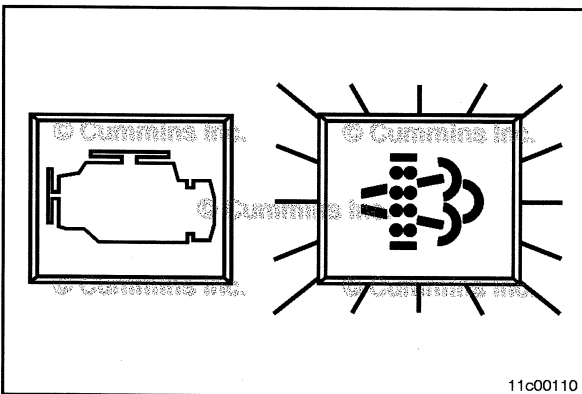




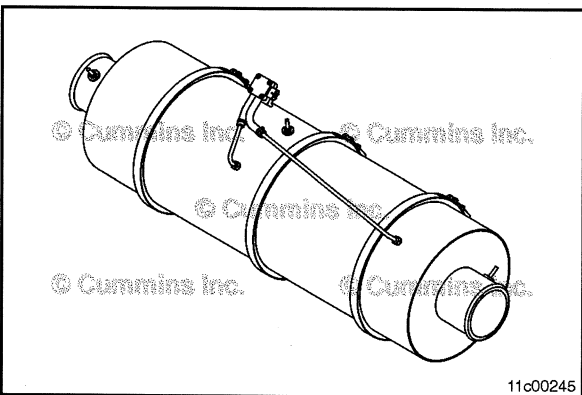
Once the SCR Performance Test is started, follow the INSITE™ electronic service tool on-screen instructions. When the test is started, the engine idle speed will be raised automatically to the required level.

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.



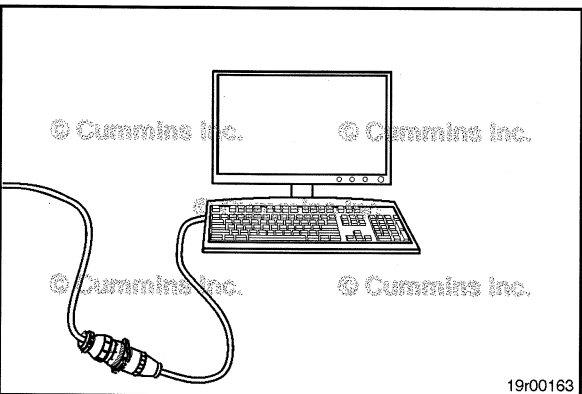
Once the test is complete, check for active fault codes and/or engine indicator lamps. If **any** active fault codes are present, follow the appropriate fault code troubleshooting tree.



## Snap Acceleration Test (014-017) General Information

Use the following procedure 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.



### 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

### 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 system.

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 system. 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.

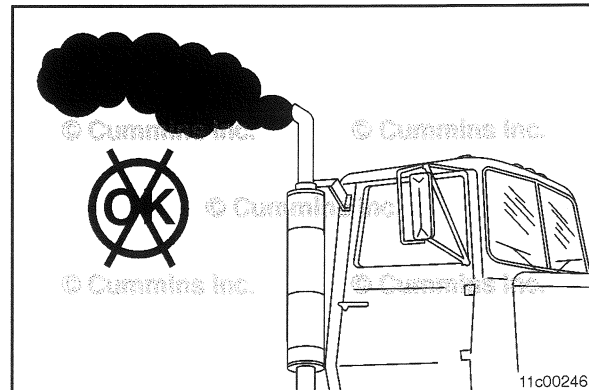
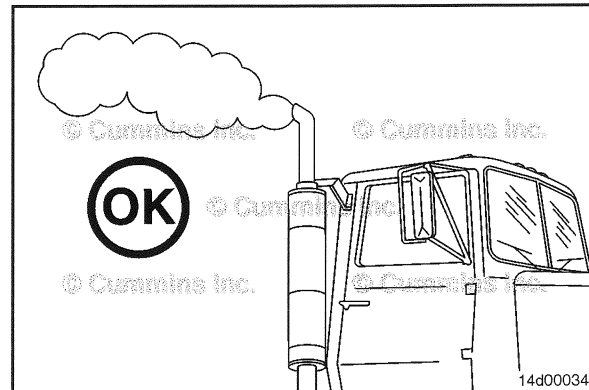
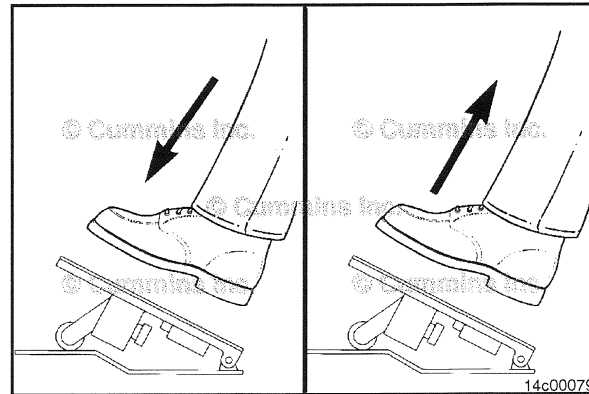
**NOTE:** If an opacity meter is used to measure the condition of the exhaust gas leaving the exhaust system outlet, the engine and aftertreatment system **must** be at operating temperature.

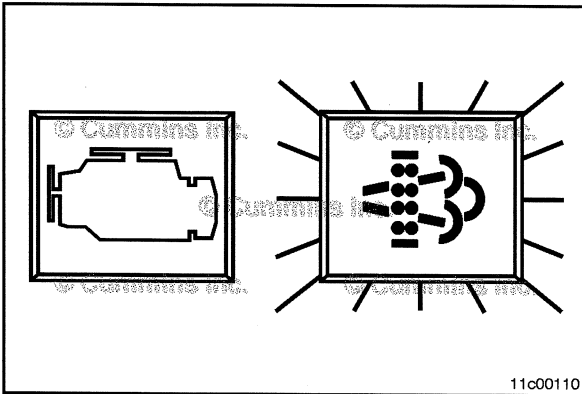
White smoke can indicate condensation in the exhaust and/or some unburned fuel. White smoke is **not** an indication of a malfunction of the aftertreatment system.

If excessive white smoke is present, see the appropriate troubleshooting symptom tree in Section TS.

A small puff of black smoke upon acceleration that clears at steady state high idle is normal. Visible black smoke out of the exhaust system outlet that does not clear at steady state indicates a malfunction of the aftertreatment or engine systems. See the appropriate troubleshooting symptom tree in Section TS.

**NOTE:** If the vehicle has experienced the aftertreatment 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.





### 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.

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.

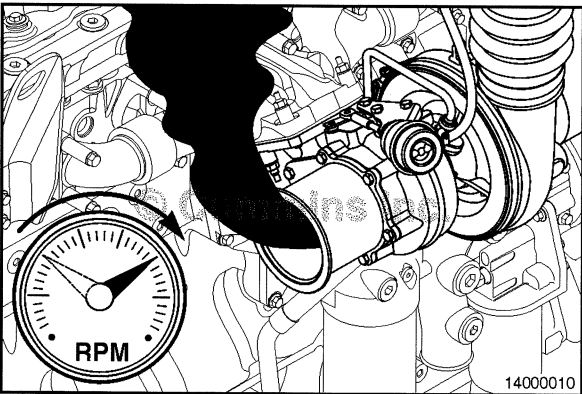
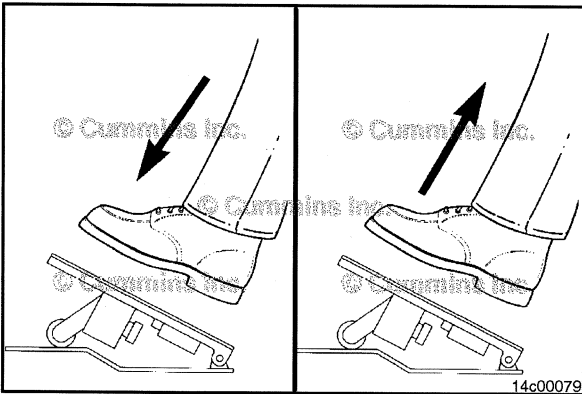
The vehicle transmission **must** be in neutral.

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.



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.

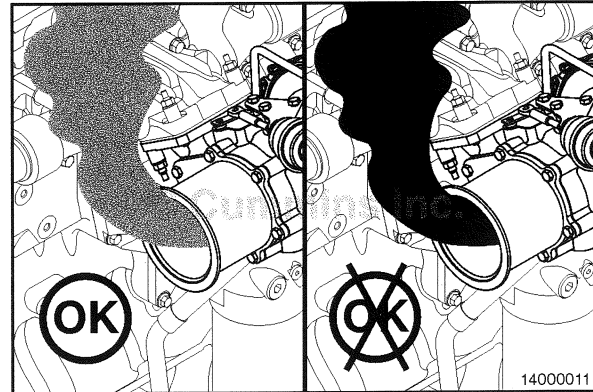
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A small puff of black smoke upon acceleration that clears at a steady high idle speed is normal.



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. Reference the Black Smoke - Excessive troubleshooting symptom tree in Section TS.

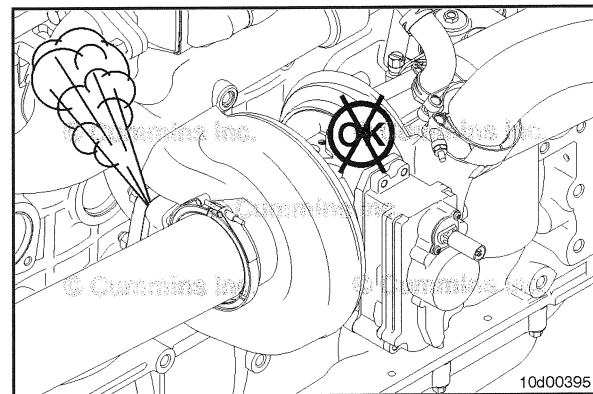


Reconnect the exhaust system.

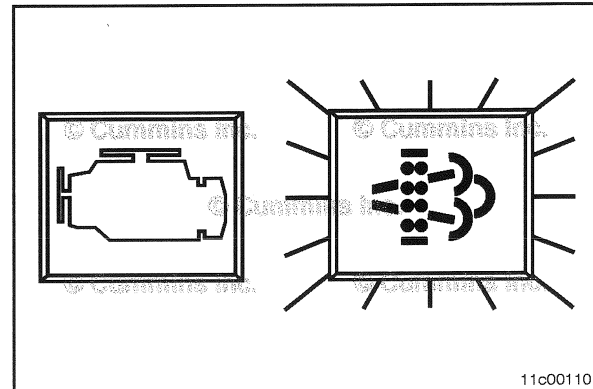
Inspect the exhaust piping for leaks, cracks, and loose connections.

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 illuminated engine indicator lamps. If **any** active fault codes are present, follow the appropriate fault code troubleshooting tree.







# Section 16 - Mounting Adaptations - Group 16

## Section Contents

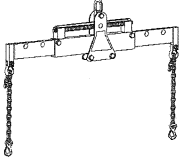
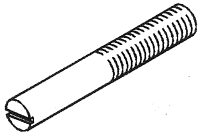
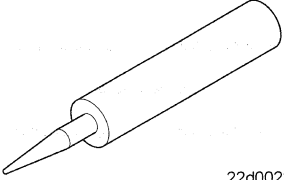
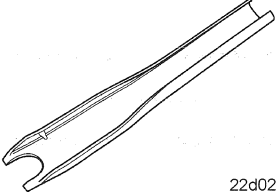
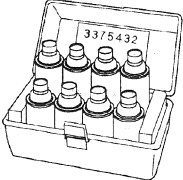
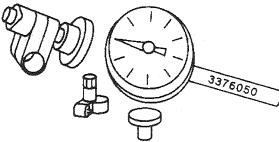
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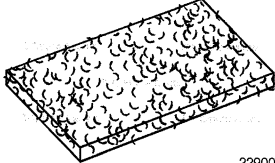
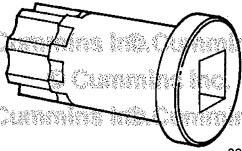
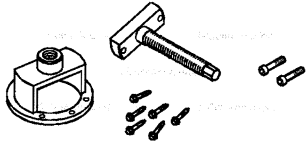
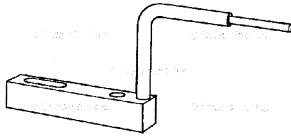
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## Service Tools

### 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
3162871	<p align="center"><b>Engine Lifting Fixture</b></p> <p>Used to remove and install the engine.</p>	 <p align="right">3162871</p>
3163934, 3164977, 3163935, 3163936, 3376638	<p align="center"><b>Guide Pin</b></p> <p>Used to help align the components during installation.</p>	 <p align="right">22d00114</p>
3164070	<p align="center"><b>RTV Sealant</b></p> <p>Used to seal flywheel housing to gear housing joint.</p>	 <p align="right">22d00220</p>
3165175	<p align="center"><b>Barring Plug Remover</b></p> <p>Used to remove flywheel housing plug. Removal of this plug is required prior to using Barring Tool, Part Number 3824591.</p>	 <p align="right">22d0223</p>
3375432	<p align="center"><b>Crack Detection Kit</b></p> <p>Used to clean and inspect components for cracks.</p>	 <p align="right">3375432</p>
3376050	<p align="center"><b>Dial Indicator Gauge</b></p> <p>Used with attachment, Part Number ST-1325, for checking flywheel housing runout.</p>	 <p align="right">3376050</p>

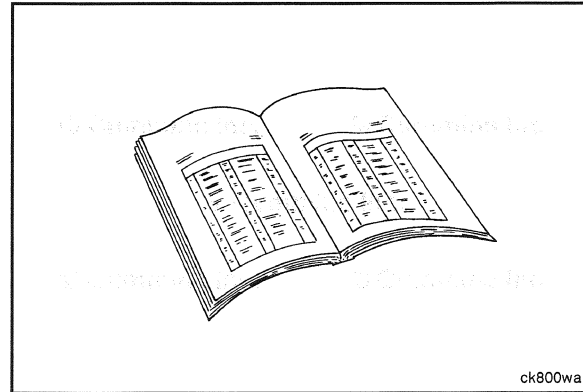
Tool No.	Tool Description	Tool Illustration
3823258	<p align="center"><b>Abrasive Pad</b></p> <p>Used to clean surfaces and fix minor scrapes.</p>	 <p align="right">22900039</p>
3824591	<p align="center"><b>Barring Tool</b></p> <p>Used to engage the flywheel ring gear to rotate the crankshaft.</p>	 <p align="right">3824591</p>
4919533	<p align="center"><b>Oil Seal Replacer (rear)</b></p> <p>Used to remove/install rear crankshaft seal.</p>	 <p align="right">22d00087</p>
ST-1325	<p align="center"><b>Dial Gauge Attachment</b></p> <p>Used with dial indicator, Part Number 3376050, for checking flywheel housing runout.</p>	 <p align="right">st-1325</p>

## Engine Lifting Brackets (016-001) 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.

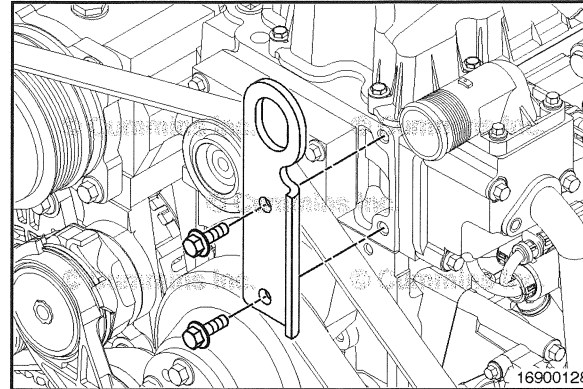
- Disconnect the batteries. See equipment manufacturer service information.
- For the front lifting bracket it may be necessary to remove the alternator and alternator bracket. Refer to Procedure 013-001 in Section 13. Refer to Procedure 013-003 in Section 13.



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### Remove Front

Remove the capscrews and the front lifting bracket.

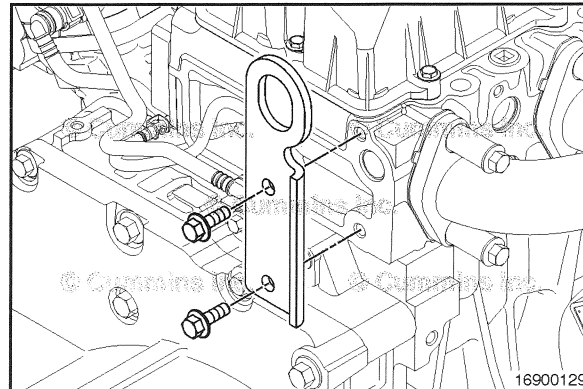


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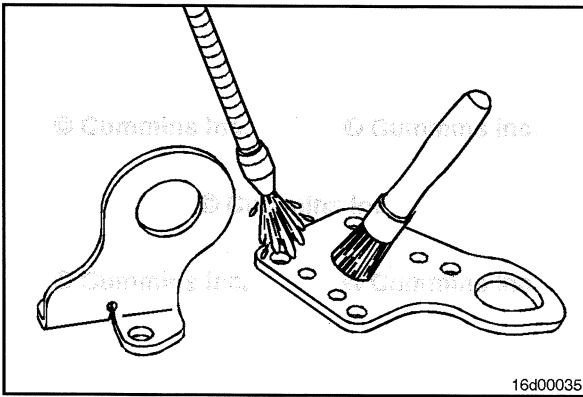
### Rear

Remove the capscrews and the rear lifting bracket.

**NOTE:** Some engines use a two bolt rear lifting bracket and some engines use a four bolt rear lifting bracket.



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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.

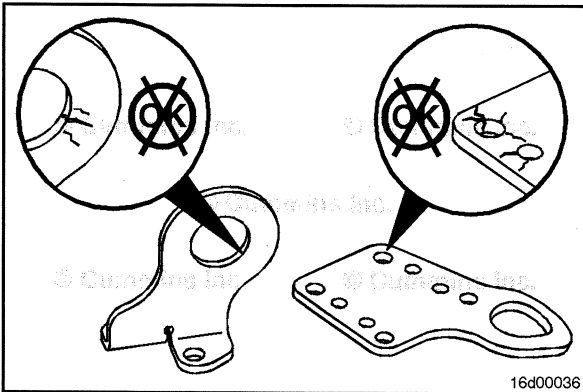
#### ▲ WARNING ▲

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

#### ▲ 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.

Use steam or solvent to clean the lifting brackets. Dry with compressed air.

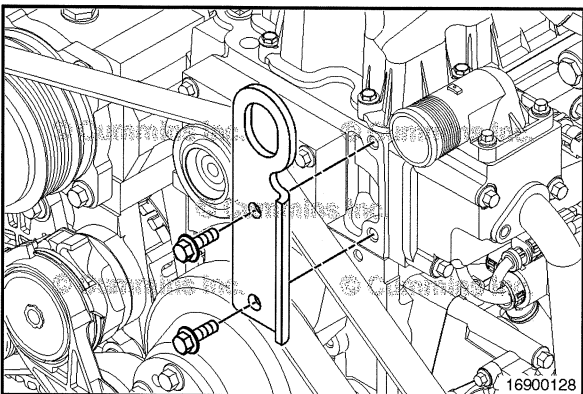


#### ▲ WARNING ▲

Do not use a cracked or damaged bracket. Do not weld a cracked bracket. Personal injury can result.

Inspect the brackets for cracks or damage.

Replace the bracket if it is cracked or damaged.



### Install

#### Front

For engines **not** equipped with pad mount alternators, install the cap screws and front bracket.

Tighten the cap screws.

**Torque Value:**  
M8 24 N•m [ 212 in-lb ]

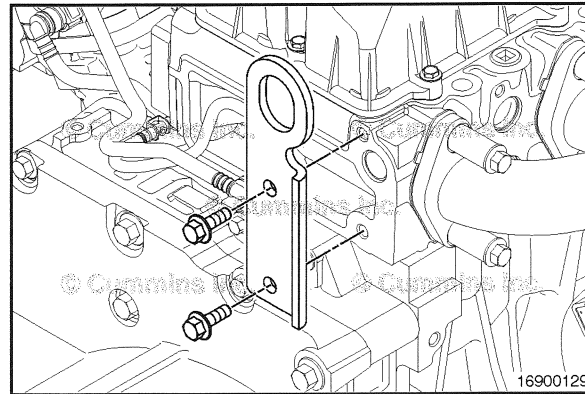
**Torque Value:**  
M10 43 N•m [ 32 ft-lb ]

### Rear

Install and tighten the rear bracket and capscrews.

**NOTE:** Some engines use a two bolt rear lifting bracket and some engines use a four bolt rear lifting bracket.

**Torque Value:** 77 N•m [ 57 ft-lb ]

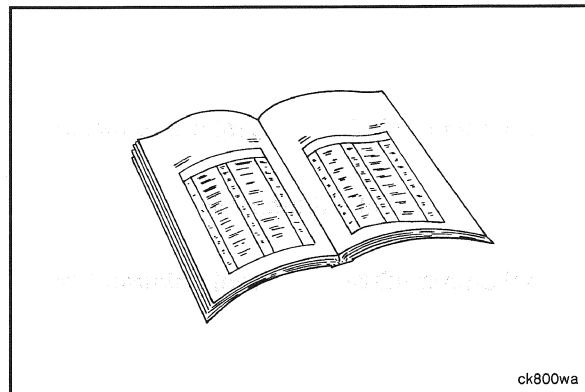


### Finishing Steps

#### ⚠ WARNING ⚠

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

- Install the alternator and alternator bracket, if removed. Refer to Procedure 013-001 in Section 13. Refer to Procedure 013-003 in Section 13.
- Connect the batteries. See equipment manufacturer service information.



## Engine Support Bracket, Front (016-002)

### General Information

Due to the number of different engine mounting configurations, the following procedure is written to be generic. Some of the illustrations may **not** represent the actual part being removed and installed.

### Initial Check

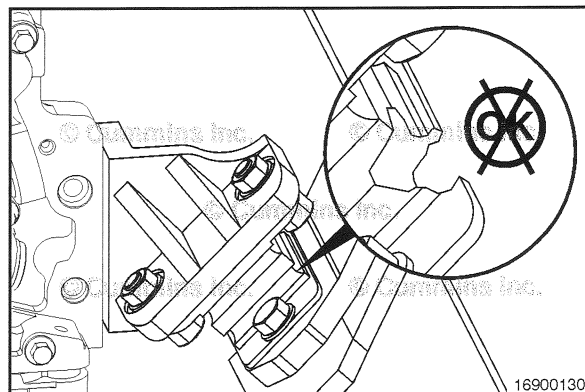
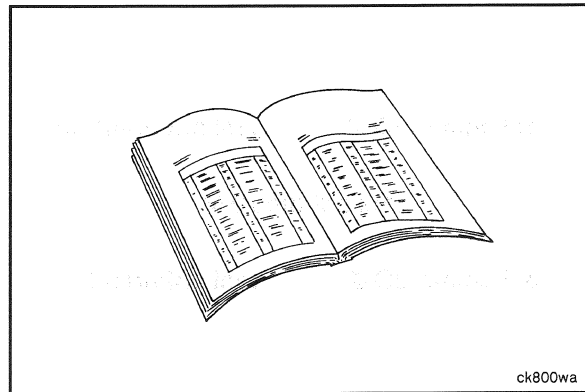
#### ⚠ CAUTION ⚠

Damaged engine mounts and brackets can cause engine misalignment. Drivetrain component damage can result in excessive vibration complaints.

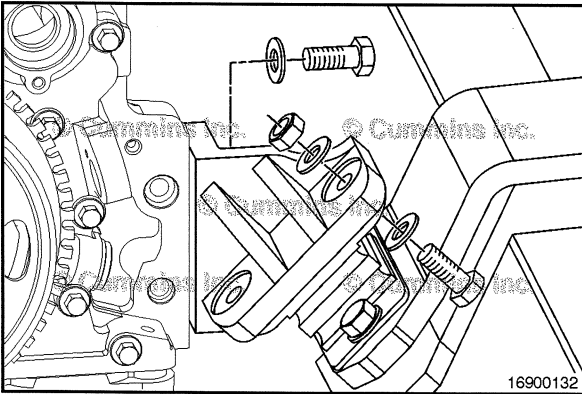
For all engine mounts, inspect all rubber-cushioned mounts for cracks or damage.

Inspect all mounting brackets for cracks or damaged bolt holes.

Replace any damage parts as necessary.







### Remove

#### ▲ WARNING ▲

The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

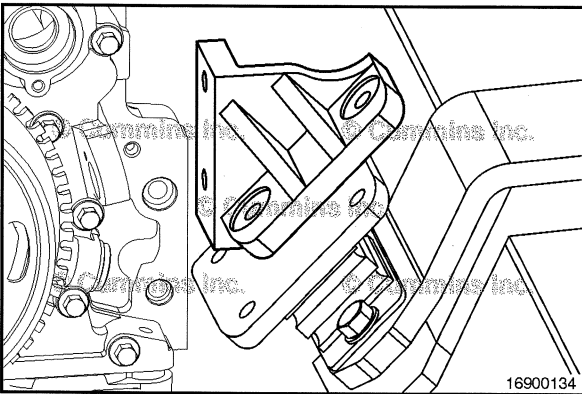
#### ▲ WARNING ▲

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.

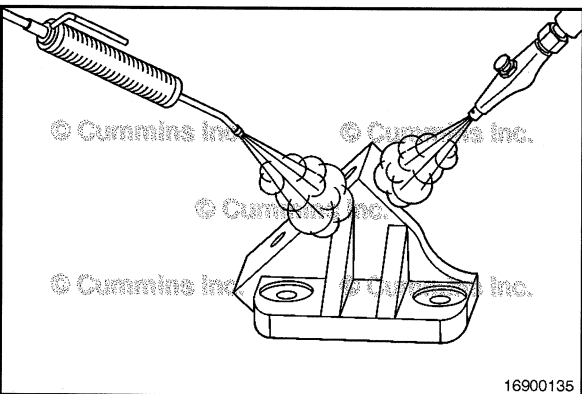
Use a hoist or lifting fixture to support the front of the engine.

**NOTE:** When removing the front engine mount fasteners, keep track of the location of any shims or spacers used.

Remove the capscrews from the front engine mount.



For side mount, remove the side engine mount capscrews and the brackets.



### Clean and Inspect for Reuse

#### ▲ WARNING ▲

When using a steam cleaner, wear protective clothing as well as safety glasses or a face shield. 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 as well as protective clothing to reduce the possibility of personal injury.

#### ▲ WARNING ▲

Compressed air used for cleaning should not exceed 207 kPa [30 psi]. Use only with protective clothing, as well as goggles/shield, and gloves to reduce the possibility of personal injury.

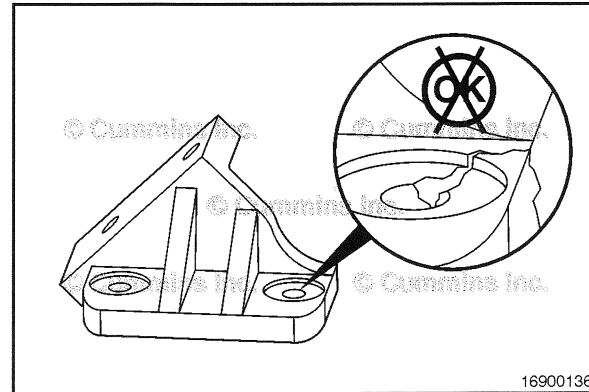
Use steam or solvent to clean the front engine support bracket(s).

Dry with compressed air.

Inspect the engine support bracket for cracks or damage.

If the engine support bracket is cracked, it **must** be replaced.

**NOTE:** Some front engine support brackets have rubber inserts. Make sure to inspect the inserts for separation, cracking and deterioration. If any damage is found, the front engine support bracket **must** be replaced.



### Install

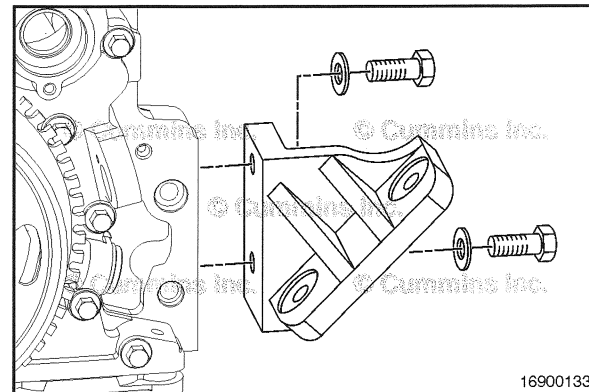
For front mount, install the front mount bracket and capscrews.

**Torque Value:**

Grade 8.8 80 N•m [ 60 ft-lb ]

**Torque Value:**

Grade 12.9 125 N•m [ 95 ft-lb ]



For side mount, install the side mount brackets and capscrews.

**Torque Value:**

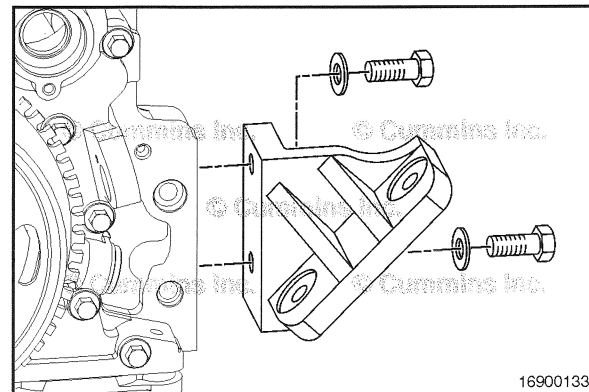
Grade 8.8 80 N•m [ 60 ft-lb ]

**Torque Value:**

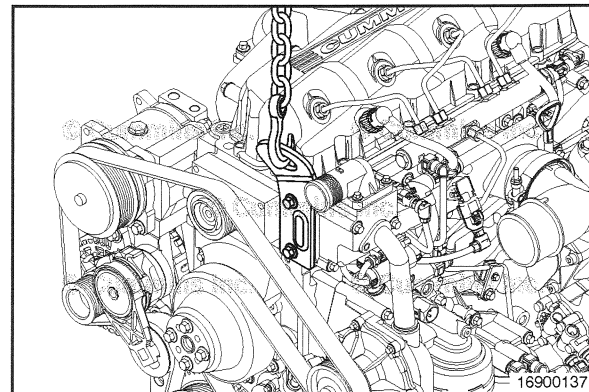
Grade 10.9 115 N•m [ 85 ft-lb ]

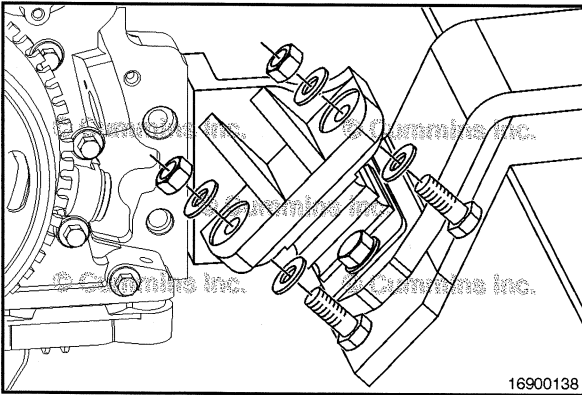
**Torque Value:**

Grade 12.9 125 N•m [ 95 ft-lb ]



Lower the front of the engine.





### Non Cummins® Engine Mounting Bolts

**NOTE:** Make sure to install any shims or spacers in the same location as removed.

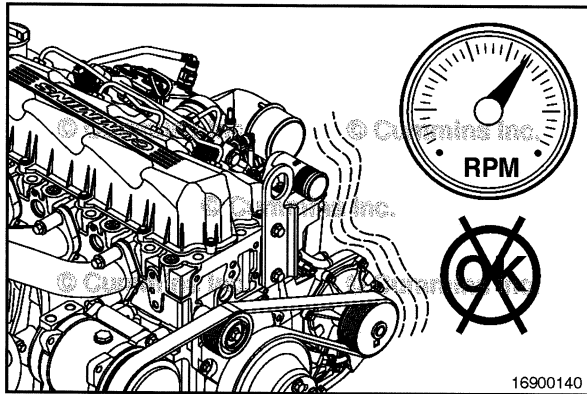


Install the front engine mount fasteners and tighten. See equipment manufacturer service information.



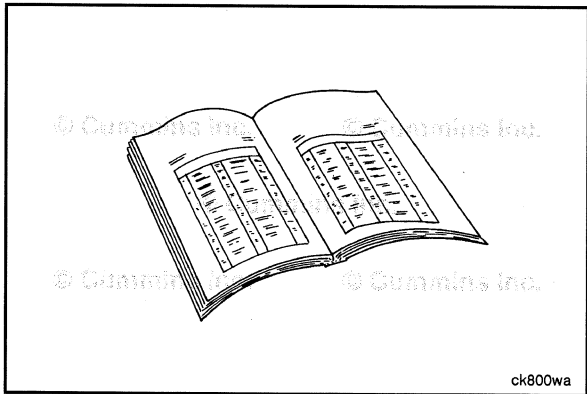
If previously loosened, tighten the rear engine mounting fasteners. See equipment manufacturer service information.

Remove the lifting fixture or hoist from the front of the engine.



### Cummins® Engine Mounting Bolts

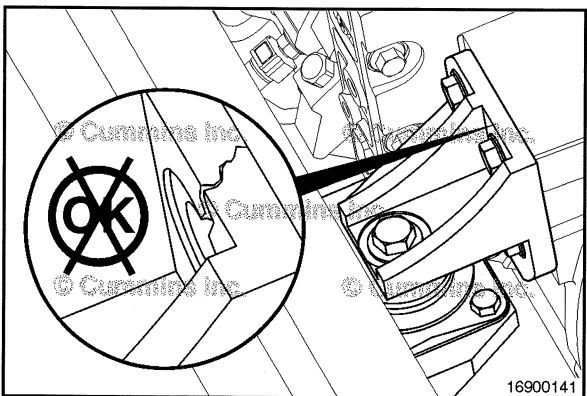
Operate the engine and check for noise or vibration.



## Engine Support Bracket, Rear (016-003)

### General Information

Due to the number of different engine mounting configurations, the following procedure is written to be generic. Some of the illustrations may **not** represent the actual part being removed and installed.



### Initial Check

#### ⚠CAUTION⚠

Damaged engine mounts and brackets can cause engine misalignment. Drivetrain component damage can result in excessive vibration complaints.

Inspect all rubber-cushioned mounts for cracks or damage.

Inspect all mounting brackets for cracks or damaged bolt holes.

Replace any damaged parts as necessary.

## Remove

### ⚠ WARNING ⚠

The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

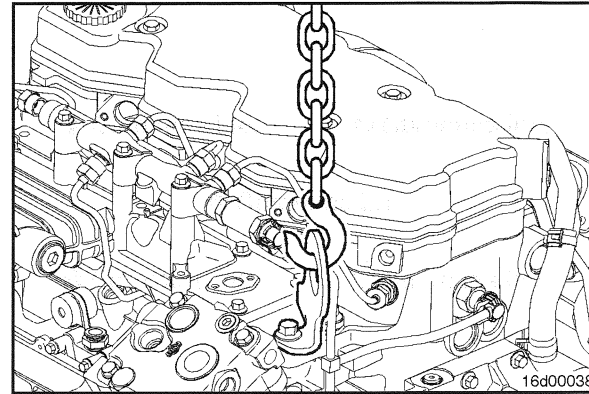
### ⚠ WARNING ⚠

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.

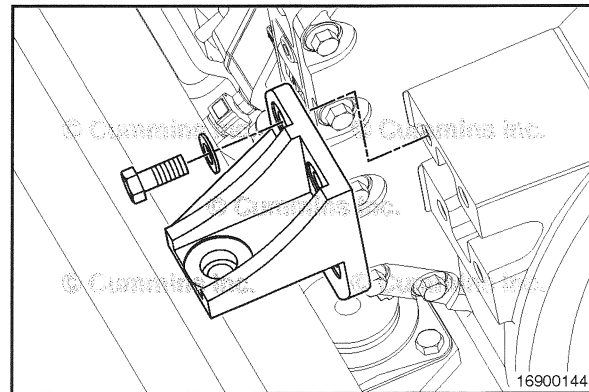
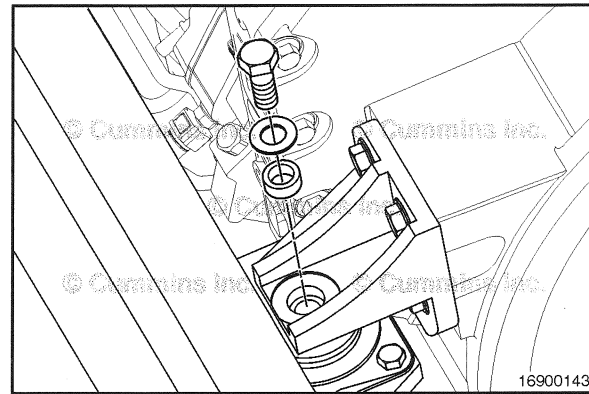
Use a hoist or lifting fixture to support the rear of the engine.

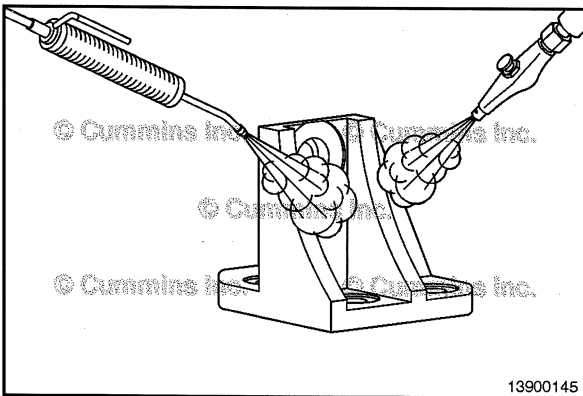
**NOTE:** When removing the rear engine mount fasteners, keep track of the location of any shims or spacers used.

Remove the engine mount fasteners.



Remove the rear support capscrews and bracket.





### Clean and Inspect for Reuse

#### ▲ WARNING ▲

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

#### ▲ WARNING ▲

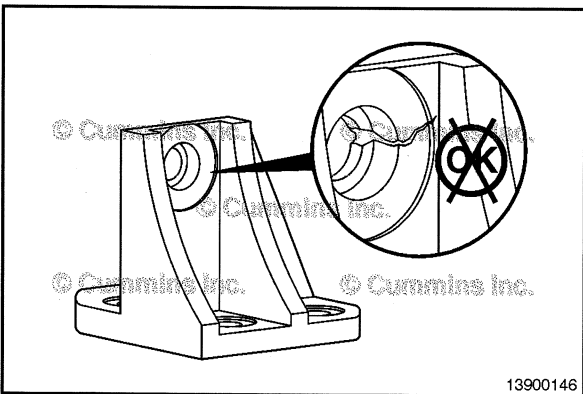
When using solvents, acids, or alkaline materials for cleaning, follow the manufacturers recommendations for use. Wear goggles, and protective clothing to reduce the possibility of personal injury.

#### ▲ 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 front engine support.

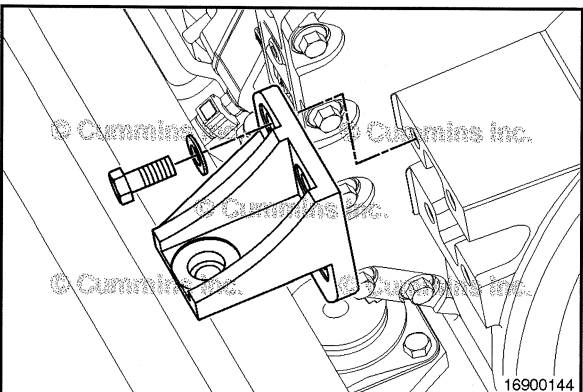
Dry with compressed air.



Inspect the support bracket for cracks or damage.

If the support bracket is cracked, it **must** be replaced.

**NOTE:** Some rear engine support brackets have rubber inserts. Make sure to inspect the inserts for separation, cracking and deterioration. If any damage is found, the rear engine support bracket **must** be replaced.



### Install

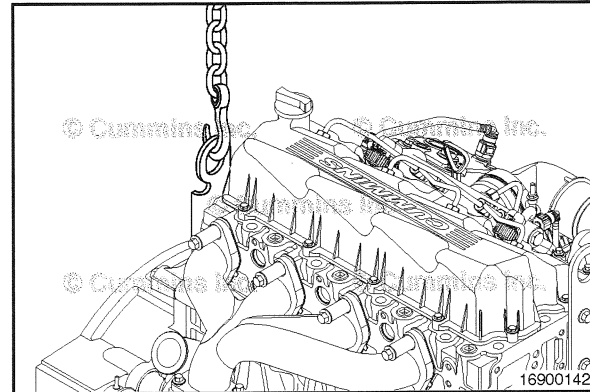
Install the support bracket and mounting capscrews.

**Torque Value:** 77 N•m [ 57 ft-lb ]



**NOTE:** Make sure to install any shims or spacers in the same location as removed.

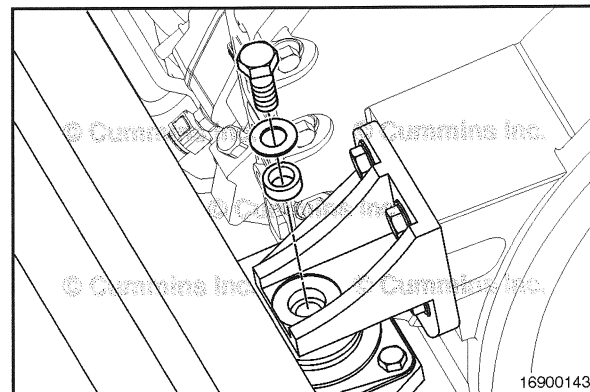
Lower the rear of the engine.



Install the rear engine mount fasteners.

Tighten to the original equipment manufacturer (OEM) specifications.

Remove the lifting fixture or hoist from the rear of the engine.



## Flexplate (016-004) Preparatory Steps

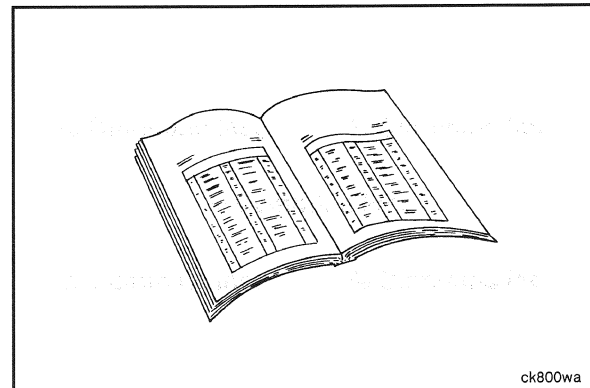
### ⚠ WARNING ⚠

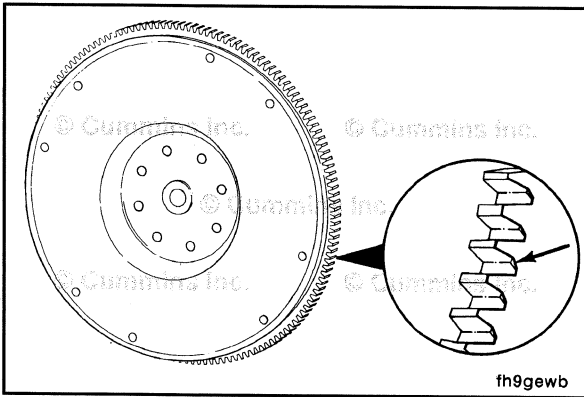
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

### ⚠ 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.

- Disconnect the batteries. See equipment manufacturer service information.
- Remove the transmission and related components. See equipment manufacturer service information.

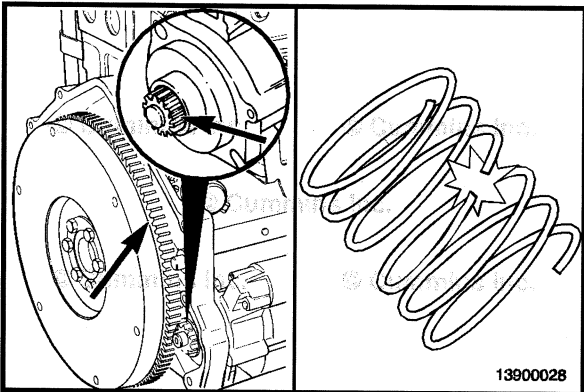




### Initial Check

For automotive and industrial applications, inspect the flexplate ring gear teeth for damage.

If the flexplate ring gear is damaged, make sure to evaluate the following possible causes prior to replacing the flexplate.



### Mechanical

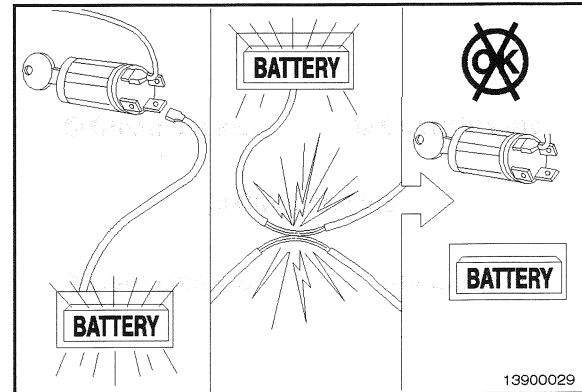
A mechanical issue can typically be identified by seeing damage to the ring gear of the flexplate in 3 distinct locations for 6 cylinder engines (commonly called 120 degree milling), and 2 locations for 4 cylinder engines (commonly called 180 degree milling). The following can be causes for mechanical issues:

- 1 The possibility of improper starter motor spacing. Refer to Procedure 013-020 in Section 13.
- 2 The interference between the ring gear land area and the starting motor pinion. The wrong starting motor might be installed. See equipment manufacturer service information.
- 3 The possibility of 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.
- 4 The torque converter/transmission is damaged or incorrectly mounted. See equipment manufacturer service information.
- 5 Incorrect starting motor pinion to flexplate ring gear pitch and teeth match. See equipment manufacturer service information.

### Electrical

An electrical issue can typically be identified by seeing damage to the ring gear of the flywheel 360 degrees around the circumference of the ring gear (commonly called 360 degree milling). The following can be causes for electrical issues:

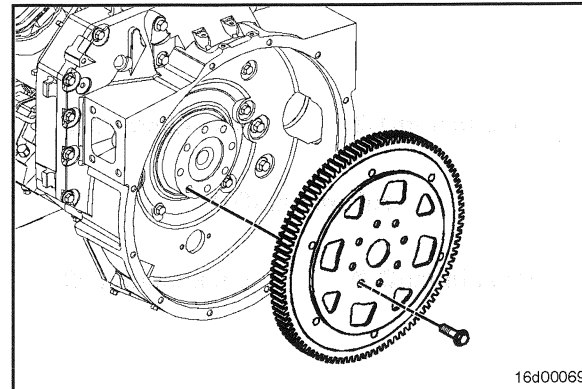
- 1 The operator is attempting to start engine while engine is already running. Check if a starter lockout feature is available through the OEM (activated with the INSITE™ electronic service tool) or the starting motor manufacturer.
- 2 The keyswitch is causing intermittent starting motor engagement when the engine is running. Inspect the key switch. Refer to Procedure 013-020 in Section 13.
- 3 The orientation of the starter relay, 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 Intermittent starter motor wiring issues. See equipment manufacturer service information.



### Remove

Remove the flexplate capscrews and flexplate.

**NOTE:** Some flexplates require mounting plates and/or adapters. It may be necessary to remove any mounting plates and/or adapters prior to or with the flexplate. Make sure to note the location of any mounting plates and/or adapters for later installation.

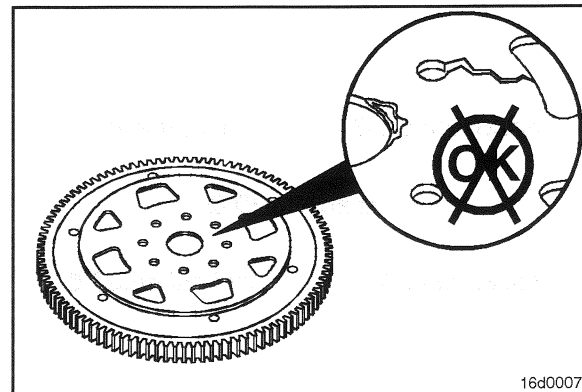


### Inspect for Reuse

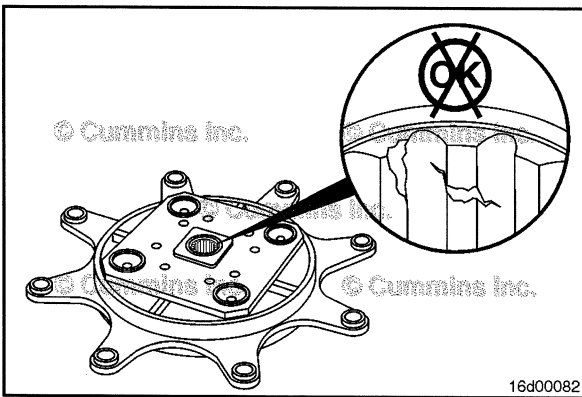
Inspect the teeth of the ring gear for chips or uneven wear.

Check the flexplate for cracks.

Replace the flexplate if any damage is found.

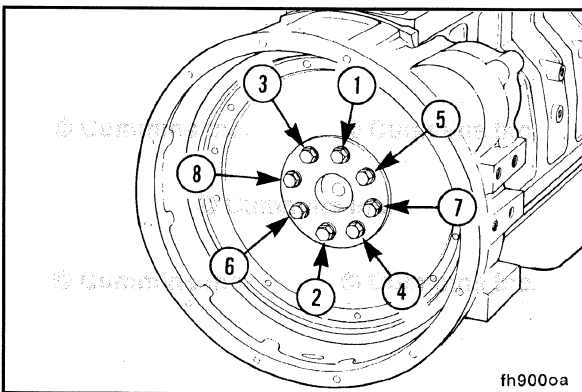






Check the flexplate for cracks at the mounting holes, drive splines, and the inner drive plate.

Replace the flexplate if any damage is found.



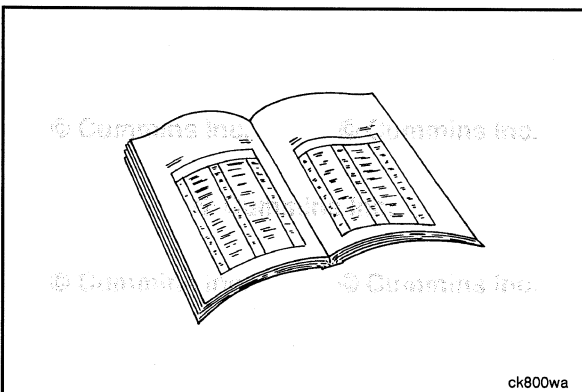
### Install

**NOTE:** Some flexplates require mounting plates and/or clamp rings. It will be necessary to install any mounting plates and/or clamp rings prior to or with the flexplate as noted during removal.

Install the flexplate cap screws and flexplate, and tighten the cap screws.

#### Torque Value:

Flexplate Cap screws 30 N•m [ 22 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.

#### ▲ 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.

- Connect the batteries. See equipment manufacturer service information.
- Install the transmission and related components. See equipment manufacturer service information.
- Operate engine and check for noise or vibration.

## 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. See equipment manufacturer service information.

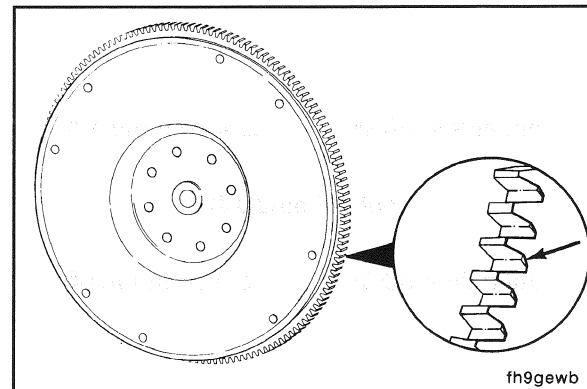
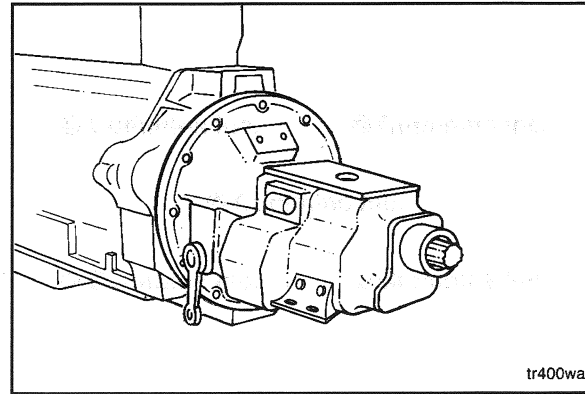
**NOTE:** Use a container that can hold at least 26 liters [27 qt] of lubricating oil.

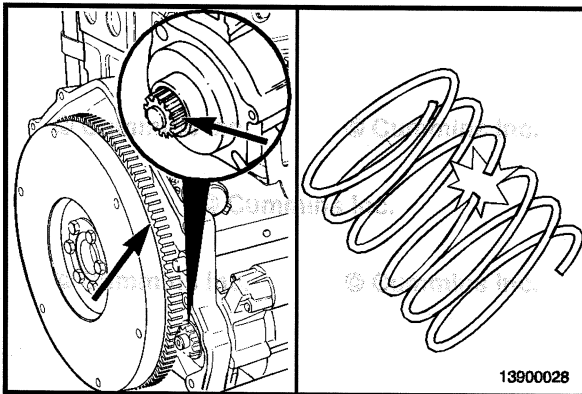
- If equipped with a wet flywheel housing, drain the oil from the flywheel housing by removing the plug in the bottom of the flywheel housing.
- Remove the transmission and all related components, if equipped. See equipment manufacturer service information.

### Initial Check

Inspect the flywheel ring gear teeth for damage.

If the flywheel ring gear is damaged make sure to inspect the following possible causes prior to replacing the flywheel.



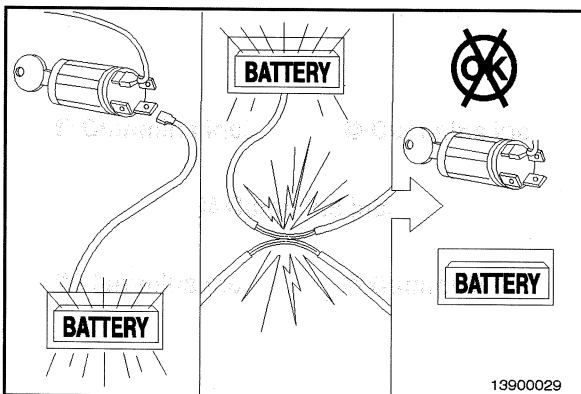


### Mechanical



A mechanical issue can typically be identified by seeing damage to the ring gear of the flywheel in three distinct locations for six cylinder engines (commonly called 120 degree milling), and two locations for four cylinder engines (commonly called 180 degree milling). The following could be causes for mechanical issues:

- 1 Upon installation of the flywheel, make sure to check for proper starter motor spacing. Refer to Procedure 013-020 in Section 13.
- 2 There may be interference between the ring gear land area and the starting motor pinion. The wrong starting motor may be installed. See equipment manufacturer service information.
- 3 There may 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.
- 4 The ring gear may be improperly installed or damaged. Refer to Procedure 016-008 in Section 16.
- 5 The flywheel face runout may be out of specification. See the Measure section of this procedure.
- 6 There may be an incorrect starting motor pinion to flywheel ring gear pitch/teeth match. See equipment manufacturer service information.



### Electrical



An electrical issue can typically be identified by seeing damage to the ring gear of the flywheel 360 degrees around the circumference of the ring gear (commonly called 360 degree milling). The following could be causes for electrical issues:

- 1 Operator is attempting to start engine while engine is already running. Check if a starter lockout feature is available through the original equipment manufacturer (OEM) (activated with INSITE™ electronic service tool) or the starting motor manufacturer.
- 2 Keyswitch 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 may be intermittent starter motor wiring issues. See equipment manufacturer service information.

### Remove

**NOTE:** Use the barring tool, Cummins® Part Number 3824591, to hold the flywheel to prevent rotation.

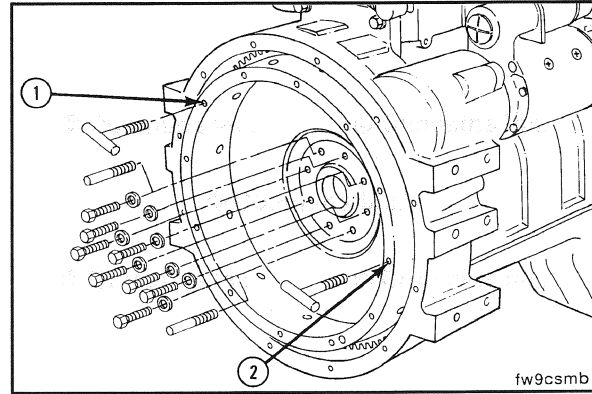
Remove two capscrews 180 degrees apart.

Install two M12 x 1.25 x 90-mm guide pins.

**NOTE:** If a clutch is used in the equipment, the threads in the clutch pressure plate mounting capscrew holes can be metric or standard. Be sure to use the correct capscrews.

Determine the capscrew thread design and size, and install two T-handles in the flywheel (at points 1 and 2).

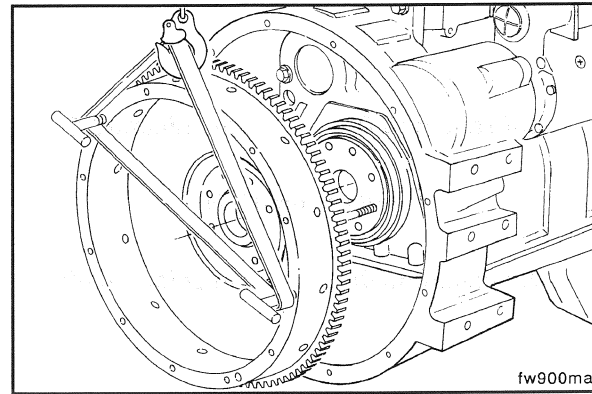
Remove the remaining six flywheel mounting capscrews.



### ⚠ 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.



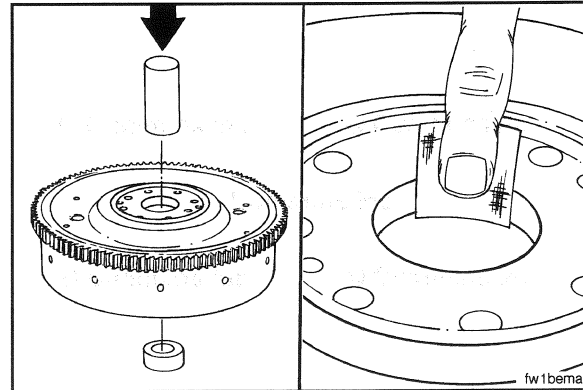
### Disassemble

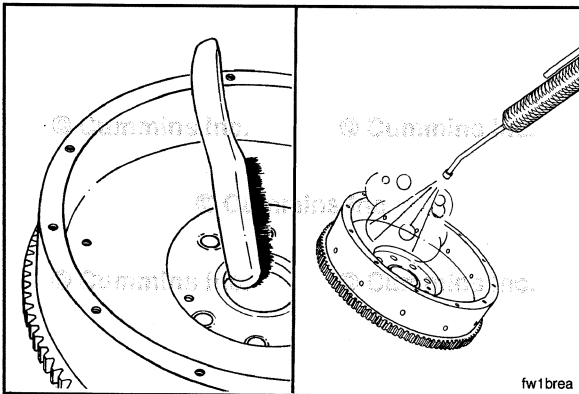
**NOTE:** Removal of the pilot bearing is only necessary if damaged or when installing a new or rebuilt clutch.

If equipped, remove the pilot bearing.

Use a mandrel and hammer to remove the pilot bearing.

Use an abrasive pad, Cummins® Part Number 3823258 or equivalent, to clean the pilot bore.





fw1brea



## 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 ▲

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

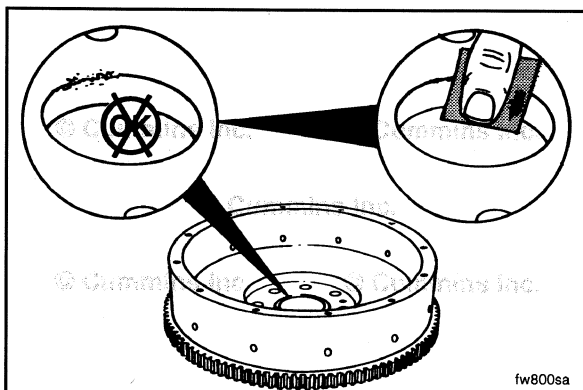
### ▲ WARNING ▲

Compressed air used for cleaning should not exceed 207 kPa [30 psi]. Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

If the pilot bearing was removed, use a wire brush to clean the crankshaft pilot bore.

Use steam or solvent to clean the flywheel.

Dry with compressed air.

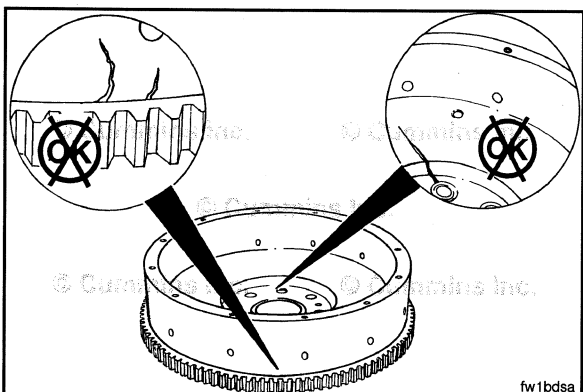


fw800sa



Inspect for nicks or burrs.

Use Scotch-Brite™ 7448 abrasive pad, or equivalent, to remove small nicks and burrs.



fw1bdsa



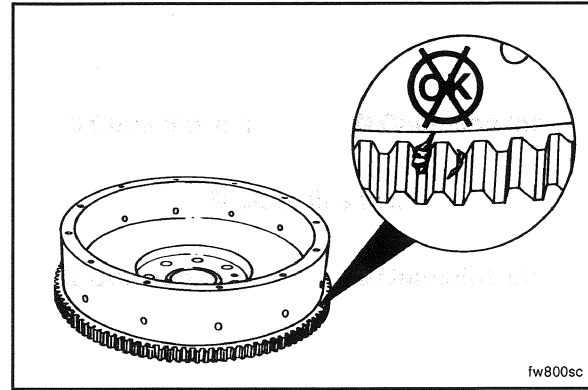
### ▲ WARNING ▲

Do not use a cracked or resurfaced flywheel. These can break, causing serious personal injury or property damage.



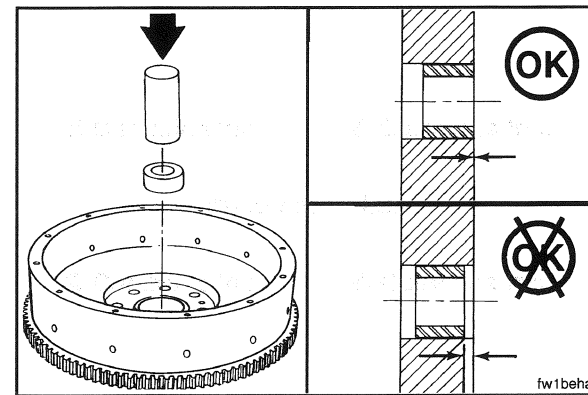
Use the crack detection kit, Cummins® Part Number 3375432, to check for cracks in the flywheel. Follow the instructions provided with the kit.

Inspect the flywheel ring gear teeth for cracks and chips.  
 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.

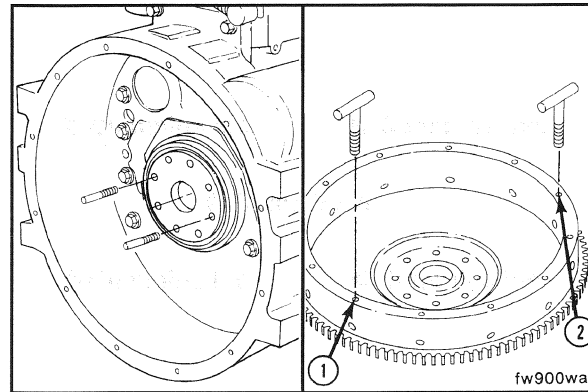


### Install

Install two M12 x 1.25 x 90-mm guide pins into the crankshaft flange 180 degrees apart.

**NOTE:** If a clutch is used in the equipment, the threads in the clutch pressure plate mounting capscrew holes can be metric or standard. Be **sure** to use the correct capscrews.

Determine the capscrew thread design and size, and install two T-handles into the flywheel (at points 1 and 2).

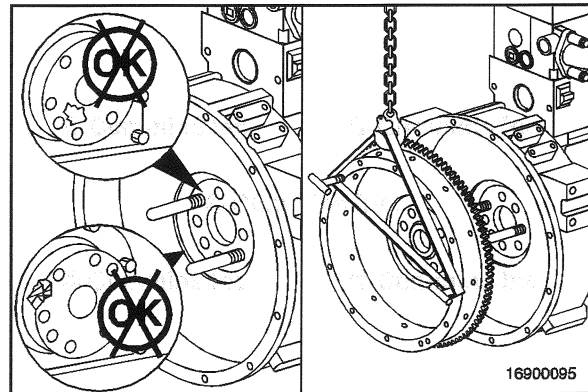


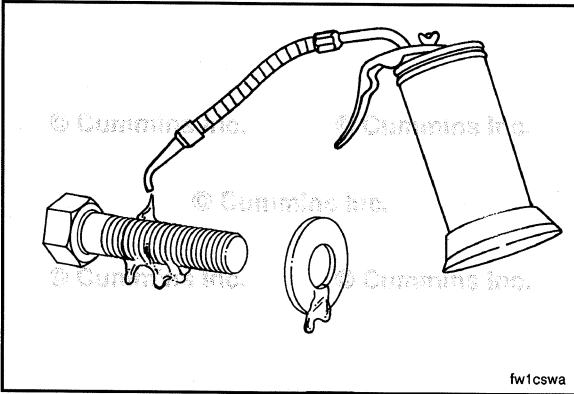
### **⚠ WARNING ⚠**

**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.**

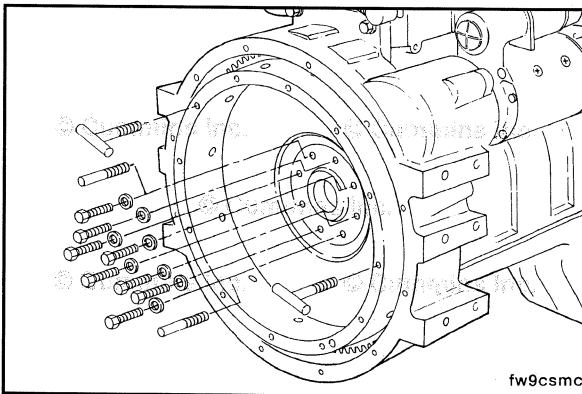
Inspect the rear face of crankshaft and flywheel mounting flange for cleanliness and raised nicks or burrs.

Install the flywheel on the guide pins.





Lubricate the threads of the capscrews and the surface of the washers with clean lubricating engine oil.

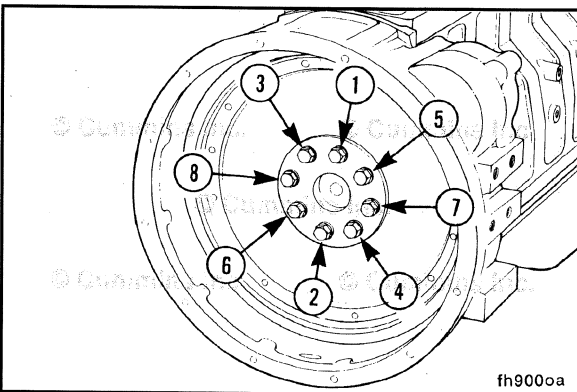


Install the six cap screws.

Remove the T-handles and guide pins.



Install the remaining cap screws into the holes from which the guide pins were removed.

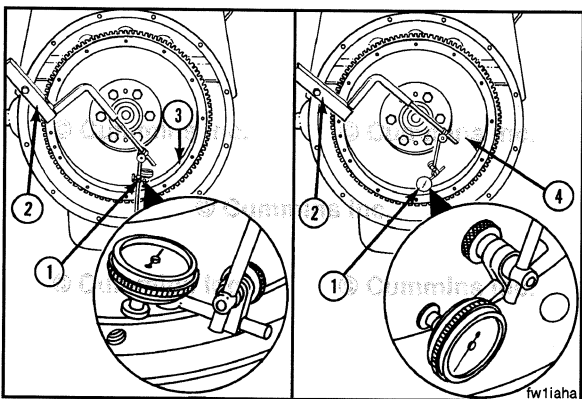


**NOTE:** Use the barring tool, Cummins® Part Number 3824591, to hold the flywheel to prevent rotation.

Tighten the capscrews in a star pattern.

**Torque Value:**

Step 1                    30 N•m                    [ 22 ft-lb ]  
Step 2                    Plus 90-degree turn



**Measure**

Flywheel Bore Runout



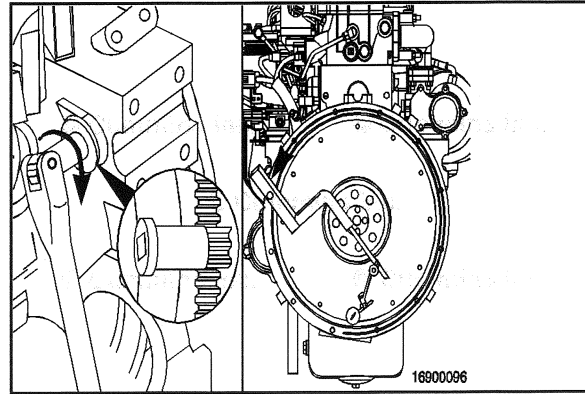
Use the dial indicator gauge (1), Cummins® Part Number 3376050 or equivalent, and dial gauge attachment (2), Cummins® Part Number ST-1325, to inspect the flywheel bore (3) and the surface (4) runout.

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, Cummins® Part Number 3824591, to rotate the crankshaft one complete revolution.



**Flywheel Total Indicator Reading**

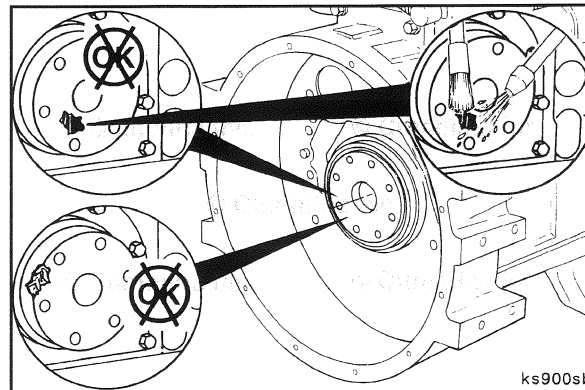
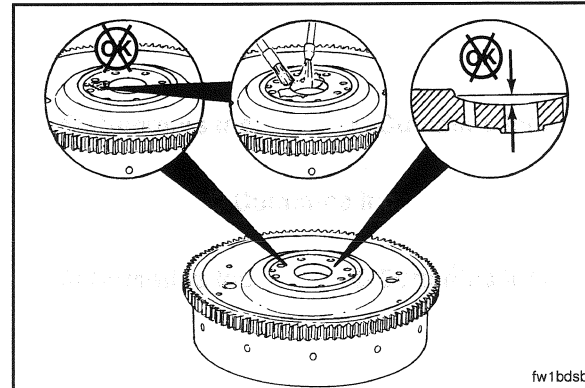
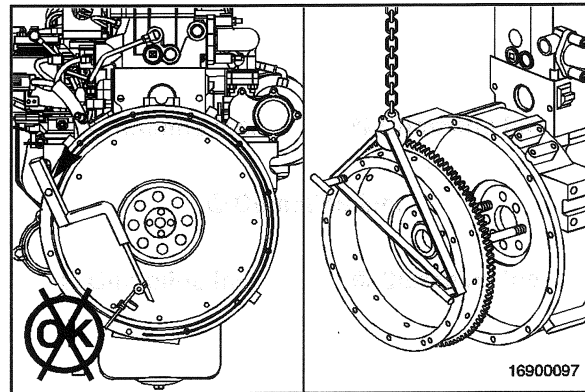
mm		in
0.127	MAX	0.0050

**⚠ WARNING ⚠**

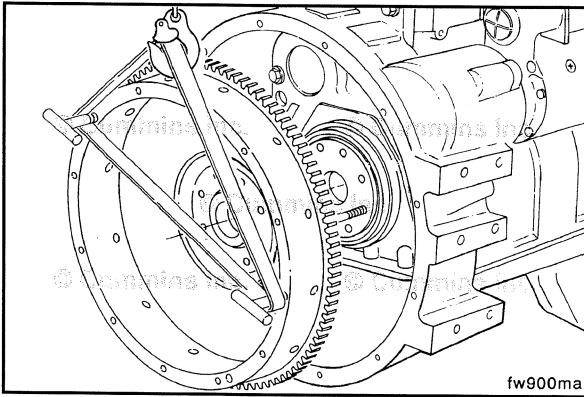
This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.

If the total indicator reading is greater than the specification, do the following:

- Remove the flywheel.
- Inspect the flywheel mounting surface for dirt or damage.
- Inspect the crankshaft for dirt or damage.





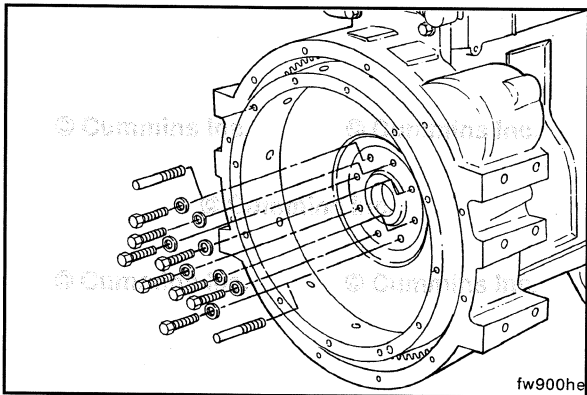


**▲ WARNING ▲**

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.



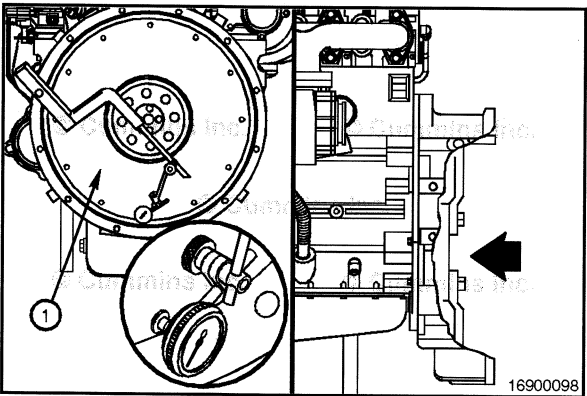
- Install the flywheel.
- Inspect the bore runout again.



- Replace the flywheel if the runout does **not** meet specifications.

**Flywheel Bore Runout**

mm		in
0.127	MAX	0.005



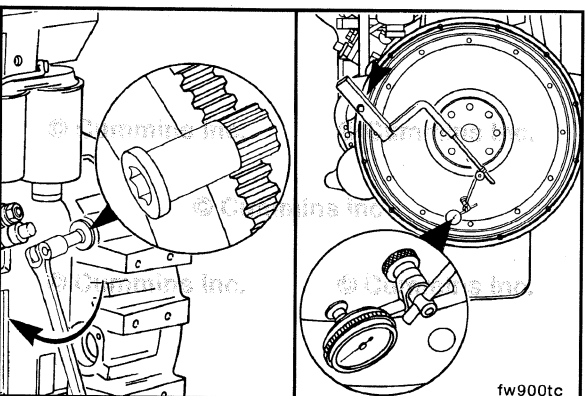
**Flywheel Face Runout**

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, Cummins® Part Number 3824591, 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 is determined by calculating the difference between the highest and lowest measurement from the four locations measured.

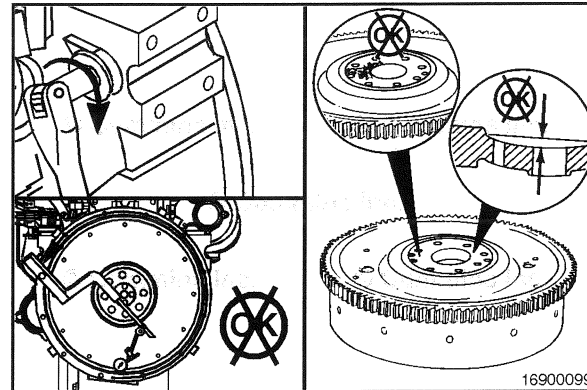
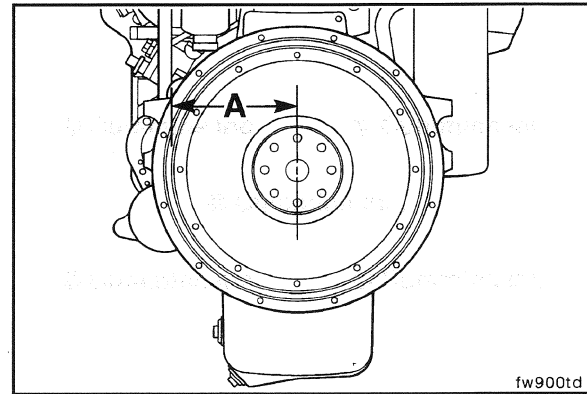
Measure the distance from the center of the flywheel to the contact tip of the indicator (A). Use this measurement to determine which specification to use from the table below.

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	0.004
127	5	0.13	0.005
152.4	6	0.156	0.006
177.8	7	0.182	0.007
203.2	8	0.208	0.008
228.6	9	0.234	0.009
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.

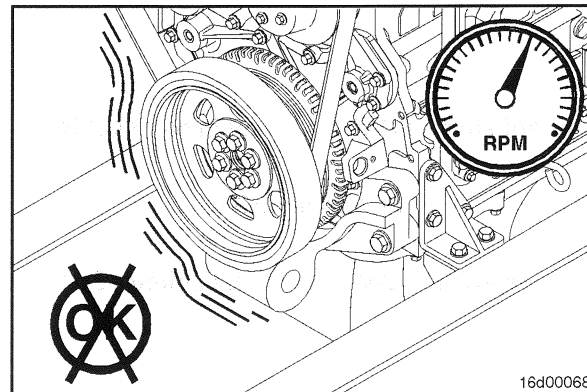


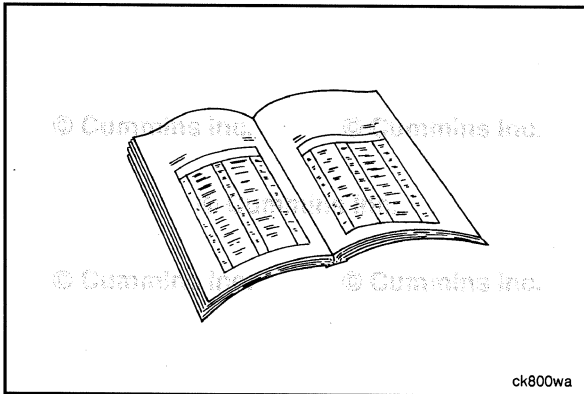
## Finishing Steps

### ⚠ 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.
- If equipped with a wet flywheel housing, fill the flywheel housing with oil. See equipment manufacturer service information.
- Connect the batteries. See equipment manufacturer service information.
- 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 cylinder head. Failure to support the engine can cause personal injury.

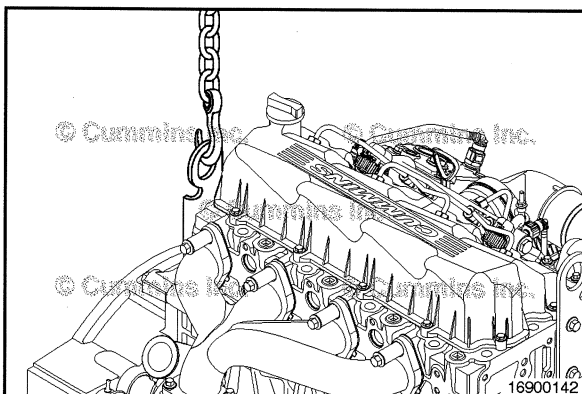
- Disconnect the batteries. See equipment manufacturer service information.
- Remove the starting motor. Refer to Procedure 013-020 in Section 13.
- Remove the transmission, clutch, and all related components, if equipped. See equipment manufacturer service information.
- Remove the flywheel/flexplate assembly. Refer to Procedure 016-005 in Section 16. Refer to Procedure 016-004 in Section 16.
- Remove the rear crankshaft seal. Refer to Procedure 001-024 in Section 1.
- Remove any OEM attached components (mufflers, shift mechanisms, air filters) to the flywheel housing. See equipment manufacturer service information.

### Remove

#### ▲ WARNING ▲

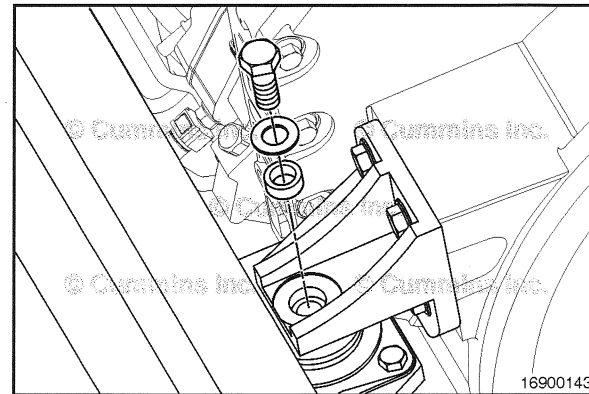
The engine lifting equipment must be designed to lift the engine and transmission as an assembly without causing personal injury.

Use a hoist or lifting fixture to support the rear of the engine.

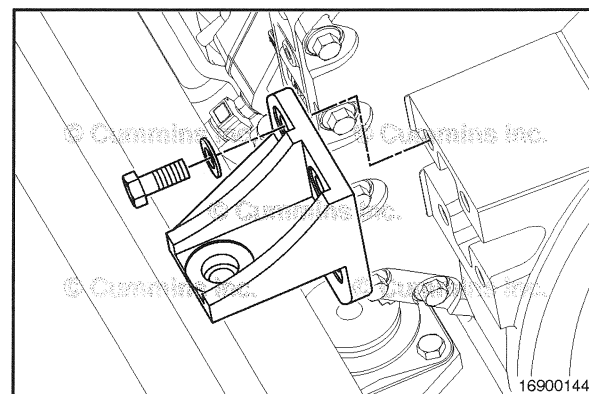


**QSF3.8 CM2350 F107**  
**Section 16 - Mounting Adaptations - Group 16**

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 ▲**

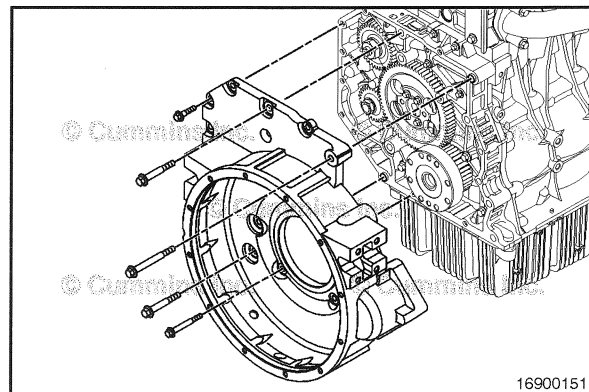
**This component or assembly weighs greater than 23 kg [50 lb]. To prevent serious personal injury, be sure to have assistance or use appropriate lifting equipment to lift this component or assembly.**

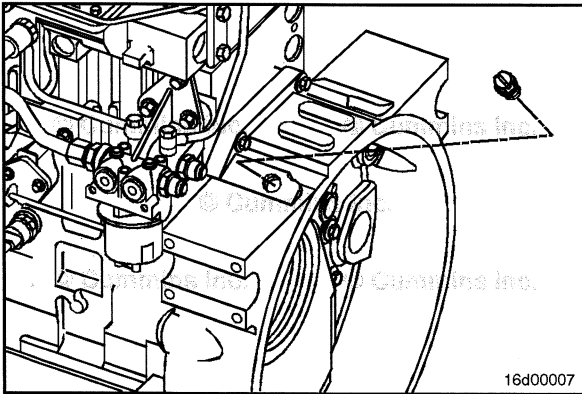
Loosen the flywheel housing capscrews, but do **not** remove.

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.

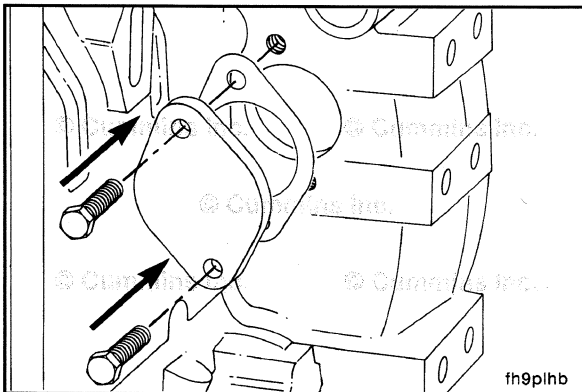
Note the location of the flywheel housing capscrews as removed. Some of the capscrews are different length/size fasteners and **must** be installed in the same location as removed.



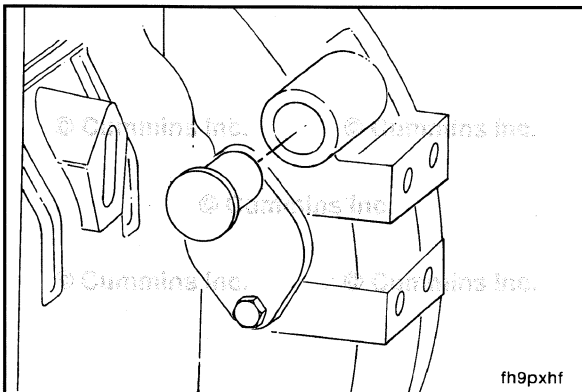


**Disassemble**

Remove and note the location of any threaded plugs in the flywheel housing.



Remove the access plate and, if equipped, the gasket.



Remove the plug from the barring gear hole.

## 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 ⚠

Compressed air used for cleaning should not exceed 207 kPa [30 psi]. Use only with protective clothing, as well as goggles/shield, and gloves 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.

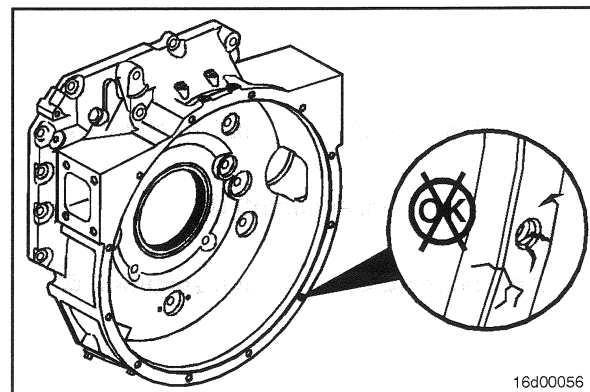
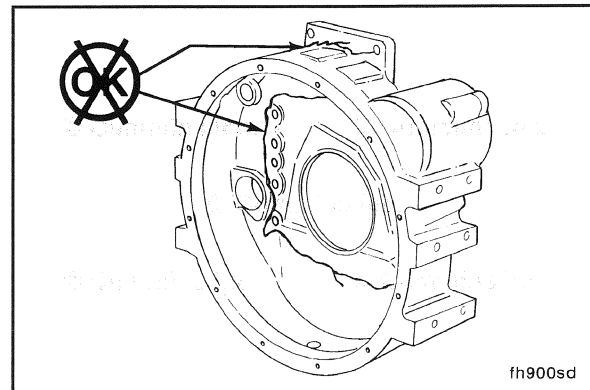
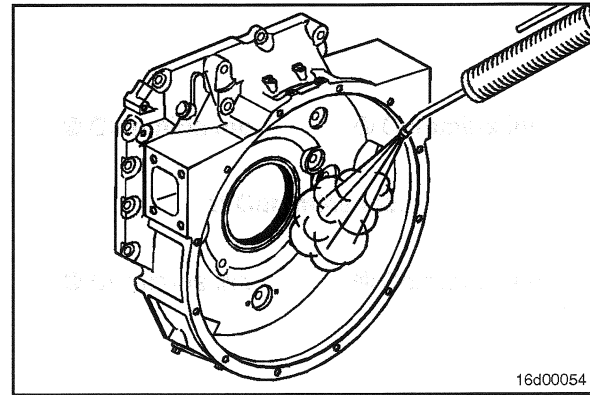
Dry with compressed air.

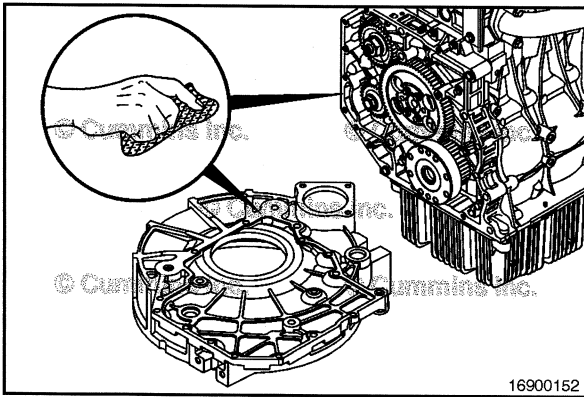
Inspect the flywheel housing for cracks, especially in the area of the flywheel housing that mounts to the cylinder block or rear gear housing.

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.



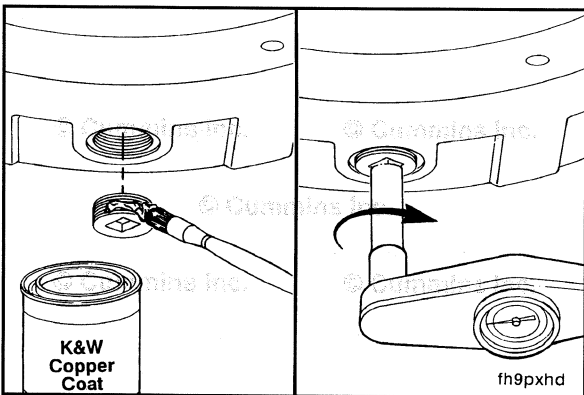


Inspect the rear face of the gear housing and flywheel housing mounting surface for cleanliness and raised nicks or burrs.



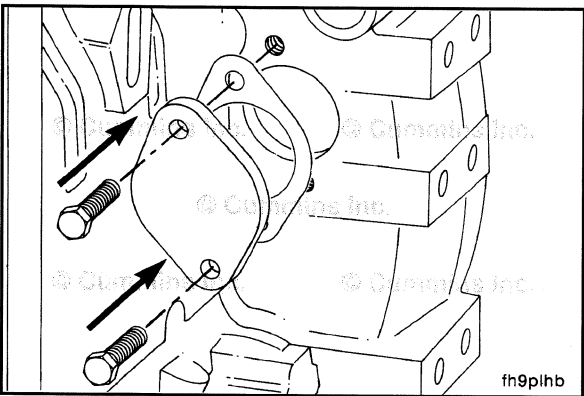
Use fine crocus cloth to remove small nicks and burrs.

Thoroughly clean the flywheel housing and gear housing mating surfaces. These surfaces **must** be clean of oil and debris.



### Assemble

Install and tighten the plugs. Refer to Procedure 017-007 in Section 17.



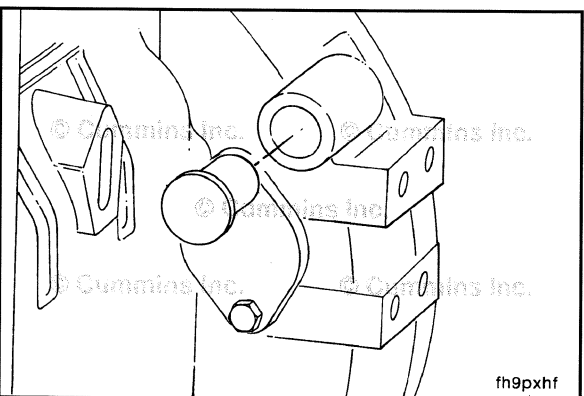
Install the access plate and new gasket.

Install the capscrews and tighten.

**Torque Value:** 24 N·m [ 212 in-lb ]



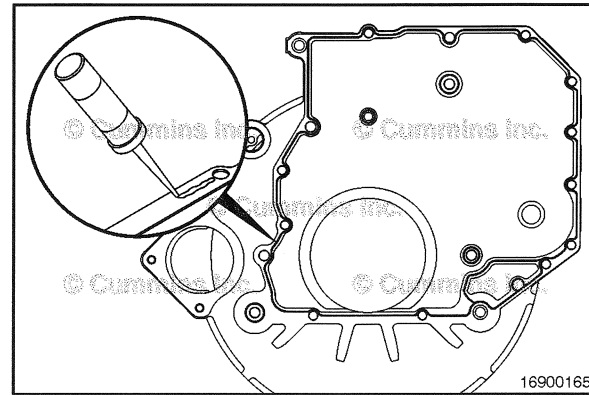
**NOTE:** If a gasket was **not** previously installed, apply sealant, Cummins® Part Number 3164067, to the perimeter of the access plate.



Install the barring gear hole plug. Use a new o-ring.

## Install

Apply a silicon bead of Loctite™ 509, or equivalent, to the flywheel mounting surface, as shown.



**NOTE:** Before installing the flywheel housing, make sure any locating dowel rings are in the same position as when the flywheel housing was removed.

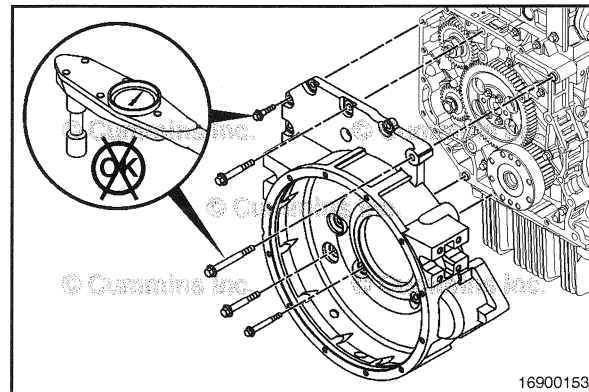


Install a new gasket between the gear housing and the flywheel housing.

Install the flywheel housing and capscrews.

Tighten the flywheel housing capscrews finger tight.

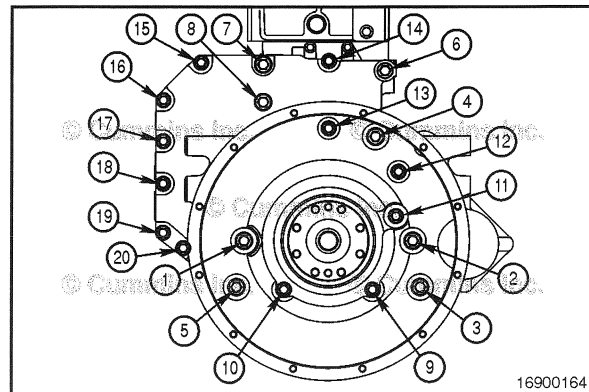
**NOTE:** Some engines are equipped with one additional capscrew **not** shown in the illustration. Tighten this capscrew last in the sequence.



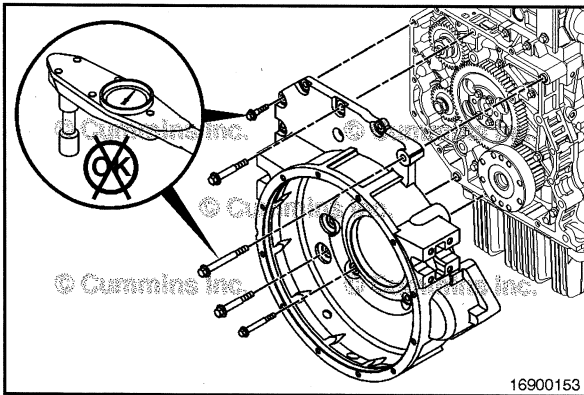
See the illustration for the flywheel housing capscrew torque sequence.

**Torque Value:**  
M10 49 N•m [ 36 ft-lb ]

**Torque Value:**  
M12 85 N•m [ 63 ft-lb ]







## Measure



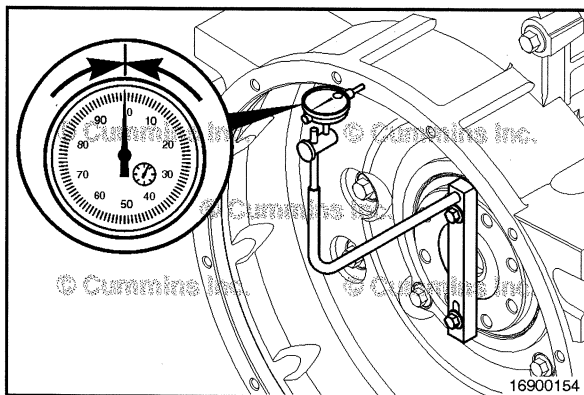
### ⚠CAUTION⚠

When barring the engine using service tool, Cummins® Part Number 3824591, 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 the flywheel housing (or rear gear housing for rear gear train engines) is being replaced or if troubleshooting a vibration/alignment issue. It is **not** necessary to measure bore alignment or face alignment when installing the original flywheel housing unless the dowel rings were removed during a previous repair.

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.



## 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.

Attach the dial indicator gauge, Cummins® Part Number 3376050, to the crankshaft. Use mounting tool, Cummins® Part Number ST1325, to attach the dial indicator to the crankshaft 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 or the indicator slips, the readings obtained will **not** be accurate.

Position the indicator at the 12-o'clock position, and zero the gauge.

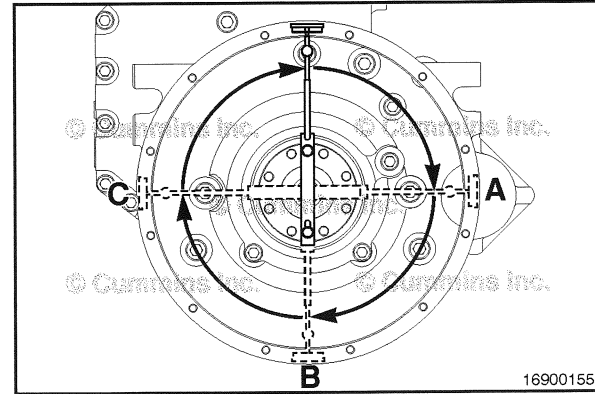
**NOTE:** The crankshaft **must** be pushed toward the front of the engine to remove the crankshaft end clearance each time a position is measured.

Use the barring tool, Cummins® Part Number 3824591, to slowly rotate the crankshaft.



Record the readings at the 3-o'clock (A), 6-o'clock (B), and 9-o'clock positions (C).

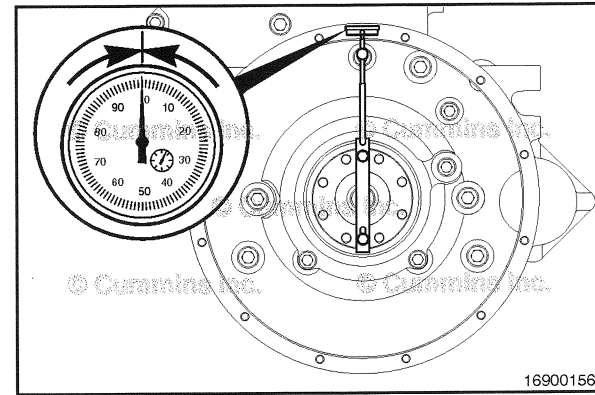
The values for A, B, and C could be positive or negative.



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.

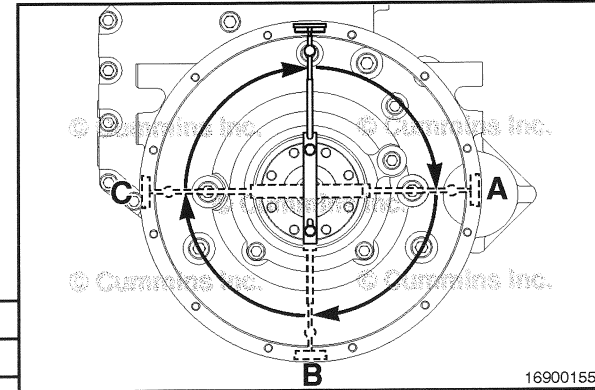


Total indicator reading is determined by calculating the difference between the highest and lowest measurement from the four locations measured.

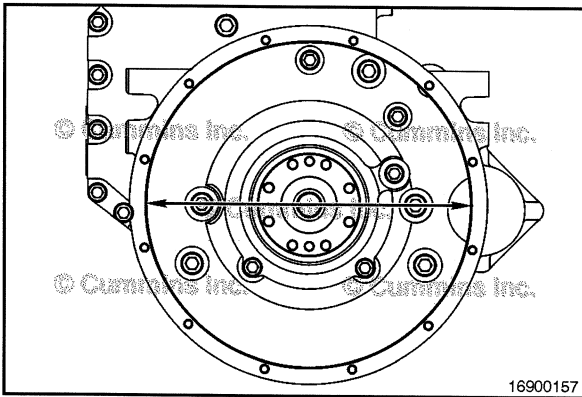
As the example below illustrates, the total indicator reading would be:

$$+0.08 \text{ mm} - (-0.05 \text{ mm}) = 0.13 \text{ mm}$$

$$[+0.003 \text{ in} - (-0.002 \text{ in}) = 0.005 \text{ in}]$$



Example:			
12 o'clock	0.00 mm		
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]	

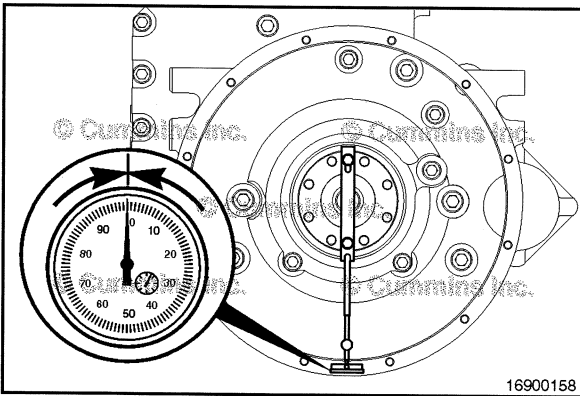


The maximum allowable total indicator reading is determined by the diameter of the housing bore. If out of specifications, replace the housing.

**NOTE:** For rear gear train engines, the rear gear housing may also be the cause of the total indicator reading being out of specification.

**Flywheel Housing Bore and Face Runout**

SAE Number	Bore Diameter	
	mm	in
00	784.15 to 784.65	30.990 to 31.010
0	657.45 to 647.95	25.490 to 25.510
1/2	584.00 to 584.40	22.992 to 23.008
1	510.98 to 511.38	20.117 to 20.133
2	447.55 to 447.81	17.620 to 17.630
3	409.45 to 409.71	16.120 to 16.130

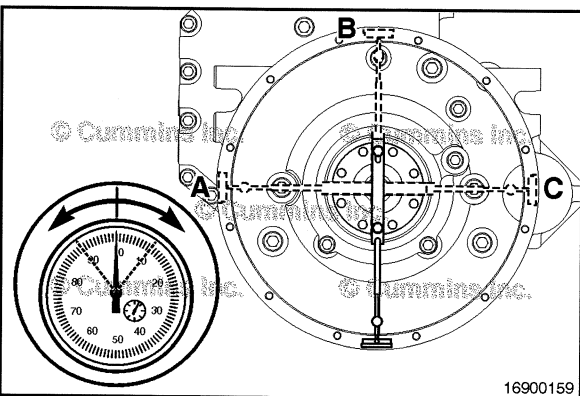


**Bore Alignment**

Attach the dial indicator gauge, Cummins® Part Number 3376050, to the crankshaft. Use mounting tool, Cummins® Part Number ST1325, to attach the dial indicator to the crankshaft 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 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.

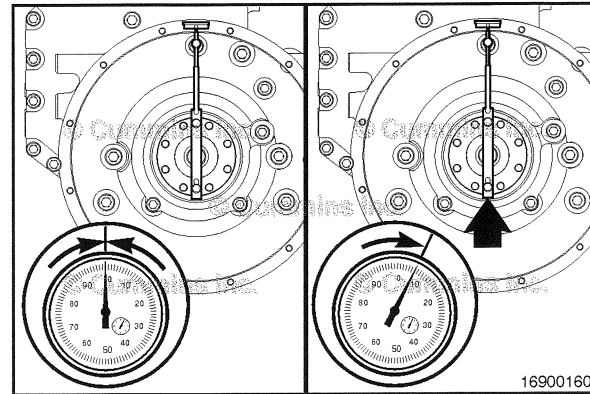
The values for A, B, and C could be positive or negative. See the illustration to determine the correct sign when recording these values.

**⚠ 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).

Example:

- Six o'clock = reference = 0
- Nine o'clock = (A) = 0.004
- Twelve o'clock = (B) = 0.003
- Three 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.

9 o'clock	a = 0.004
3 o'clock	c = -0.002
<b>Total Horizontal</b>	<b>a - c = .006</b>
12 o'clock	b = .003
<b>Bearing Clearance</b>	<b>d = .002</b>
<b>Total Vertical</b>	<b>b + d = .005</b>

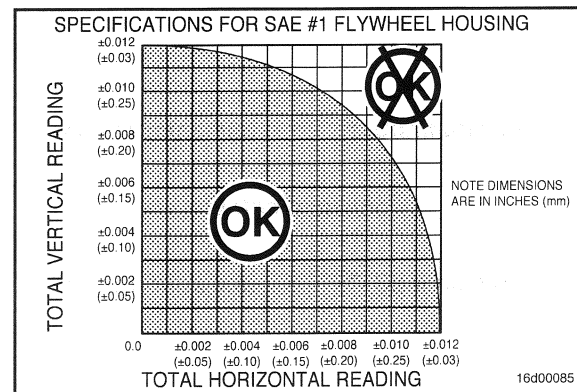
**NOTE:** Use the corresponding chart for the SAE 1, 2 or 3 flywheel housings being measured.

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 specifications for the flywheel housing being measured when comparing measurements.



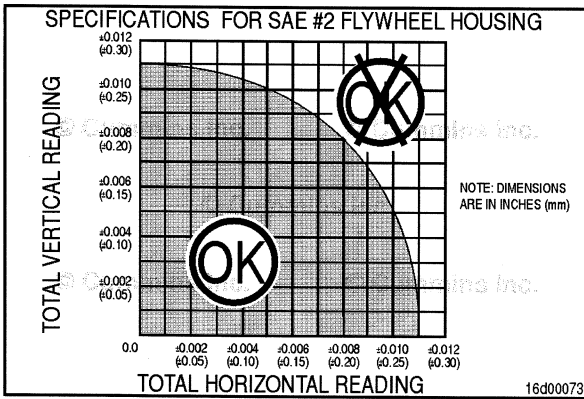


Chart for an SAE 2 flywheel housing.

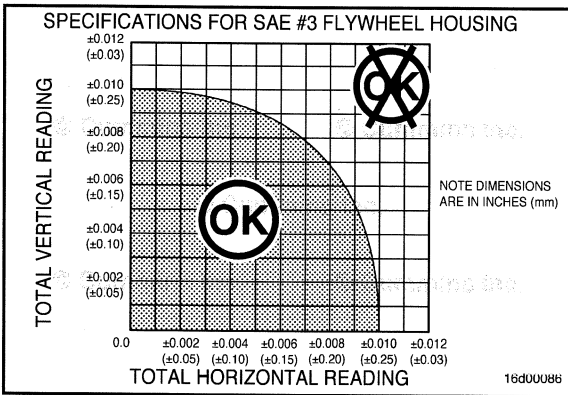
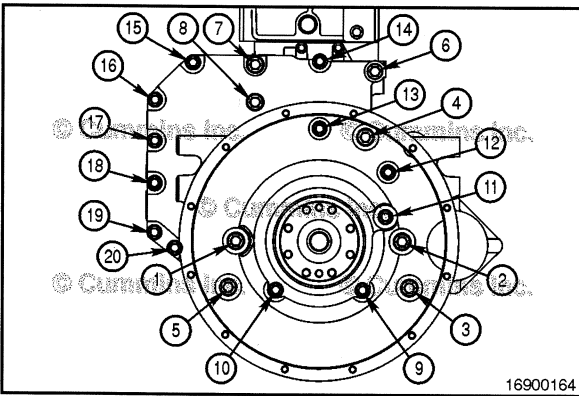


Chart for an SAE 3 flywheel housing.



**NOTE:** Some engines are equipped with one additional capscrew **not** shown in the illustration. Tighten this capscrew last in the sequence.

Tighten the capscrews in the sequence shown.

**Torque Value:**  
M10 49 N•m [ 36 ft-lb ]

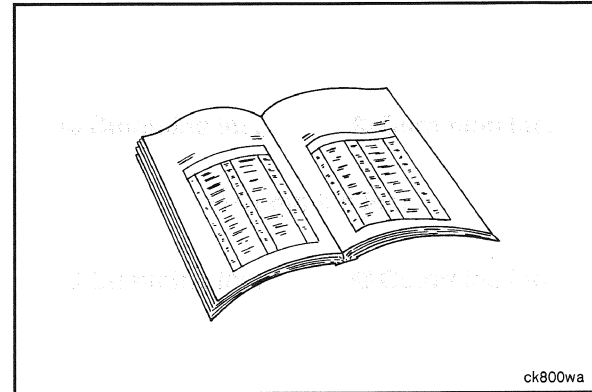
**Torque Value:**  
M12 85 N•m [ 63 ft-lb ]

## 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 rear crankshaft seal. Refer to Procedure 001-024 in Section 1.
- Install the flywheel/flexplate assembly. Refer to Procedure 016-005 in Section 16. Refer to Procedure 016-004 in Section 16.
- Install the starting motor. Refer to Procedure 013-020 in Section 13.
- Install the transmission and related components, if equipped. Refer to the OEM service manual.
- If previously removed, attach any OEM components (mufflers, shift mechanisms, air filters) to the flywheel housing. See equipment manufacturer service information.
- Connect the batteries. See equipment manufacturer service information.
- Operate the engine and check for leaks.



ck800wa

## Flywheel Ring Gear (016-008)

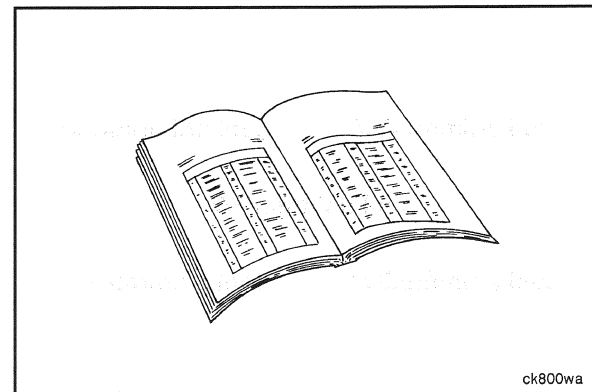
### General Information

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.

If may be necessary to replace the entire flywheel assembly.

**NOTE:** The ring gear on a flexplate is **not** replaceable. If the ring gear is damaged on a flexplate, the flexplate **must** be replaced as an assembly.



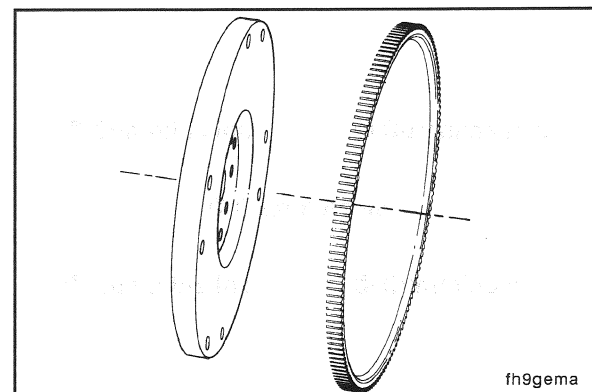
ck800wa

### Disassemble

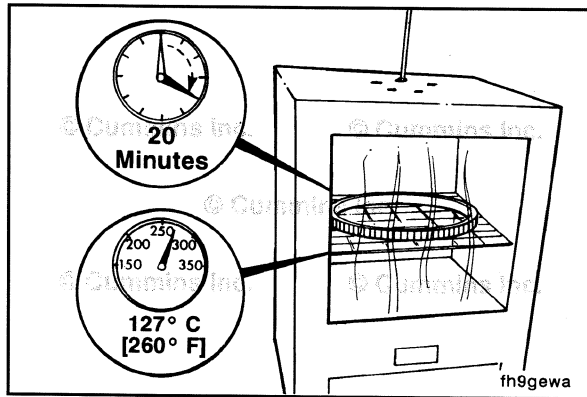
### ▲ WARNING ▲

To reduce the possibility of severe eye damage, wear eye protection when you drive the gear from the flywheel. Do not use a steel drift pin or damage to the component can occur.

Use the brass drift pin to drive the ring gear from the flywheel.

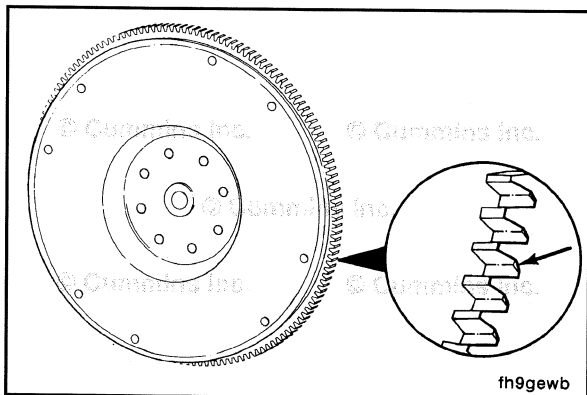


fh9gema



### Assemble

Heat the new ring gear for 20 minutes in an oven preheated to 127°C [261°F].



### ⚠ WARNING ⚠

To reduce the possibility of burns, wear protective gloves when installing the heated 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.

# Section 17 - Miscellaneous - Group 17

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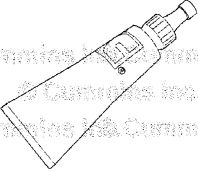

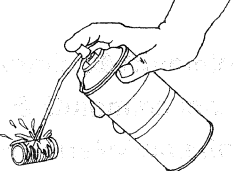
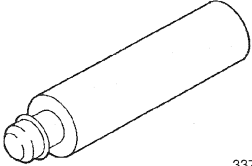
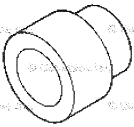
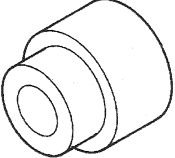


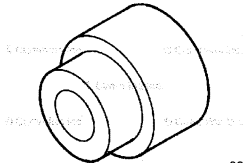
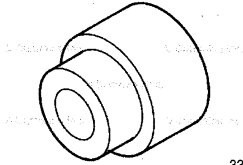
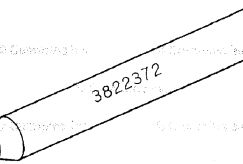
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## Service Tools

### Miscellaneous

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	<p align="center"><b>Pipe Plug Sealant</b></p> <p>Used when installing pipe plugs to reduce the possibility of leaks.</p>	 <p align="right">3375066</p>
3375068	<p align="center"><b>Cup Plug Sealant</b></p> <p>Used when installing cup plugs to reduce the possibility of leaks.</p>	 <p align="right">3375068</p>
3824510	<p align="center"><b>Quick Dry (QD™) Spray Cleaner</b></p> <p>Used to clean cup plug opening.</p>	 <p align="right">3824510</p>
3164085	<p align="center"><b>Cup Plug Driving Tools (universal handle)</b></p> <p>Required use with driver heads to install new cup plugs to their proper depth, plus avoiding damage to the cup plug and the surrounding area.</p>	 <p align="right">3164085</p>
3376816	<p align="center"><b>Cup Plug Driving Tools (driver head, 1-inch nominal)</b></p> <p>Required to install new cup plugs to their proper depth, plus avoiding damage to the cup plug and the surrounding area.</p>	 <p align="right">3376816</p>
3376817	<p align="center"><b>Cup Plug Driving Tools (driver head, 1-1/4-inch nominal)</b></p> <p>Required to install new cup plugs to their proper depth, plus avoiding damage to the cup plug and the surrounding area.</p>	 <p align="right">3376817</p>

Tool No.	Tool Description	Tool Illustration
3823520	<p><b>Cup Plug Driving Tools (driver head, 11/16-inch nominal)</b> Required to install new cup plugs to their proper depth, plus avoiding damage to the cup plug and the surrounding area.</p>	 <p>3376817</p>
3823524	<p><b>Cup Plug Driving Tools (driver head, 2-1/4-inch nominal)</b> Required to install new cup plugs to their proper depth, plus avoiding damage to the cup plug and the surrounding area.</p>	 <p>3376817</p>
3822372	<p><b>Cup Plug Driving Tools</b> Required to install new cup plugs to their proper depth, plus avoiding damage to the cup plug and the surrounding area.</p>	 <p>3822372</p>

## Cup Plug (017-002)

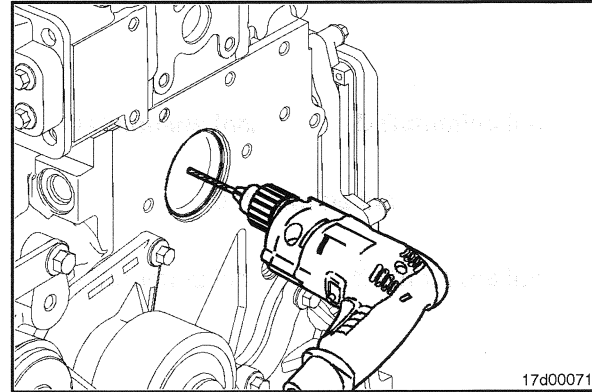
### Remove

#### ⚠ 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.

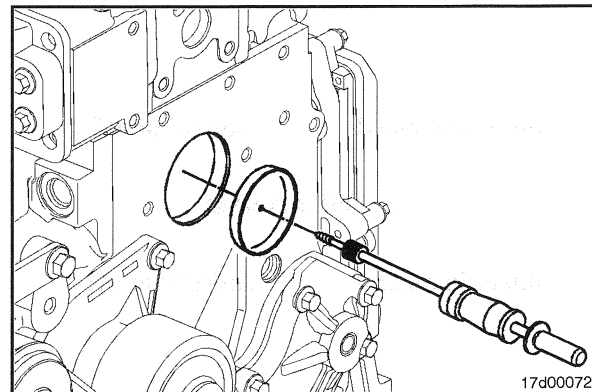
Use a center punch to mark the cup plugs for drilling.

Drill a 1/8-inch hole in the cup plug.



Use a dent puller to remove the plug.

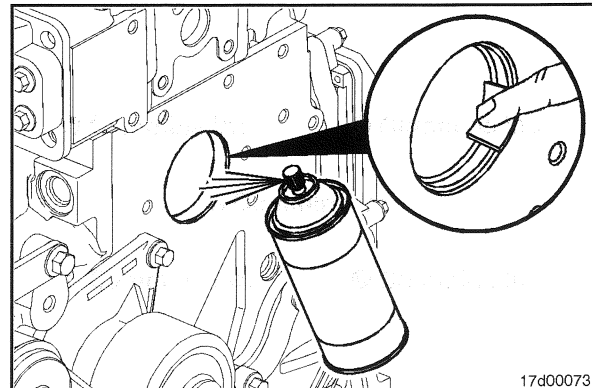
Discard all used cup plugs. Do **not** use them again.



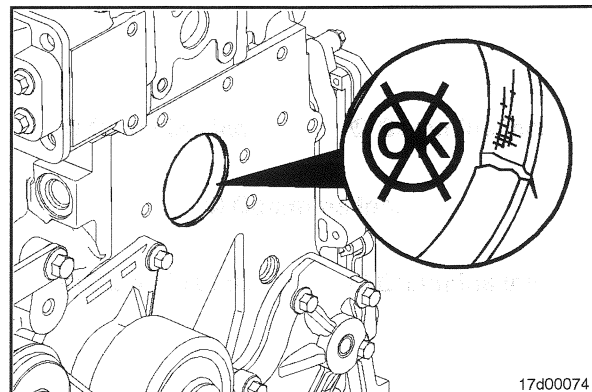
### Clean and Inspect for Reuse

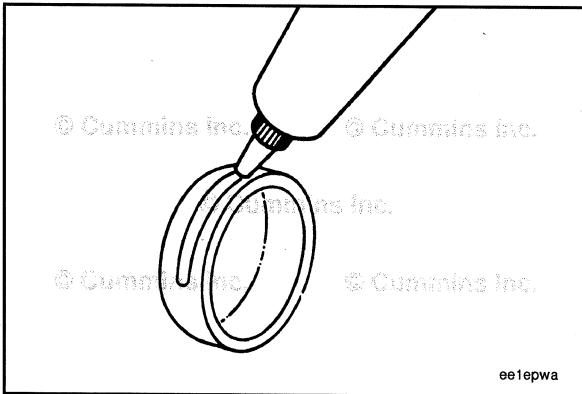
Thoroughly clean the cup plug hole, use a Scotch-Brite™ Pad, or equivalent.

Use spray cleaner, Cummins® Part Number 3375433, or equivalent, to clean the bore for the final time.



Inspect the cup plug bores for damage.





### Install

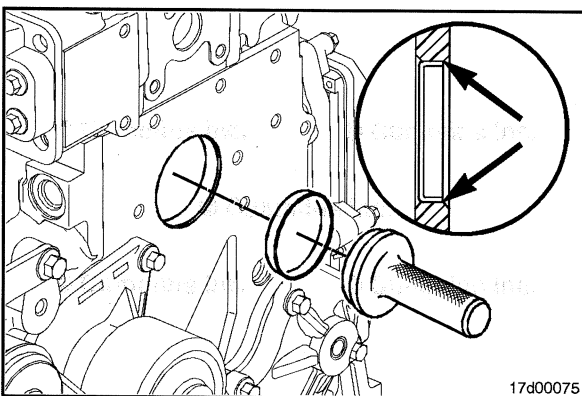


#### ⚠ CAUTION ⚠

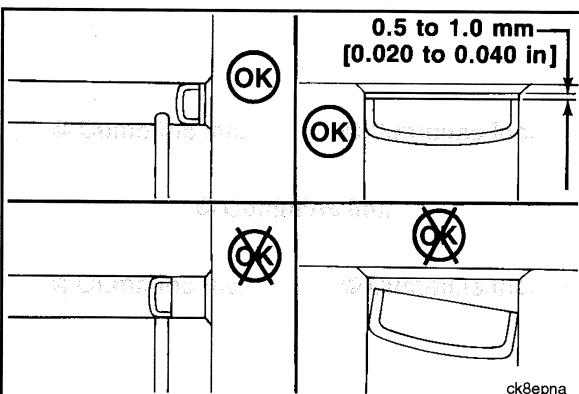
Excessive sealant can run back into the engine and cause damage to other components. Allow the sealant to dry for a minimum of 2 hours before operating the engine. The plug can come out of the bore if the sealant is not dry.

Apply a 2-mm [1/16-in] bead of cup plug sealant, Cummins® Part Number 3375068, or equivalent, to the outside circumference of the cup plug and the inside circumference of the cup plug bore.

**NOTE:** Do **not** install a used cup plug. Discard all plugs after removal.



Install the cup plug with the appropriate cup plug driver. Reference Cummins® Service Products Catalog, Bulletin 3377710.

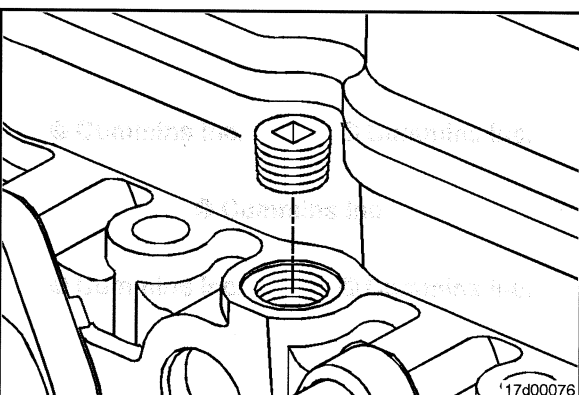


#### ⚠ CAUTION ⚠

Do not install the cup plug too deeply. If the cup plug is not installed straight and flat, it must be replaced with a new cup plug or engine damage can result.



The cup plug **must** be installed with the edge of the cup plug 0.5 to 1.0 mm [0.020 to 0.040 in] deeper than the leading chamfer of the bore.



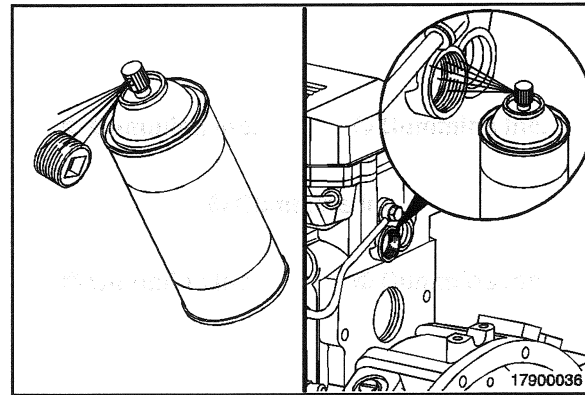
### Pipe Plug (017-007)

#### Remove

Remove the pipe plug.

### Clean

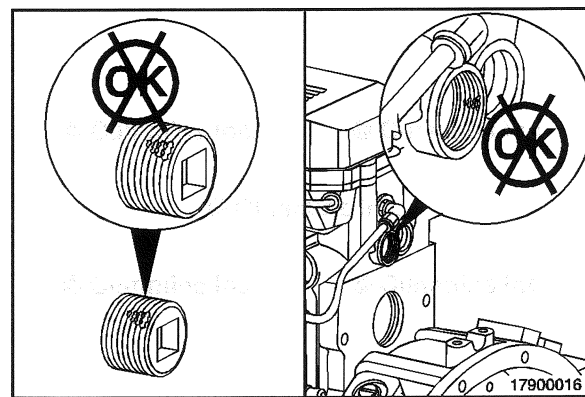
Use spray cleaner, Cummins® Part Number 3375433, or equivalent, to clean the threads of the pipe plugs and threaded bores.



### Inspect for Reuse

Inspect the threads of the pipe plugs for mutilation or damage.

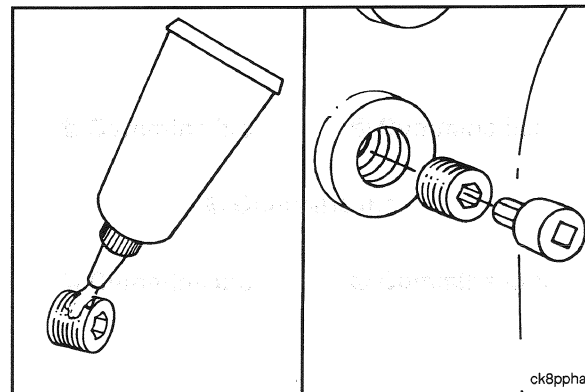
Inspect the threaded bores for damage.



### Install

Apply a film of pipe plug sealant, Cummins® Part Number 3375066, or equivalent, to the threads.

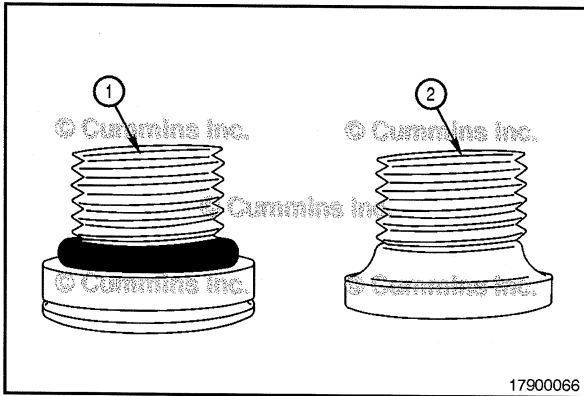
Install the pipe plugs.



Tighten the pipe plugs. Refer to the adjoining chart for the appropriate torque values.



Pipe Plug Torque Values						
Thread	Size		Torque		Torque	
	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]
1 1/4	42.2	[1.66]	75	[55]	115	[85]
1 1/2	48.3	[1.90]	85	[65]	135	[100]



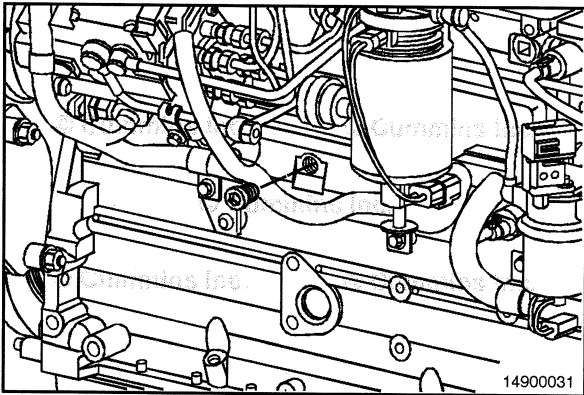
## Straight Thread Plug (017-011)

### General Information

Two types of straight thread plugs are used:

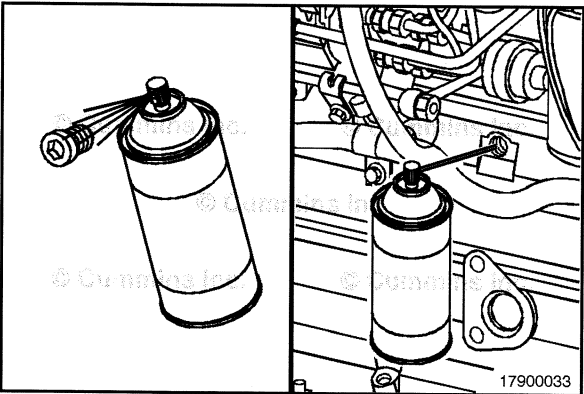
- 1 Straight thread plug with o-ring
- 2 Straight thread plug with formed in-place sealant.

The two plugs are interchangeable and reusable. The **only** difference between the two plugs is the installation torque value. See the install step of this procedure.



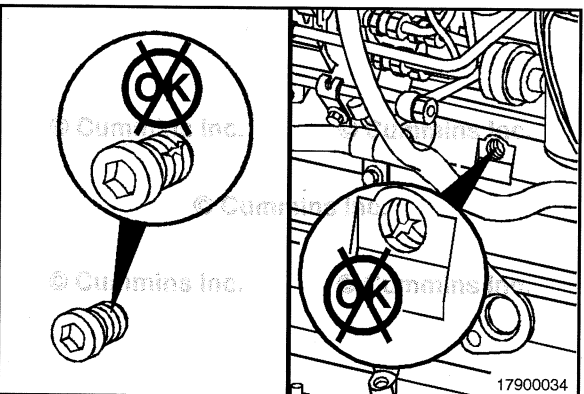
### Remove

Select the appropriate size Allen wrench or socket, and remove the plug.



### Clean and Inspect for Reuse

Use spray cleaner, Part Number 3375433, 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.

Replace the plugs, if damaged.

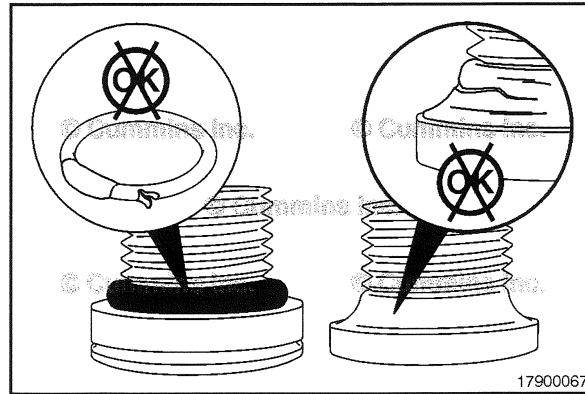
Inspect the threaded bores for damage.

Repair the bores, if necessary.

For straight thread plugs with an o-ring, inspect the o-ring for cuts, tears, or deformation. Replace the o-ring if necessary.



For straight thread plugs with formed in-place sealant, inspect the sealant for damage. If damaged, replace the entire plug.



17900067

**Install**

If equipped with a straight thread plug with o-ring, install a new o-ring on the straight-thread plug, if required.

Lubricate the o-ring with clean 15W-40 oil.

Install and tighten the plug.

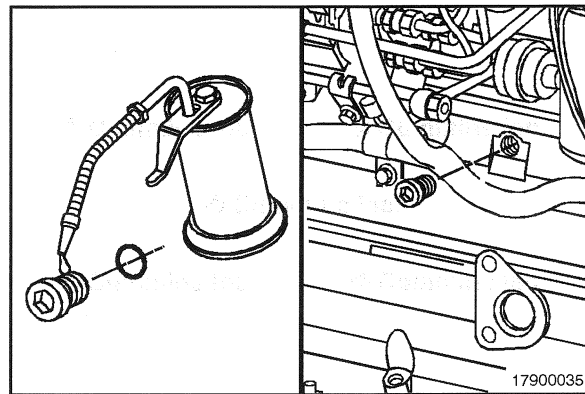
**Torque Value:**  
M10 10 N•m [ 89 in-lb ]

**Torque Value:**  
M12 20 N•m [ 177 in-lb ]

**Torque Value:**  
M14 25 N•m [ 221 in-lb ]

**Torque Value:**  
M16 35 N•m [ 25 ft-lb ]

**Torque Value:**  
M18 45 N•m [ 33 ft-lb ]



17900035

If equipped with a straight thread plug with formed in-place sealant, install and tighten the plug.

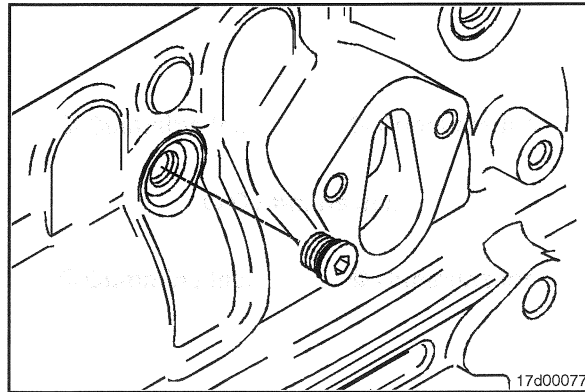
**Torque Value:**  
M10 18 N•m [ 160 in-lb ]

**Torque Value:**  
M12 25 N•m [ 221 in-lb ]

**Torque Value:**  
M14 30 N•m [ 22 ft-lb ]

**Torque Value:**  
M16 40 N•m [ 30 ft-lb ]

**Torque Value:**  
M18 50 N•m [ 37 ft-lb ]



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# Section 19 - Electronic Controls - Group 19

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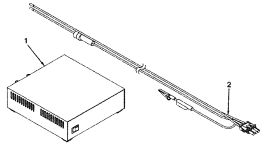
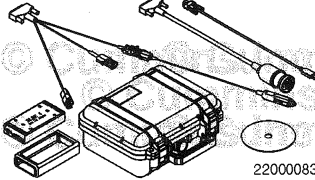
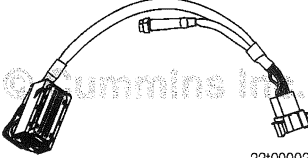
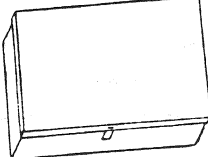
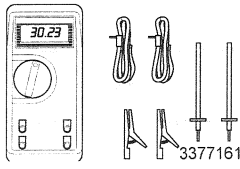
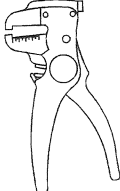


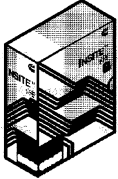
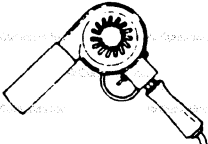
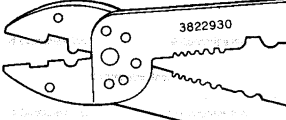
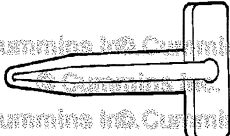


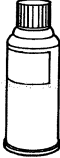
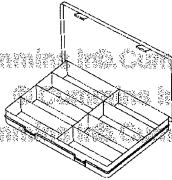
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## Service Tools

### 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
2892089	<p align="center"><b>Electrical Power Supply Kit</b></p> <p>Used with the appropriate Cummins® bench calibration cables to allow the engine control module (ECM) to be calibrated prior to being installed on the engine. (1) Part Number 2892082 - Electrical power supply (input: 120-VAC, 60 Hz, 5.5 Amp; output: 13.8-VDC, 23 Amp; includes power cable with NEMA 5-15 plug). (2) Part Number 2892084 - Electrical power cable (1.83 m [6 ft], includes 10 Ampere Time Delay Fuse).</p>	
2892092	<p align="center"><b>Data Link Adapter Kit</b></p> <p>INLINE™ 6 adapter and associated cables are used to connect a computer to an engine data link.</p>	 <p align="right">22000083</p>
2892289	<p align="center"><b>ECM Benchtop Calibration Harness Adapter</b></p> <p>Used to calibrate CM2350 engine control modules off the engine. Use with base harness, Part Number 3163151. Reference Service Tool Instruction, Bulletin 3377791, for additional information.</p>	 <p align="right">22100002</p>
2892512	<p align="center"><b>CM2350 ECM Connector Repair Kit</b></p> <p>Contains the following service tools: Pinout Connector Tool, Part Number 2892510, Test Leads (2), Part Number 3164113, Delphi Retainer Removal Tool, Part Number 4918921. Reference Service Tool Instruction, Bulletin 3400414, for additional information.</p>	
3400162	<p align="center"><b>Digital Multimeter Kit</b></p> <p>Used to test various electrical circuits. Includes Deluxe Multimeter, Part Number 3164489, Pressure Adapter, Part Number 3164491, and Immersion Probe, Part Number 3164492.</p>	 <p align="right">3377161</p>
3400045	<p align="center"><b>Wire Stripping Tool</b></p> <p>Used to remove insulation from wiring to prepare for electrical connectors.</p>	 <p align="right">SP000794</p>

Tool No.	Tool Description	Tool Illustration
3886388	<p><b>INSITE™ Electronic Service Tool Software Kit</b></p> <p>Used to troubleshoot, program, and adjust engines with electronic controlled fuel systems. Contact a Cummins® Authorized Repair Location for the latest revision.</p>	 <p>3824801</p>
3822860	<p><b>Heat Gun</b></p> <p>Used to repair connector wires.</p>	
3822930	<p><b>Wire Crimping Pliers</b></p> <p>Use to repair connector wires.</p>	 <p>3822930</p>
3824815	<p><b>Deutsch™ Terminal Removal Tool (Red)</b></p> <p>Used to remove 20 AWG terminal wires/pins from Deutsch™ connectors.</p>	 <p>3822760</p>
3822760	<p><b>Deutsch™ Terminal Removal Tool (Blue)</b></p> <p>Used to remove 16 AWG terminal wires/pins from Deutsch™ connectors.</p>	 <p>3822760</p>
3824816	<p><b>Deutsch™ Terminal Removal Tool (Yellow)</b></p> <p>Used to remove 12 AWG terminal wires/pins from Deutsch™ connectors.</p>	 <p>3822760</p>
3824510	<p><b>Electrical Contact Cleaner</b></p> <p>Used to clean electrical contacts and connectors.</p>	 <p>o18togt</p>
4919115	<p><b>Electrical Test Lead Kit</b></p> <p>Contains various test leads for testing electrical circuits. Reference Service Tool Instruction, Bulletin 3400282, for contents.</p>	 <p>22800627</p>

## 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.

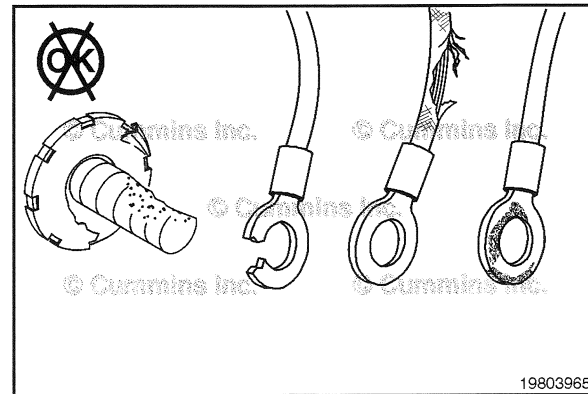
If the resistance value is **not** correct, check the batteries, cables, and cable connections.

Repair or replace the parts as required.

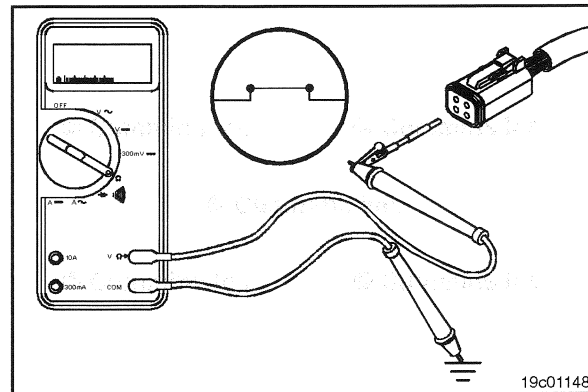
## Clutch Pedal Position Switch (019-009) General Information

The clutch pedal position switch circuit is used to disable the PTO and cruise control features.

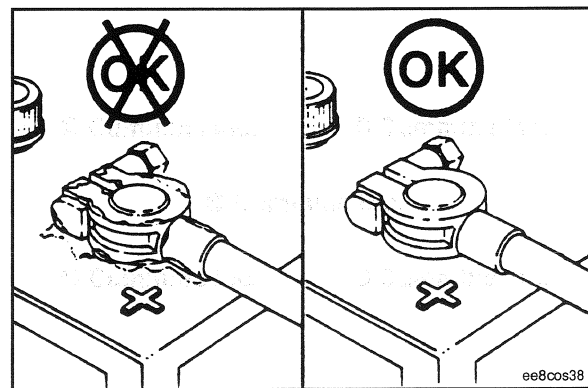
The circuit consists of an open control switch, a clutch pedal position switch signal wire, and a switch return. When the clutch pedal position switch is installed and adjusted, the contact points are held closed. When the clutch pedal is depressed, the clutch pedal position switch is in its normally open position. This will disable the PTO or cruise control operation.



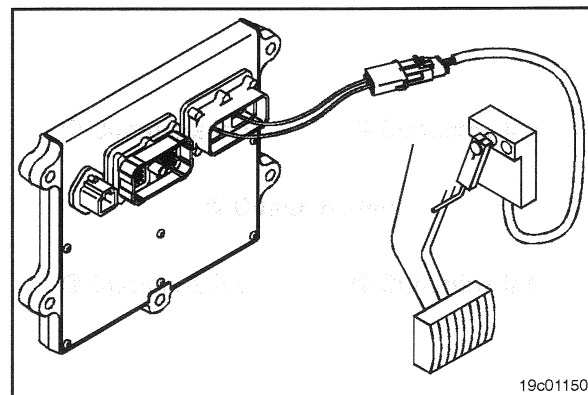
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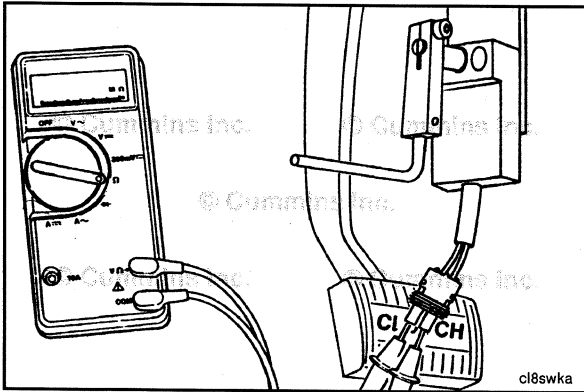
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### Resistance Check

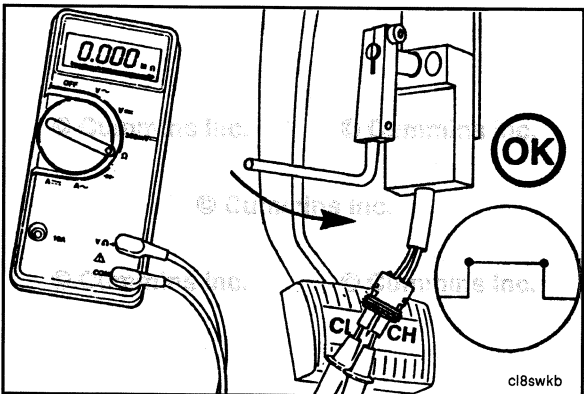
If INSITE™ is available, monitor the clutch switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

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.



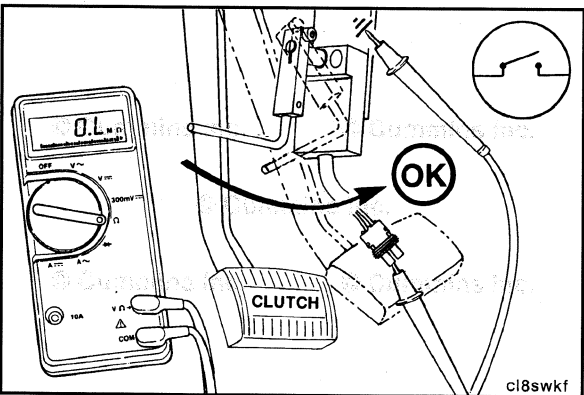
Release the clutch pedal. The multimeter **must** show a closed circuit (10 ohms or less).

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.

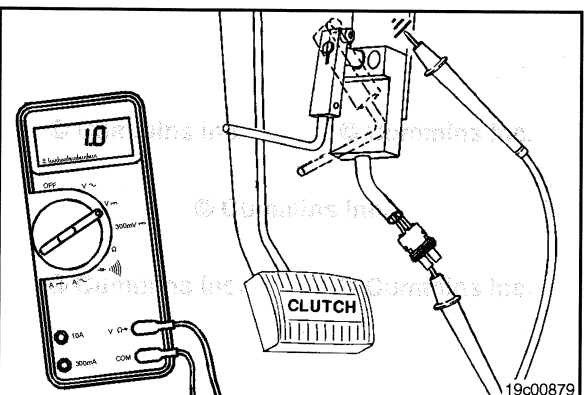


### Check for Short Circuit to Ground

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.

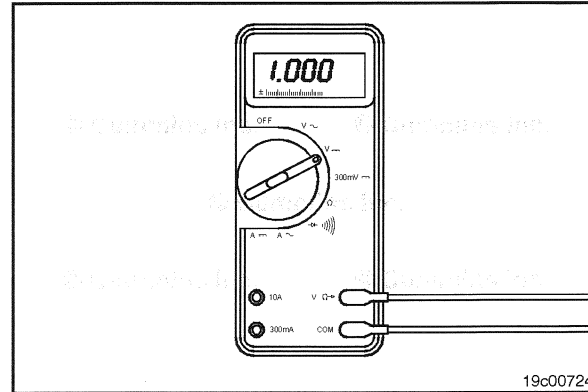


If the voltage value is more than 1.5 VDC, there is a short circuit to an external voltage source.

**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.



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## 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.

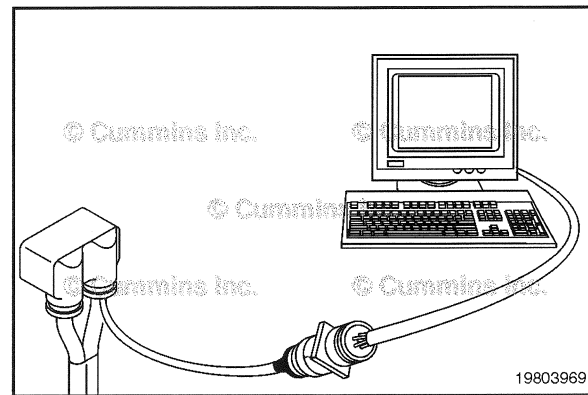
If INSITE™ electronic service tool is available, monitor the clutch pedal position switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.

Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

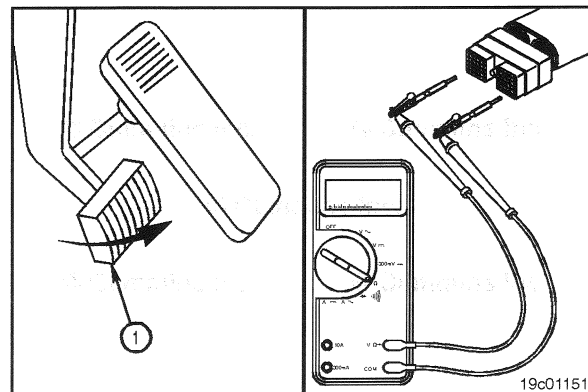
Insert a test lead into the clutch pedal position switch return pin depending on the OEM application of the OEM connector. Insert the other test lead into the clutch pedal position switch signal pin of the OEM connector.

Connect the alligator clips to the two probes of the multimeter. Adjust the multimeter to measure resistance.

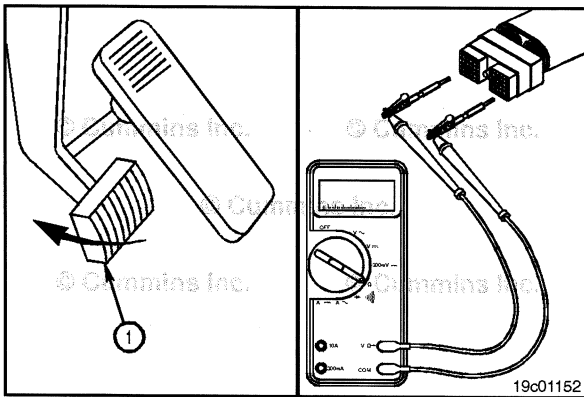
The multimeter **must** show a closed circuit (10 ohms or less) when the clutch pedal (1) is released.



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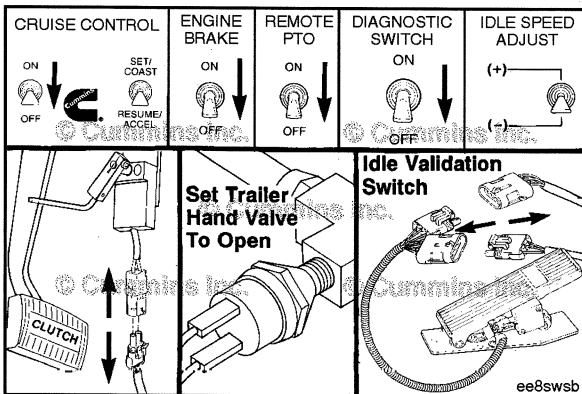


19c01151



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.



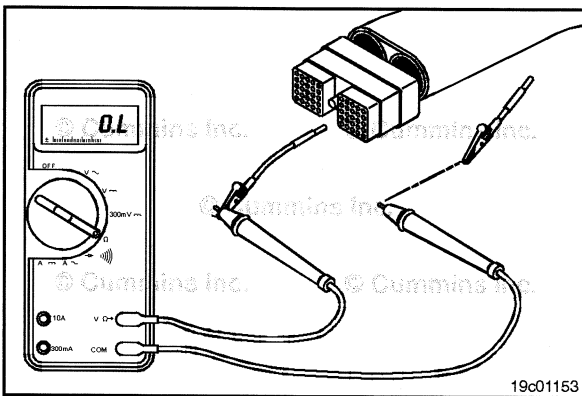
### Check for Short Circuit to Ground

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.



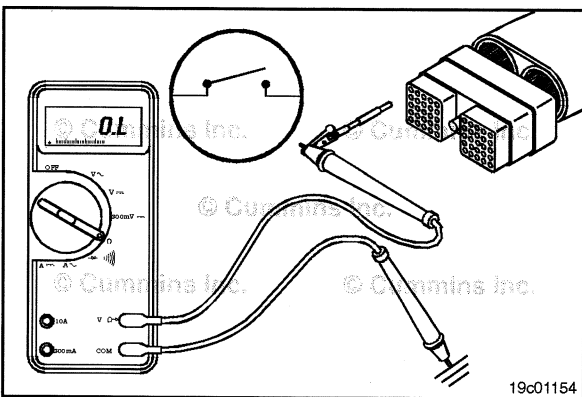
Set the service brake using the trailer brake hand valve.

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.

### 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.

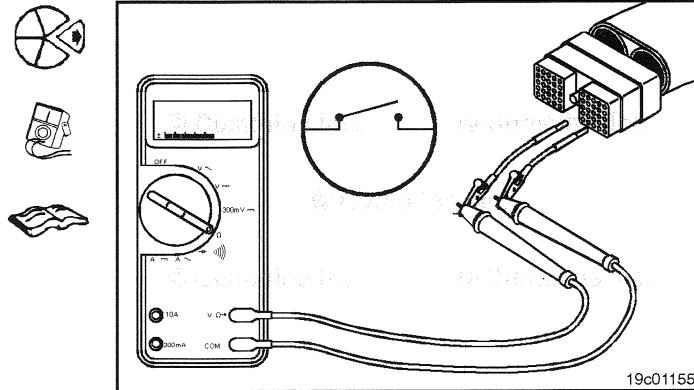
Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

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.

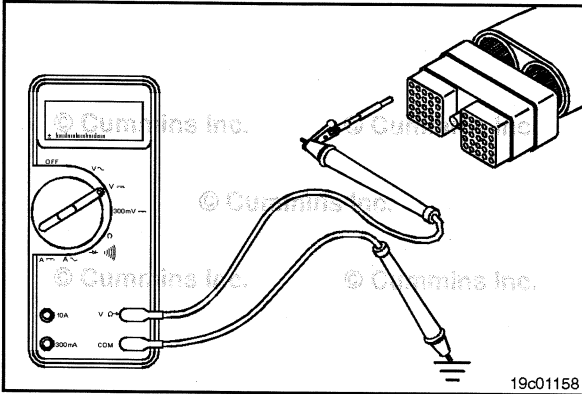
If the circuit is **not** open, there is a short circuit between the wire connected to the clutch pedal position switch signal pin and any pin that shows a closed circuit. Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

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.



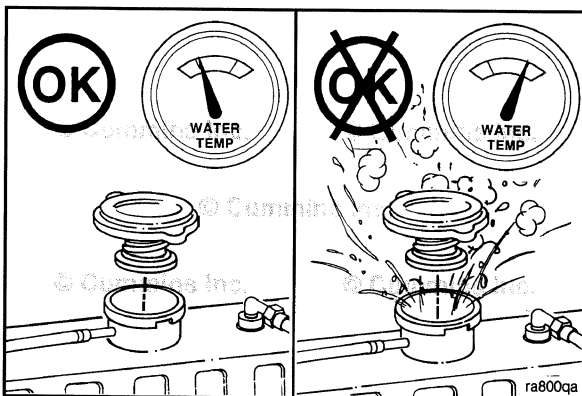
Insert test lead connected to the positive multimeter probe into the clutch pedal position switch signal pin. Disconnect the negative multimeter probe from the test lead and touch it to the engine block ground. Measure the voltage. The voltage **must** be 1.5 VDC or less.

**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.

### Initial Check

#### Three Wire Sensor OEM Harness and Engine Control Module Check

#### ⚠ CAUTION ⚠

The engine coolant level sensor can be damaged when removed. It should not be removed unless it is being replaced. Leave the engine coolant level sensor installed during the functional test.

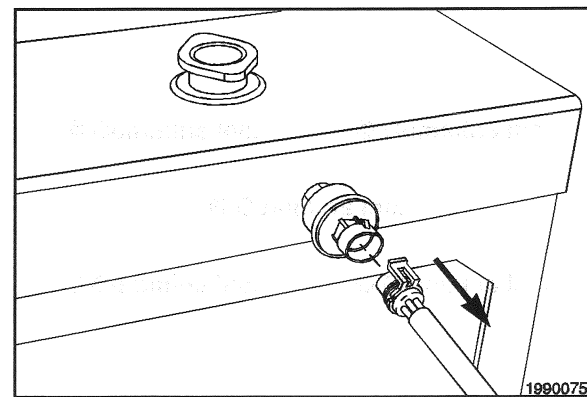
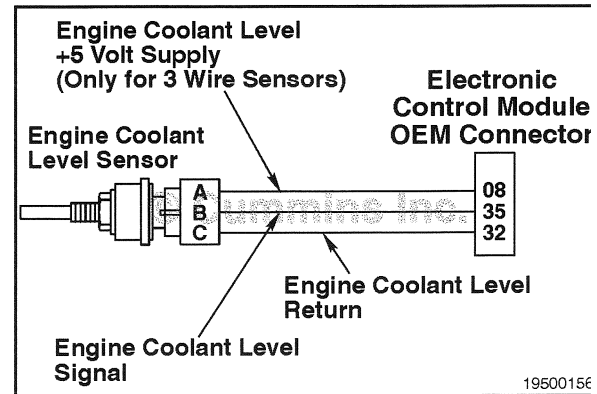
Verify there are no fault codes present. If Fault Codes 195, 196, 1695, 1696, or any other fault codes are present, troubleshoot the fault codes in section TF.

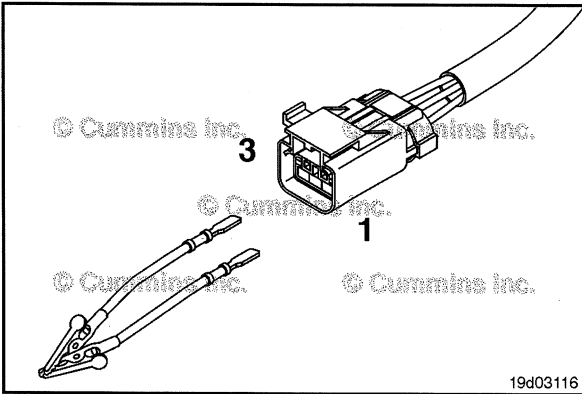
Inspect the original equipment manufacturer (OEM) harness and engine coolant level sensor connector pins for the following:

- Loose connector
- Corroded pins
- Bent or broken pins
- Pushed back or expanded pins
- Moisture in or on the connector
- Missing or damaged connector seals
- Dirt or debris in or on the connector pins
- Connector shell broken
- Wire insulation damage
- Damaged connector locking tab.

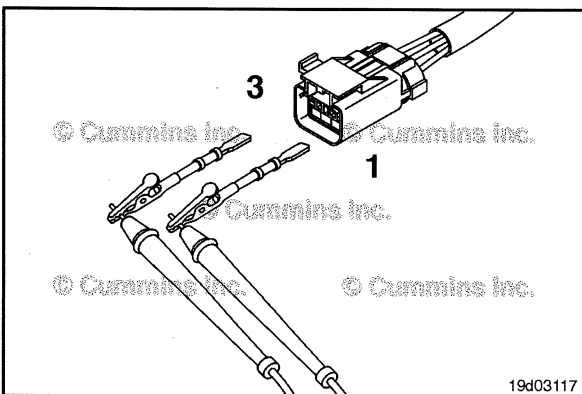
Use the following procedure for general inspection techniques. Refer to Procedure 019-361 in Section 19.

Turn keyswitch OFF, then lift up on the locking tab and pull the electrical connectors for the coolant level sensor apart from the OEM harness. With the engine coolant level sensor disconnected from the OEM harness, key ON, wait 30 seconds and check for active Fault Code 195. If Fault Code 195 is **not** active, there is a problem with either the OEM harness or the engine control module (ECM). Troubleshoot the OEM harness and the ECM as detailed below.

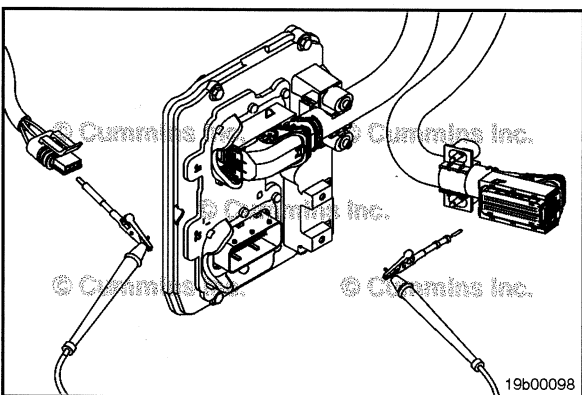




With the OEM wiring harness disconnected from the coolant level sensor, place a jumper wire between the engine coolant level sensor SIGNAL pin and the engine coolant level sensor RETURN pin at the engine coolant level sensor connector of the OEM harness. Check for active Fault Code 196. If Fault Code 196 is **not** active, there is a problem with either the OEM harness or the ECM. Troubleshoot the OEM harness and the ECM as detailed below. If unplugging the sensor causes an active Fault Code 195 and placing a jumper wire between the SIGNAL pin and the RETURN pin on the OEM harness causes an active Fault Code 196, the ECM and OEM harness are both functioning properly and further troubleshooting for the harness and the ECM can be skipped.



With the engine coolant level sensor disconnected from the OEM harness, keyswitch ON, measure the voltage between the engine coolant level SUPPLY pin and the engine coolant level RETURN pin at the engine coolant level sensor connector of the OEM harness. If this measurement is **not** between 4.75 to 5.25-VDC, there is a problem with either the OEM harness or the ECM. Troubleshoot the OEM harness and the ECM in the next step.

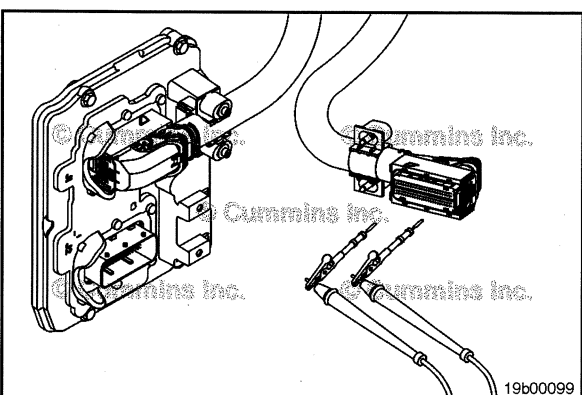


Check for continuity in the OEM wiring harness for the engine coolant level sensor SUPPLY, SIGNAL, and RETURN wires. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in section 19.



Repair or replace the OEM harness as needed. Refer to Procedure 019-071 in Section 19.

If the resistance for the engine coolant level sensor SUPPLY, SIGNAL, and/or RETURN wires is greater than 10 ohms, repair or replace the OEM wiring harness. Refer to Procedure 019-071 in Section 19.



Check for a short between the engine coolant level sensor SUPPLY, SIGNAL, and RETURN wires and all other wires in the OEM wiring harness. If the resistance measured is less than 100k ohms, repair or replace the OEM wiring harness. Refer to Procedure 019-071 in Section 19.



If a problem exists with the ECM, replace the ECM. Refer to Procedure 019-031 in Section 19.

## Test

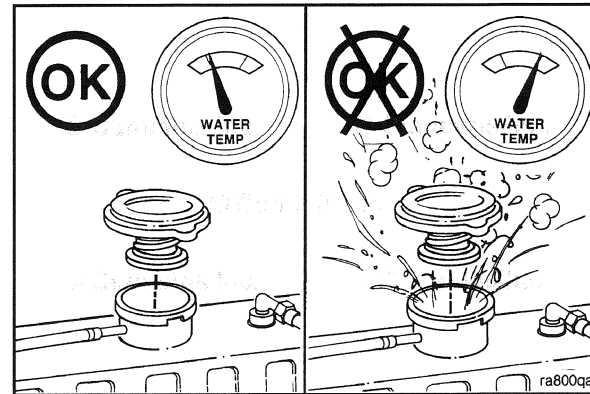
### ⚠CAUTION⚠

The engine coolant level sensor can be damaged when removed. It should not be removed unless it is being replaced. Leave the engine coolant level sensor installed during the functional test.

First check the function of the ECM and the OEM wiring harness. Reference the Three Wire Sensor OEM Harness and ECM Initial Check section.

With coolant full, above coolant level sensor, keyswitch ON, wait 30 seconds, and check for active Fault Codes 197 and/or 2448. If these fault codes become active, a damaged engine coolant level sensor has been detected and needs to be replaced. Reference the Remove and Install sections in this procedure.

Drain the coolant level below the engine coolant level sensor. Reference the Preparatory Steps section in this procedure. keyswitch ON, wait for 60 seconds, and check to see if Fault Codes 197 and/or 2448 become active. If Fault Codes 197 and/or 2448 do **not** become active, a damaged engine coolant level sensor has been detected and needs to be replaced. Reference the Remove and Install sections in this procedure.



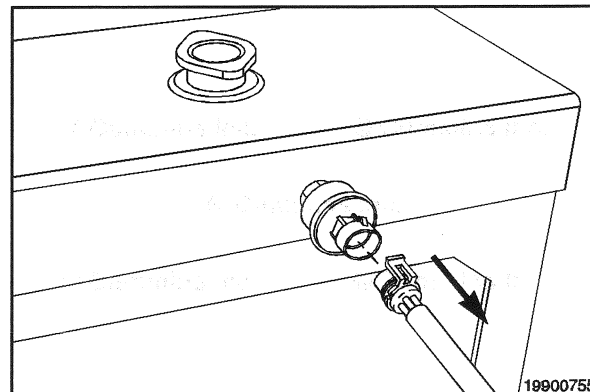
## Remove

### ⚠CAUTION⚠

The engine coolant level sensor can be damaged when removed. It should not be removed unless it is being replaced. Leave the engine coolant level sensor installed during the functional test.

Lift up on the locking tab and pull the electrical connectors apart.

Remove the sensor.



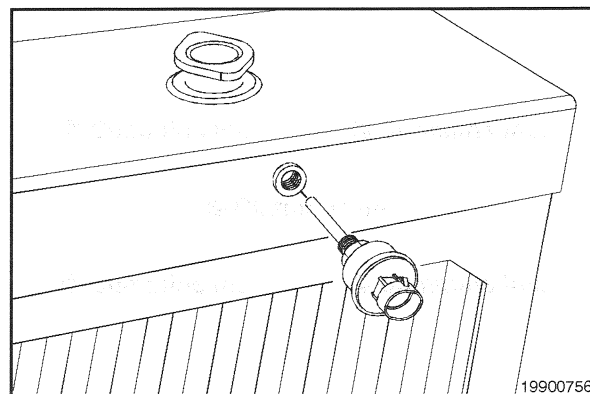
## Install

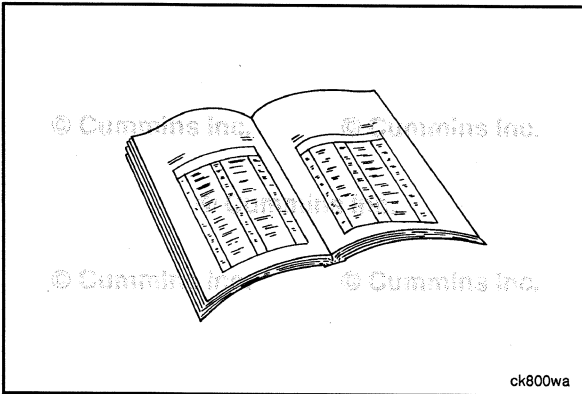
### ⚠CAUTION⚠

The engine coolant level sensor can be damaged when removed. It should not be removed unless it is being replaced. Leave the engine coolant level sensor installed during the functional test.

Install and tighten the new sensor according to the vehicle manufacturer's instructions.

Push the electrical connectors together until they lock.

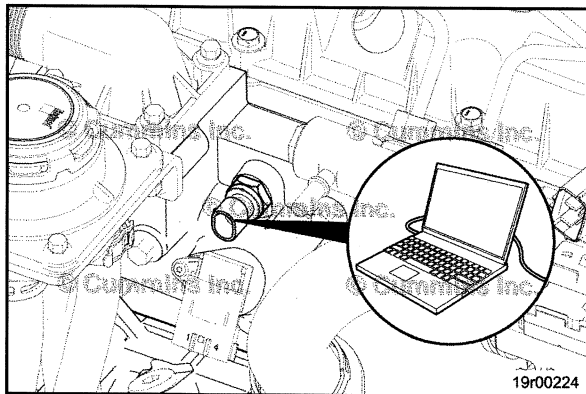




### Finishing Steps



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

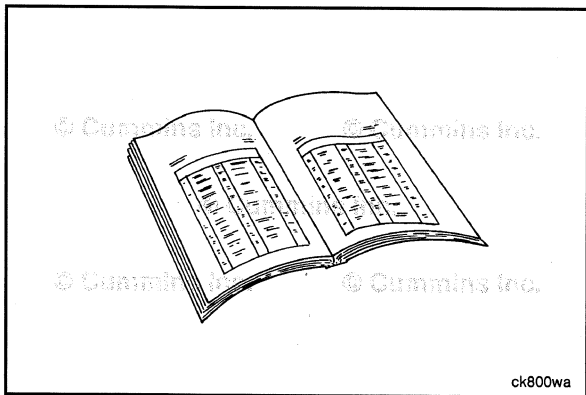


## Engine Coolant Temperature Sensor (019-019)

### Initial Check

The engine coolant temperature sensor is located in the intake manifold near the coolant outlet connection.

Connect INSITE™ electronic service tool and verify the coolant temperature reading is the same on INSITE™ electronic service tool as the gauging reading.



### Preparatory Steps



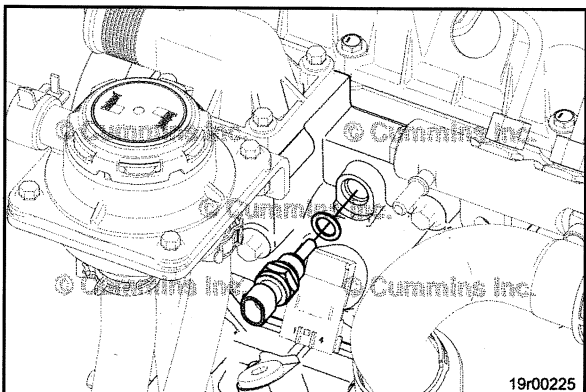
#### ▲ WARNING ▲

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

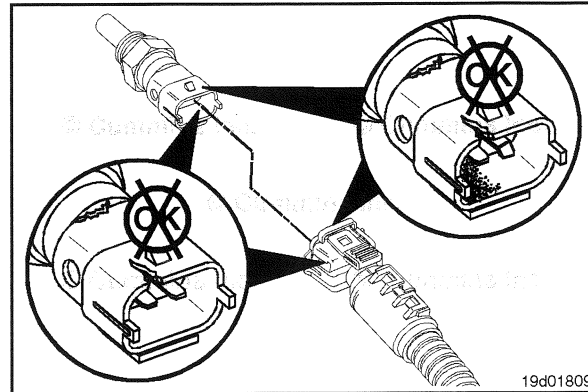
Lift up on the locking tab and pull the electrical connectors apart.

Remove the sensor.

### Inspect for Reuse

Inspect the engine harness connector and coolant 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.

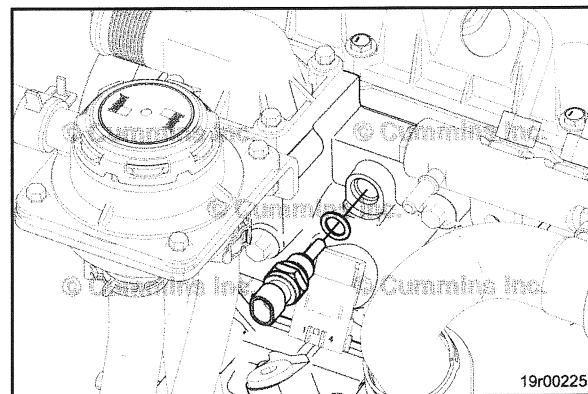


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### Install

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.  
Push the connectors together until they lock.

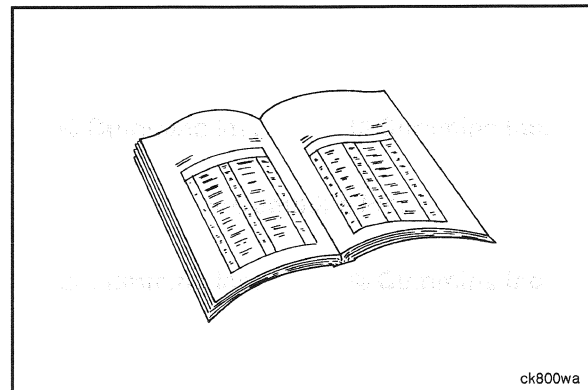
**Torque Value:** 20 N•m [ 177 in-lb ]



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### Finishing Steps

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

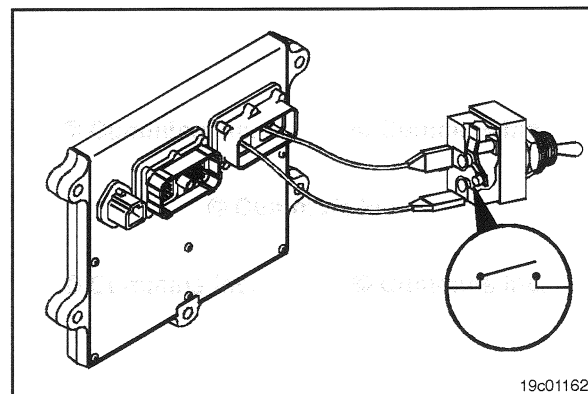


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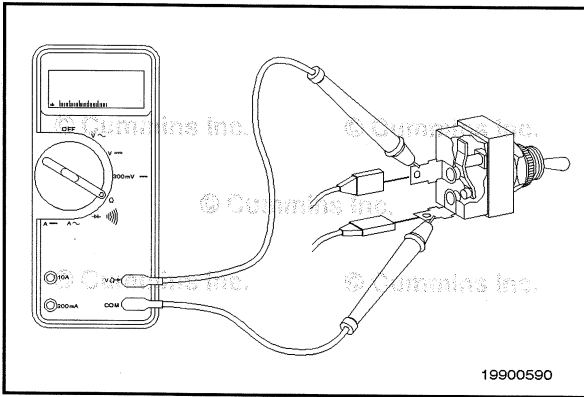
### Cruise Control or PTO ON/OFF Switch (019-021)

#### 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.



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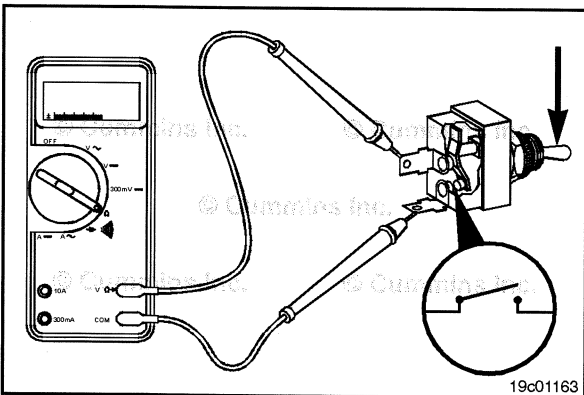


### Resistance Check



If INSITE™ is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

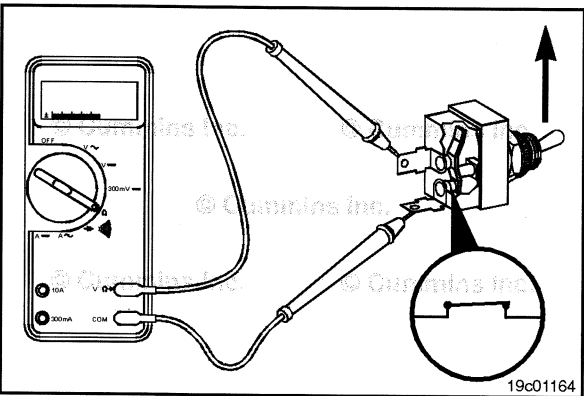
Locate the desired ON/OFF toggle switch. Remove and tag the two connectors from the terminals on the switch. Touch the multimeter probes to the terminals on the switch.



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.

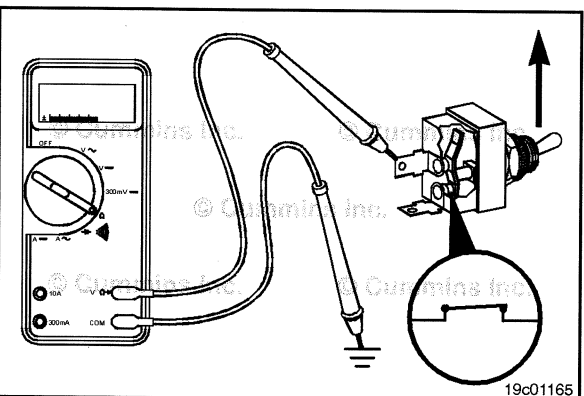


Move the switch to the ON position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).



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.

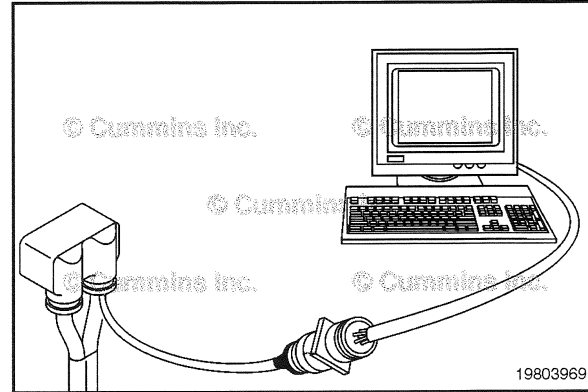
## Cruise Control or PTO ON/OFF Switch Circuit (019-022)

### 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.

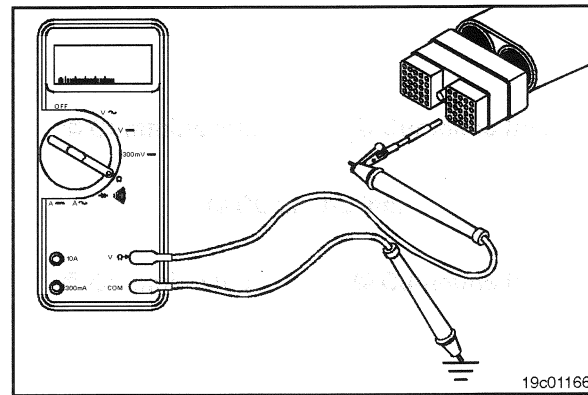
If INSITE™ electronic service tool is available, monitor the switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).



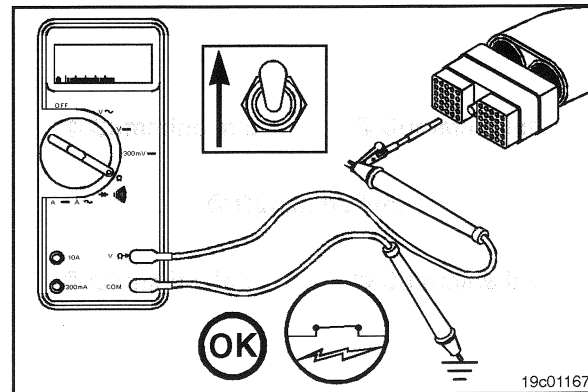
Insert the test lead into the cruise control ON/OFF switch signal pin of the original equipment manufacturer (OEM) harness connector and attach it to the multimeter probe. Touch the other probe to the engine block ground.



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.



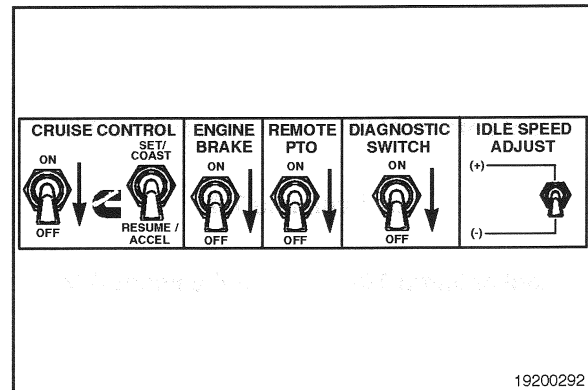
### Check for Short Circuit to Ground



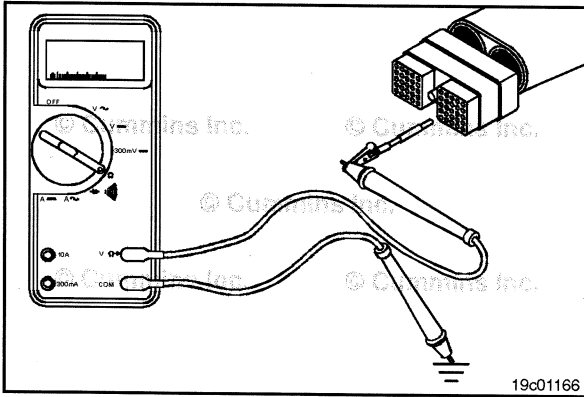
To isolate the cruise control circuit when checking for a short circuit, disconnect the OEM harness connector from the ECM and the OEM harness from the cruise control switch.

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.





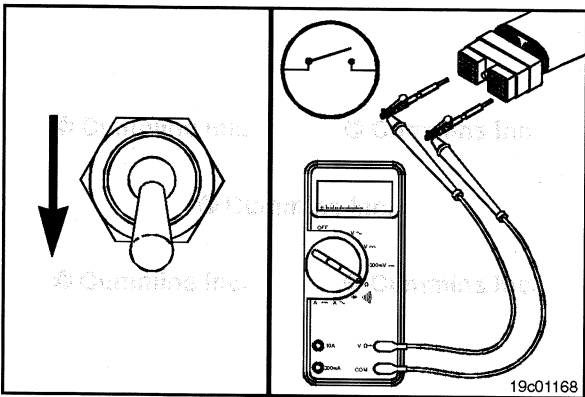


Adjust the multimeter to measure resistance. Insert a test lead into the cruise control ON/OFF switch input of the OEM harness connector and attach it to a multimeter probe. Remove the other multimeter probe from the alligator clip and touch it to the engine block ground.

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.

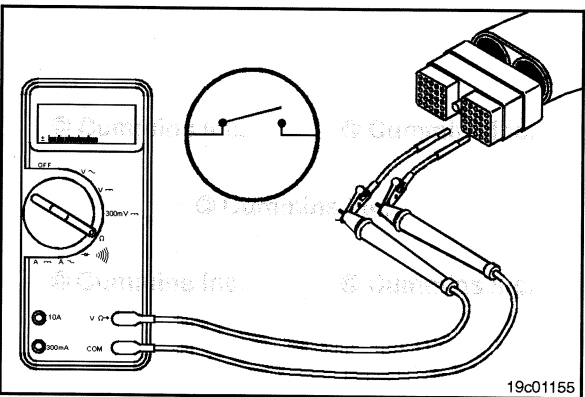
Repair or replace the wire connected to the cruise control ON/OFF switch input in the OEM harness according to the vehicle manufacturer's procedures.



### 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.

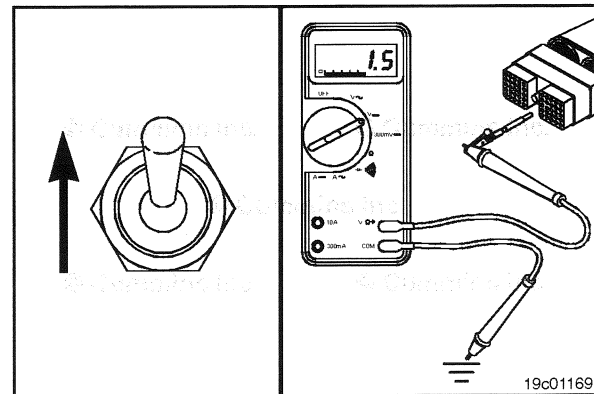
Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

### 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.

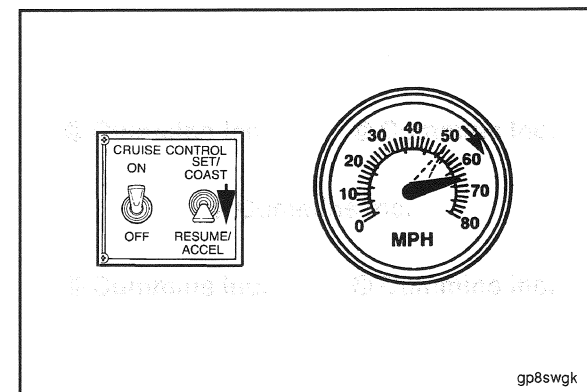
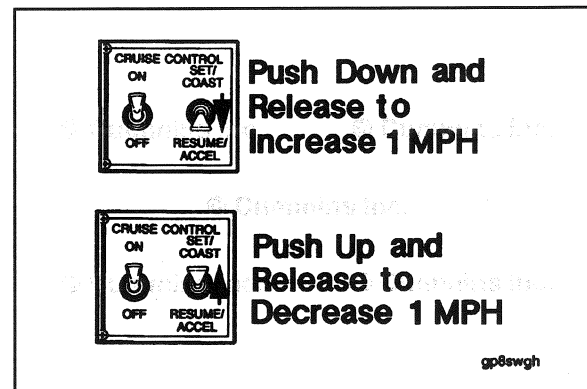
The switch can be used for: Cruise Control SET/COAST and RESUME/ACCEL, PTO INCREASE/DECREASE, IDLE INCREASE/DECREASE, ROAD SPEED GOVERNOR INCREASE/DECREASE, DIAGNOSTIC FAULT CODE INCREASE/DECREASE. For additional information, see Section F.

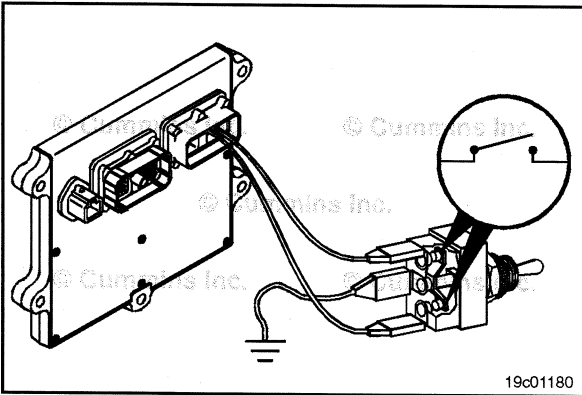
The operator can set the vehicle cruising speed when the switch is in the SET/COAST position. The SET/COAST position can also be used to reduce the vehicle cruising speed. Hold the switch in the SET/COAST position and the vehicle will coast down to a lower speed. When the select switch is released, the cruising speed will be reset.

**NOTE:** Some OEM's have switches labeled SET/ACCEL and RESUME/COAST.

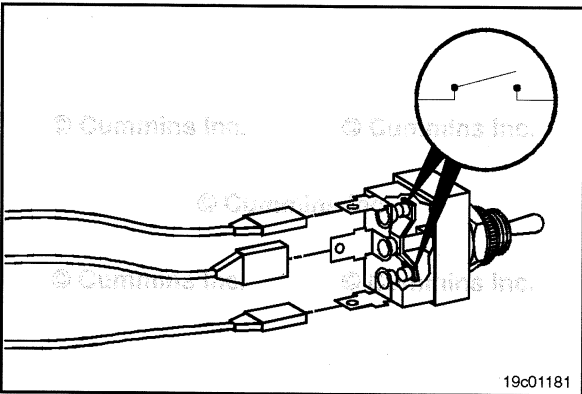
The operator can resume cruise control, after clutching or braking, by moving the switch to RESUME/ACCEL. The vehicle speed will return to the last set mph.

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.





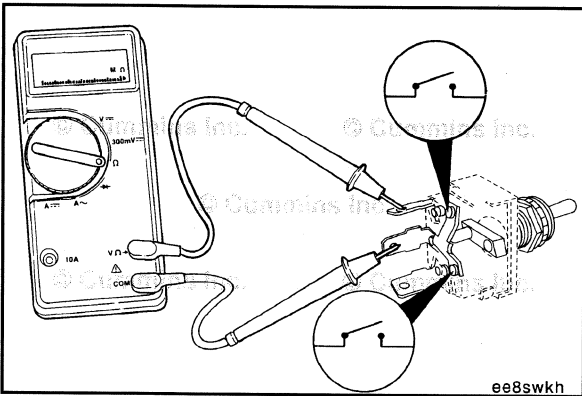
The cruise control/PTO set/resume switch circuit consists of the switch return, the cruise control/PTO resume/accel switch signal, cruise control/PTO set/coast switch signal and the vehicle mounted switch.



### Resistance Check

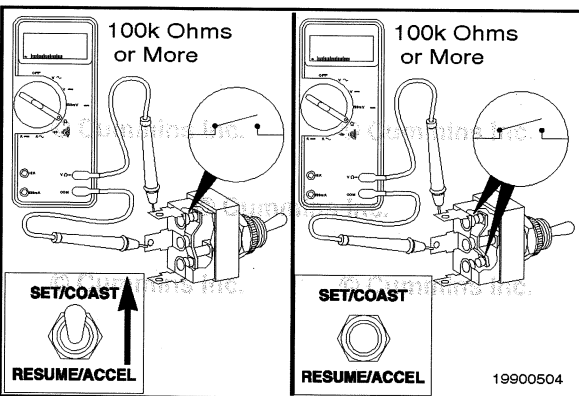
If INSITE™ is available, monitor the cruise control/PTO set/resume select switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Label the wires with the location on the switch or the wire number. Remove the three electrical connectors from the switch.



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.

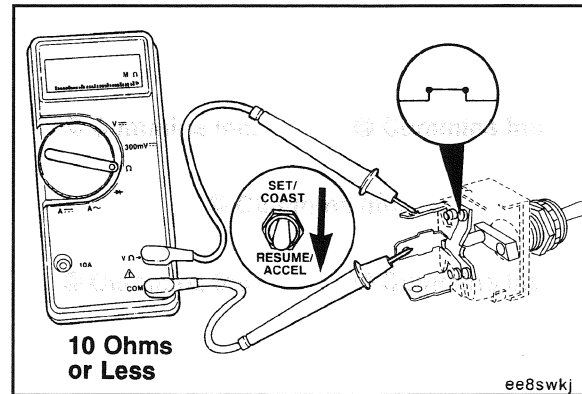


Hold the switch in the SET/COAST position. The multimeter **must** show an open circuit (100k ohms or more) when the switch is held in the SET/COAST position and after it is released. If the circuit is **not** open, the switch has failed.

Refer to the OEM troubleshooting and repair manual for replacement procedures.

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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.

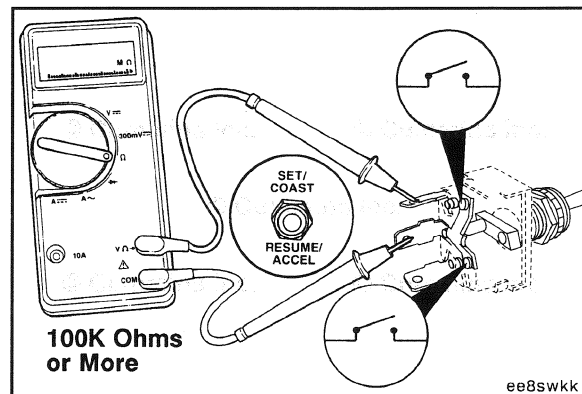


When the switch is released, the multimeter **must** show an open circuit (100k ohms or more). If the multimeter does **not** show the correct values in either test, the switch has failed.



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.

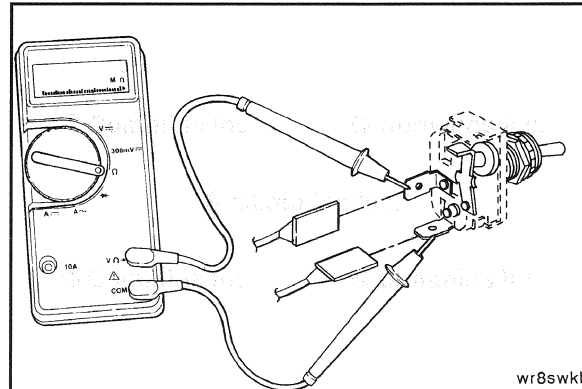


Touch one multimeter probe to the center terminal of the switch. Touch the other multimeter probe to the SET/COAST terminal of the switch.



Hold the switch in the SET/COAST position.

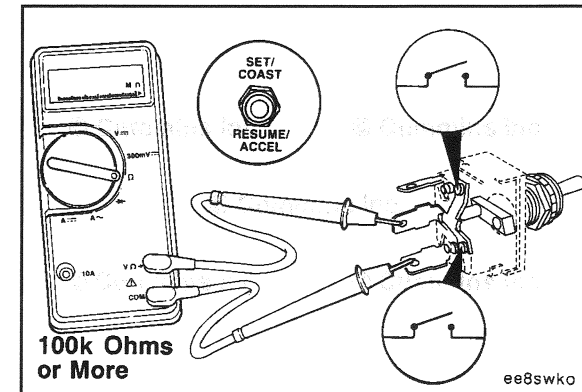
The multimeter **must** show a closed circuit (10 ohms or less) while the switch is held to the SET/COAST position.

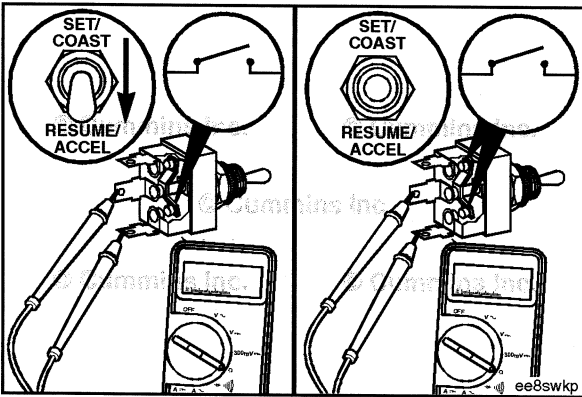


When the switch is released, the multimeter **must** show an open circuit (100k ohms or more). If the multimeter does **not** show the correct values in either test, the switch has failed.



Refer to the OEM troubleshooting and repair manual for replacement procedures.

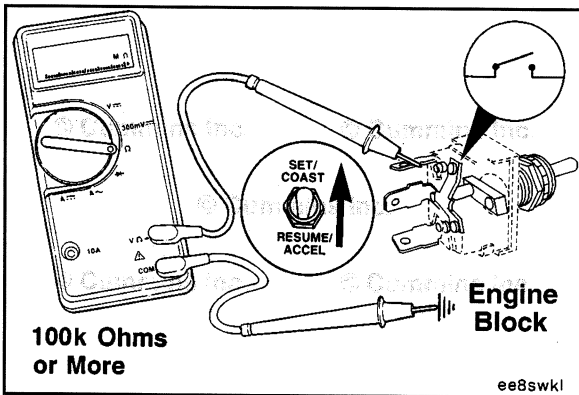




Move the switch to the RESUME/ACCEL position.

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.

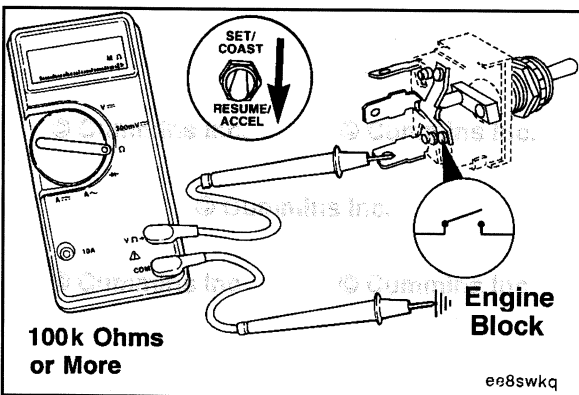


### Check for Short Circuit to Ground

Adjust the multimeter to measure resistance.

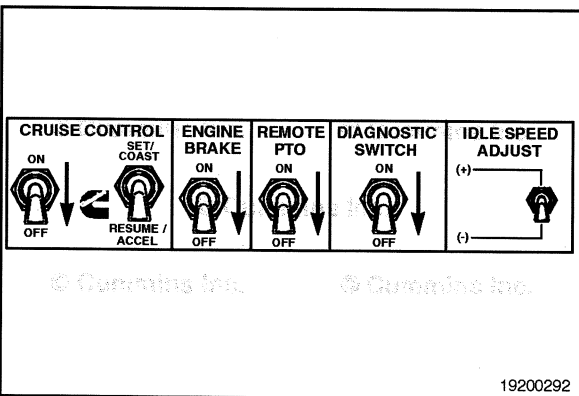
Touch one multimeter probe to the RESUME/ACCEL terminal of the switch. Touch the other multimeter probe to the chassis ground. Move the switch to the SET/COAST position then to the RESUME/ACCEL position. Measure the resistance.

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

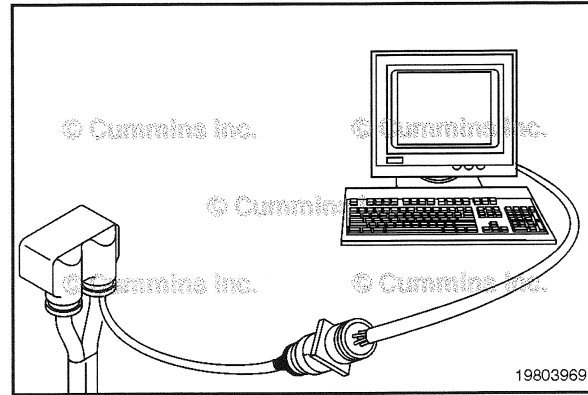
In addition to cruise control functions, the cruise control select switch also provides for increasing/decreasing idle speed, PTO speed, fault code flashout, and road speed governor limit.

### 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 INSITE™ 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.



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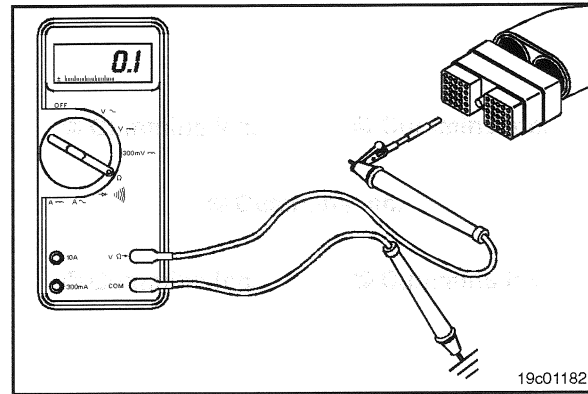
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).



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.

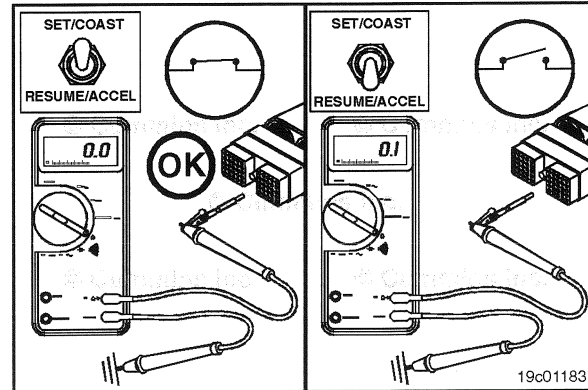


19c01182

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.

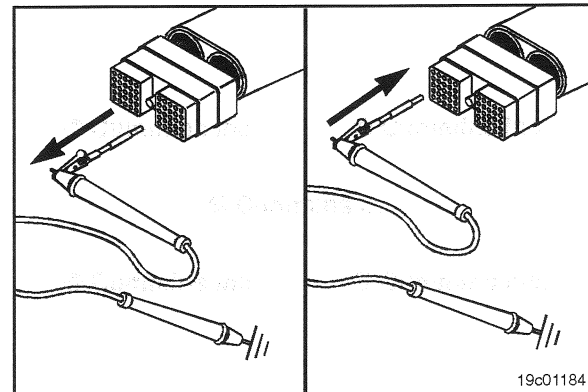


If the resistance values are **not** correct, make sure the cruise control/PTO set/coast input and the cruise control/PTO resume/accel input wires are properly installed on the cruise control select switch. If both control wires are correctly installed, inspect the cruise control/PTO set/coast input and the cruise control/PTO resume/accel wires for an open circuit, provided the cruise control select switch has been previously checked.

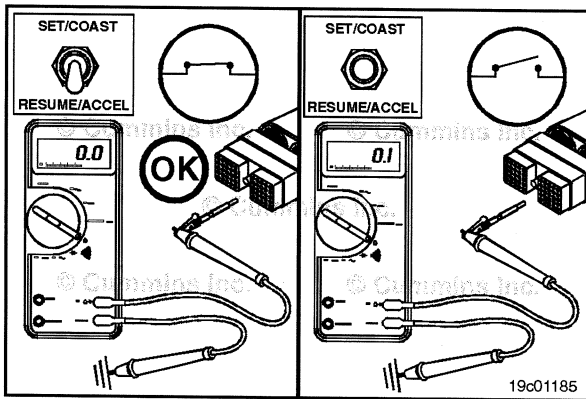


19c01183

Remove the lead from the cruise control/PTO set/coast switch signal and insert it into the cruise control/PTO resume/accel switch signal.

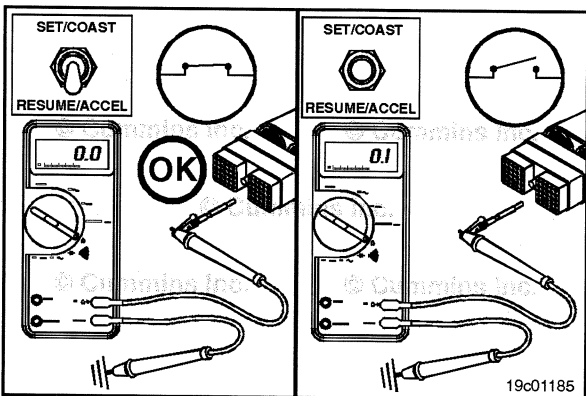


19c01184



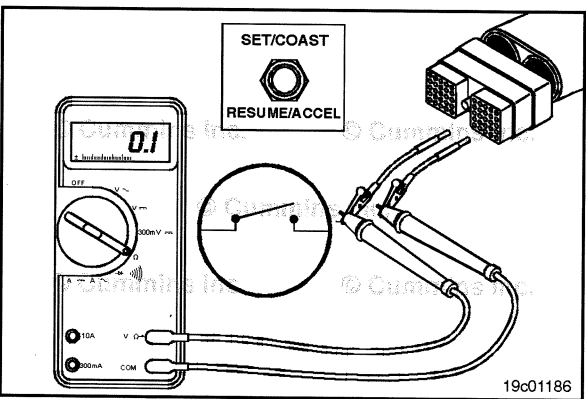
Hold the cruise control select switch in the RESUME/ACCEL position. The multimeter **must** show a closed circuit (10 ohms or less) when the switch is in the RESUME/ACCEL position and an open circuit (100k ohms or more) when the switch is released.

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.

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.

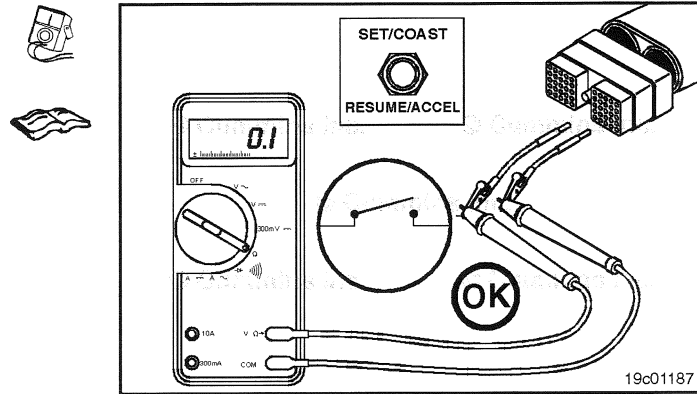
Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.

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.

Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



### Check for Short Circuit to External Voltage Source

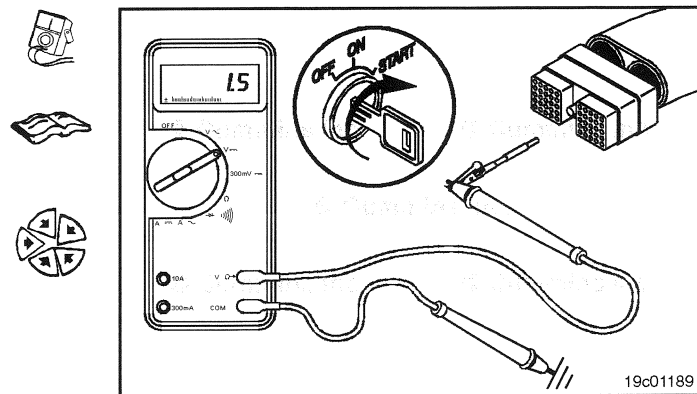
Isolate the cruise control/PTO resume/accel switch circuit as described in the previous section. Turn the vehicle keyswitch to the ON position. Adjust the multimeter to measure VDC. Insert a test lead into the cruise control/PTO resume/accel switch signal of the OEM harness connector. Connect the test 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.

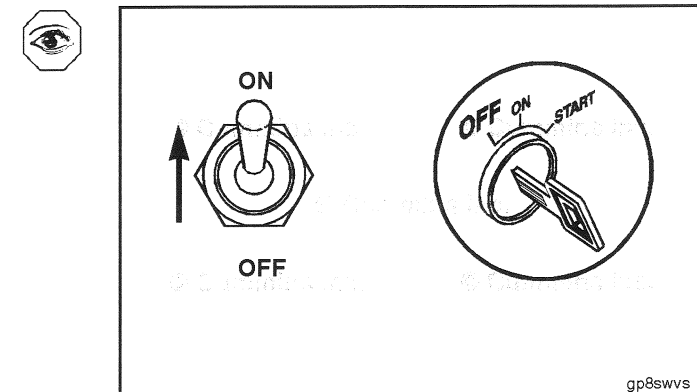


## Diagnostic Test Mode Switch (019-027)

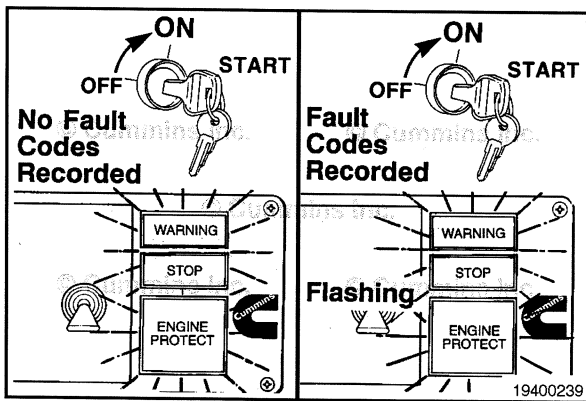
### General Information

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.

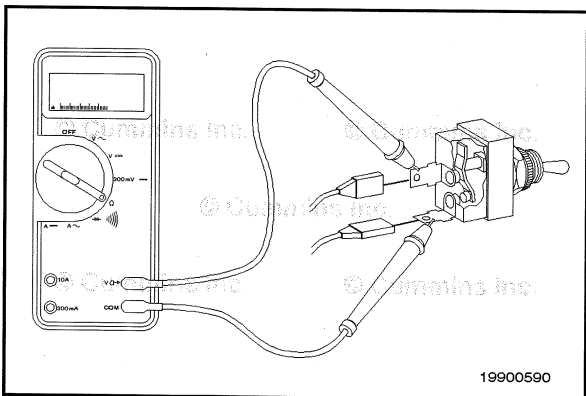






When the ECM receives the signal from the diagnostic ON/OFF switch, the yellow and red warning lights will come on and start flashing if any active fault code is recorded in the ECM. If both warning lights remain on and do **not** flash, there are no active fault codes present.

**NOTE:** The equipment **must** be stationary. If road speed is detected, the flashing sequence will **not** occur.



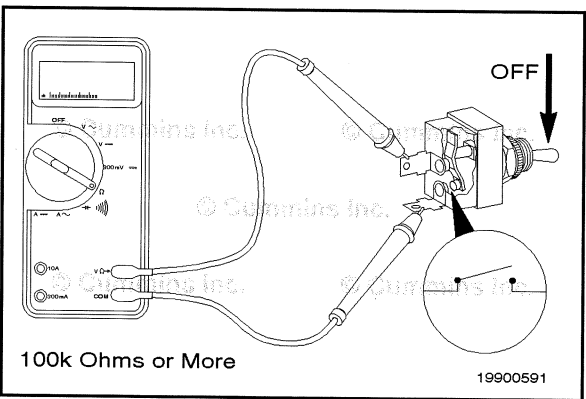
### Resistance Check



If INSITE™ 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.

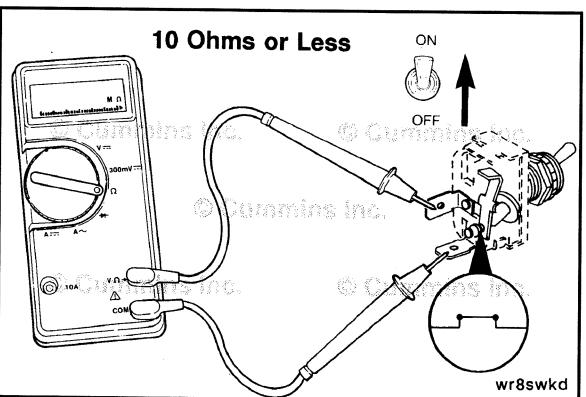


Move the switch to the OFF position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).



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.

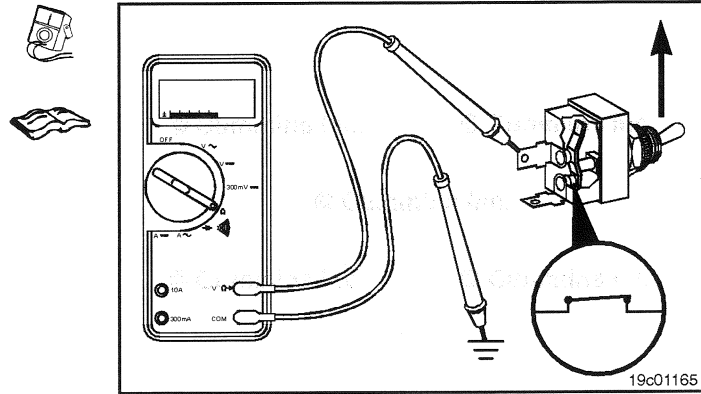


Refer to the OEM troubleshooting and repair manual for the replacement procedures.

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.



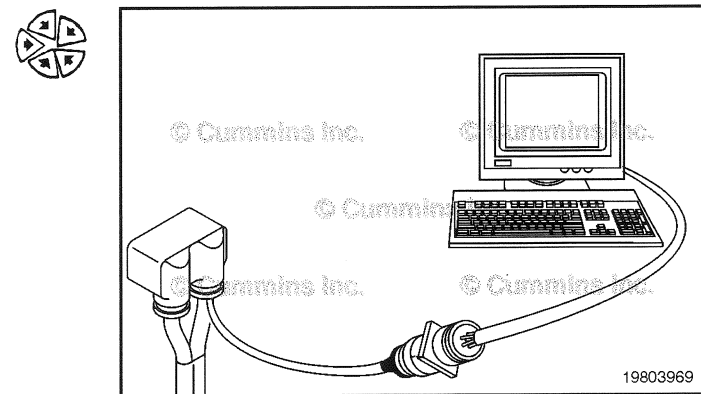
### Diagnostic Test Mode Switch Circuit (019-028)

#### 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 INSITE™ 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 connector from the electronic control unit. 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.

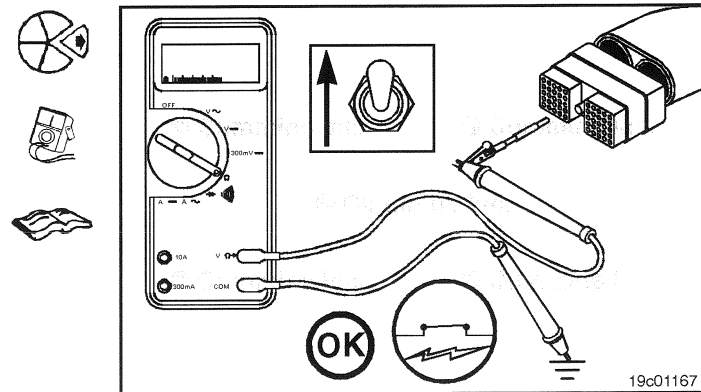
Move the ON/OFF switch to the ON position.

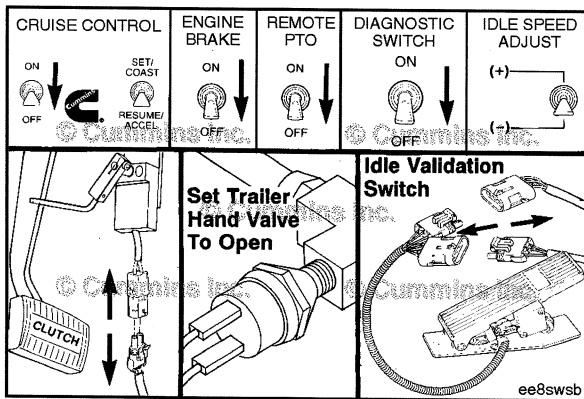
If the OEM wired the switch return to chassis ground, the multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the diagnostic test mode switch signal wire for an open circuit.

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

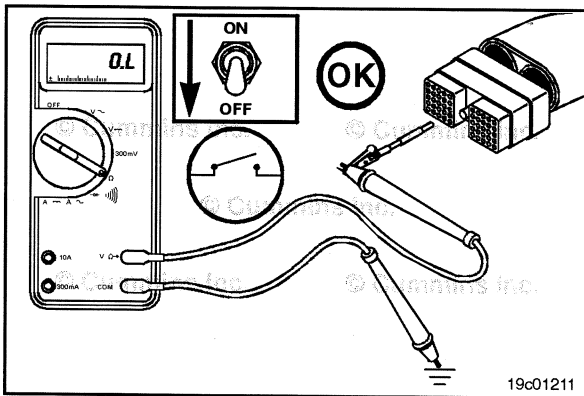
To isolate the diagnostic test mode switch signal circuit when checking for an electrical short, turn all cab panel switches to the OFF or neutral position.

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.

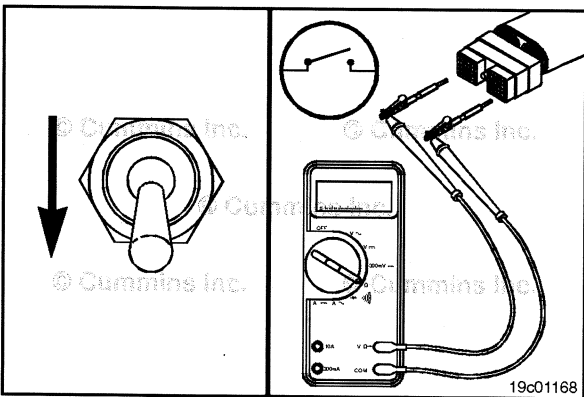


Disconnect the OEM harness connector from the electronic control unit. Set the diagnostic test mode switch to the OFF position.

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.

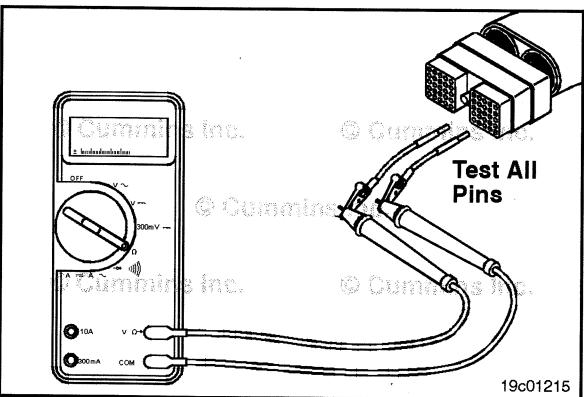
Touch the other probe to engine block or chassis ground.

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).

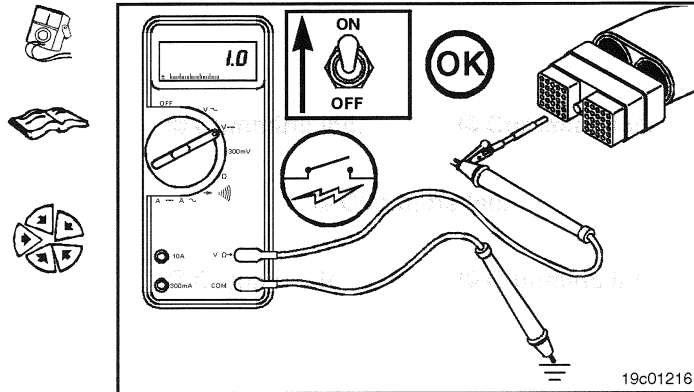
If the circuit is **not** open, there is a short circuit between the switch circuit and any pin that shows a closed circuit, provided the switch has previously been checked. Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.

### 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.

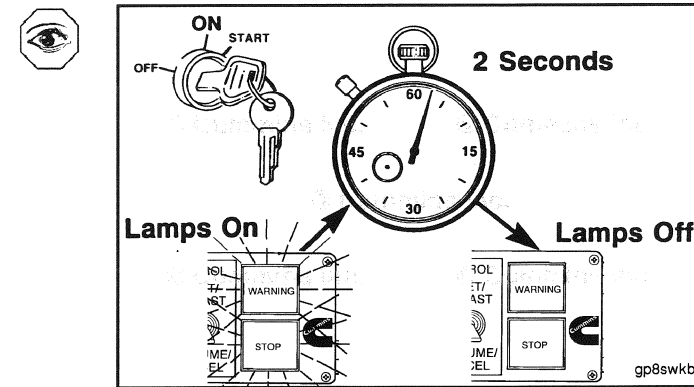
Connect all components after completing the repair.



### 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.



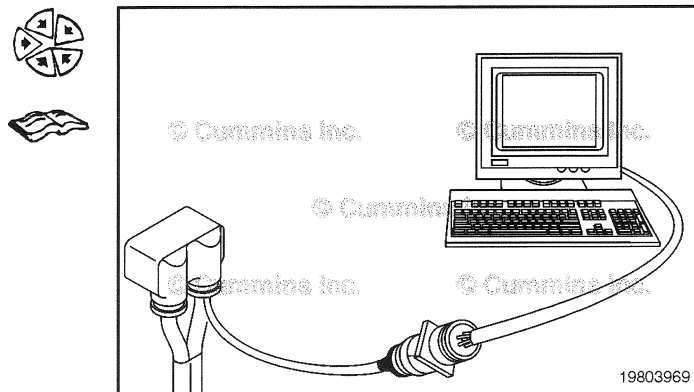
Turn the keyswitch to the OFF position.

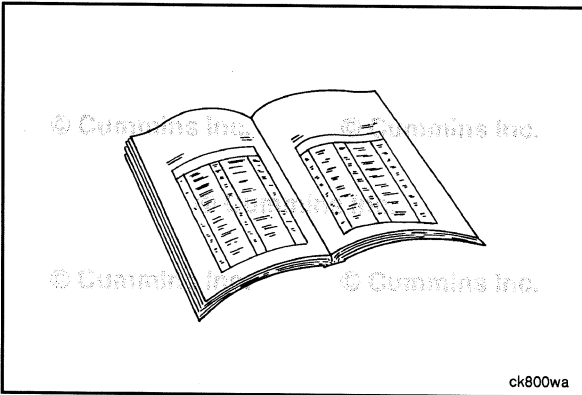
Connect an electronic service tool to the vehicle data link.

Turn the keyswitch to the ON position.

Select the monitor mode on the electronic service tool. The electronic service tool **must** be able to communicate with the engine control module (ECM). If the ECM will **not** communicate with the service tool, see the ECM - No Communication troubleshooting symptom tree in Section TS.

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.





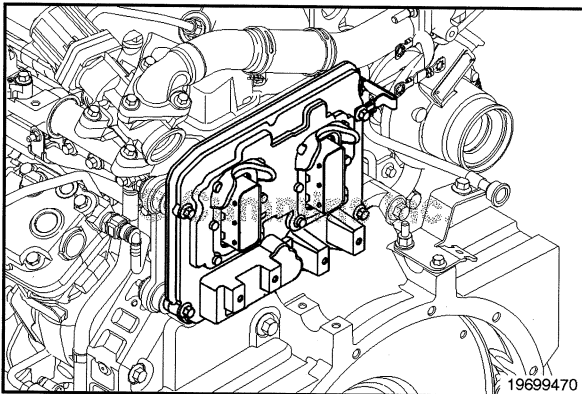
### Preparatory Steps

#### ▲ 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.

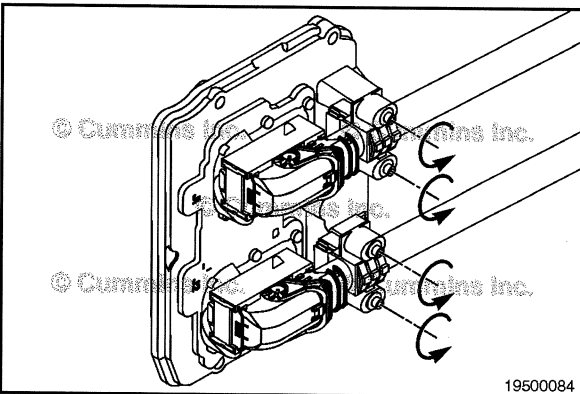


### Remove

The ECM is located on the rear gear housing.

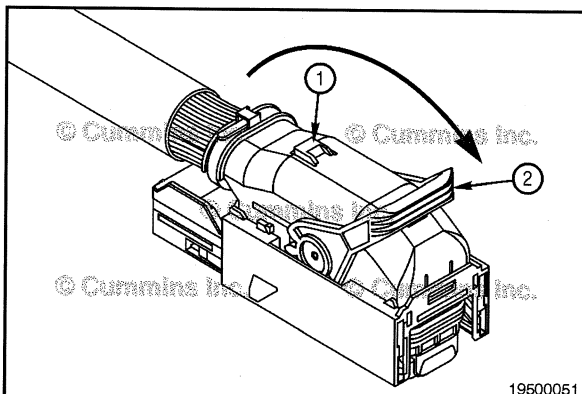


**NOTE:** Record all programmable parameters, features, and calibration information from the old ECM before disconnecting the harness connectors. This information will be needed to program the new ECM.



Remove the wiring harness hold-down clamps from the ECM.

**NOTE:** Do **not** remove the wire ties attaching the hold-down clamps to the wiring harness.

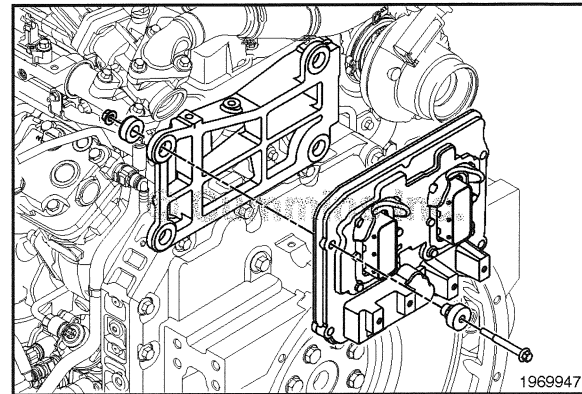


Remove the OEM connector and the engine harness connector from the ECM by pressing down on the locking tab (1) and pulling up on the lever (2).

**NOTE:** Do **not** close the lever after the connector has been removed from the ECM. Attempting to do so will cause damage to the connector.

Remove the capscrews and nuts that secure the ECM to the ECM mounting plate.

**NOTE:** In some applications, the ECM is remote mounted.  
Remove the ECM.



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## Install

### ⚠ CAUTION ⚠

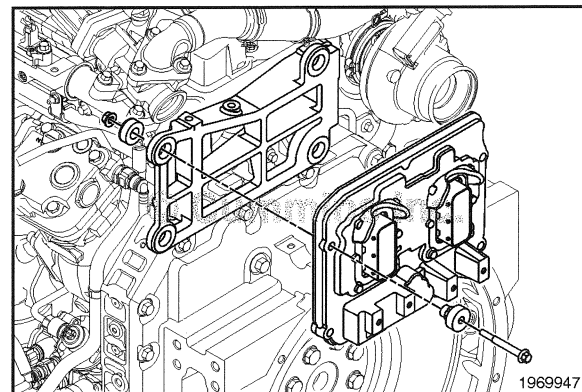
Do not paint the back side of the ECM. Make sure no grease or dirt is between the ECM and the mounting plate.

Install the capscrews and nuts that secure the ECM mounting plate to the rear gear housing.

**NOTE:** In some applications, the ECM is remote mounted.

Tighten the capscrew and nuts.

**Torque Value:** 18 N•m [ 159 in-lb ]

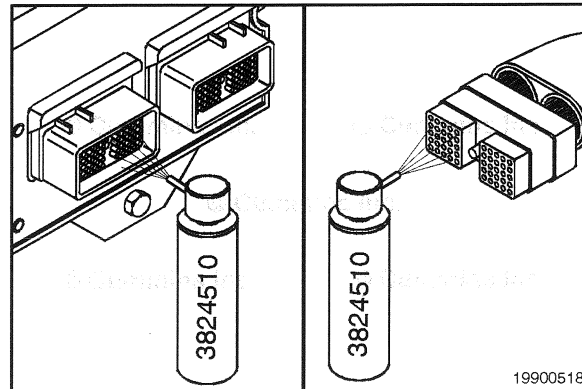


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### ⚠ CAUTION ⚠

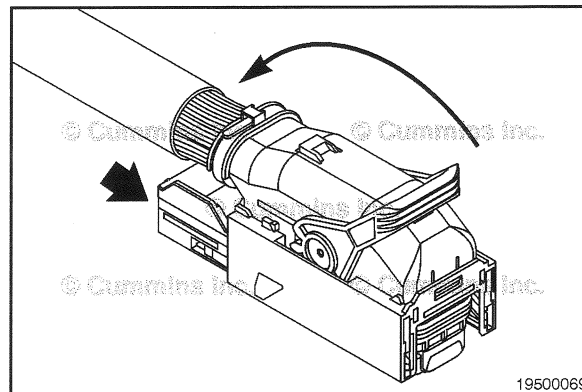
Do not blow compressed air into the ECM ports or connectors. Compressed air can contain moisture due to condensation.

Use electrical contact cleaner, Cummins® Part Number 3824510, to remove all dirt and moisture from the ECM connector ports and the harness connectors.

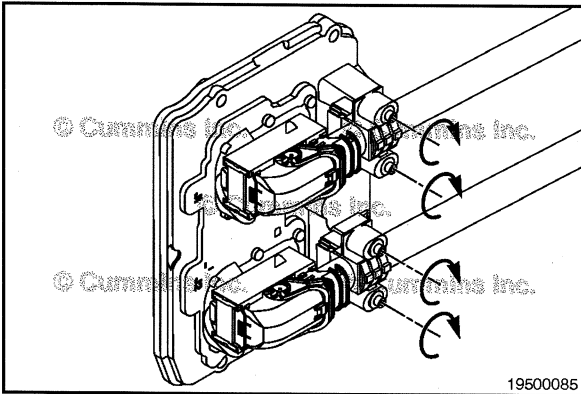


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Connect the harness to the ECM by placing the harness connector into the ECM header and pulling back on the locking lever until the connector is fully seated and the lever locking tab is engaged.



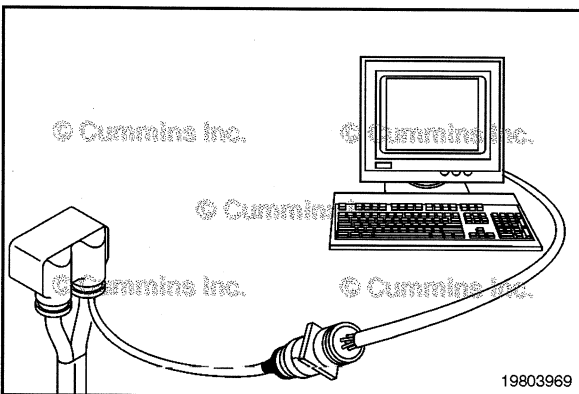
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Install the wire harness hold-down clamps. Refer to Procedure 019-043 in Section 19.

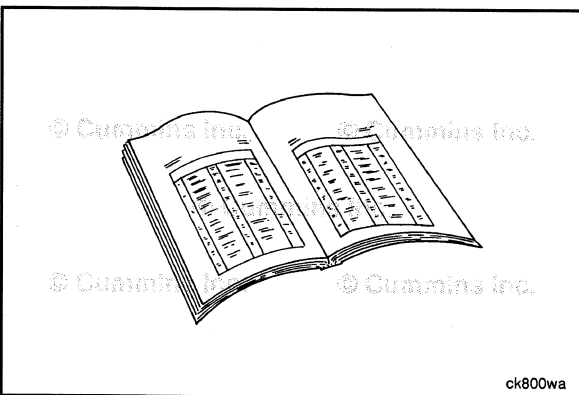


**NOTE:** Do **not** overtighten the harness hold-down clamp mounting screws. Damage to the ECM will occur.



**NOTE:** When an ECM is replaced, the new ECM **must** be calibrated. Refer to Procedure 019-032 in Section 19.

Adjust the values of ECM Distance Offset, ECM Time Offset, Engine Distance Offset, and Engine Time Offset after calibrating the ECM. These parameters can be found in the Trip Information section of Features and Parameters.



### 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 loose components.

## Engine Control Module Calibration Code (019-032)

### General Information

**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

**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.

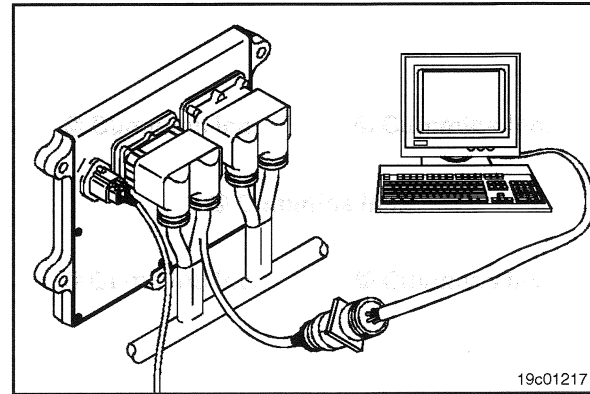
### Preparatory Steps

Connect INSITE™ electronic service tool to the service tool data link, which is located on the engine or in the cab.

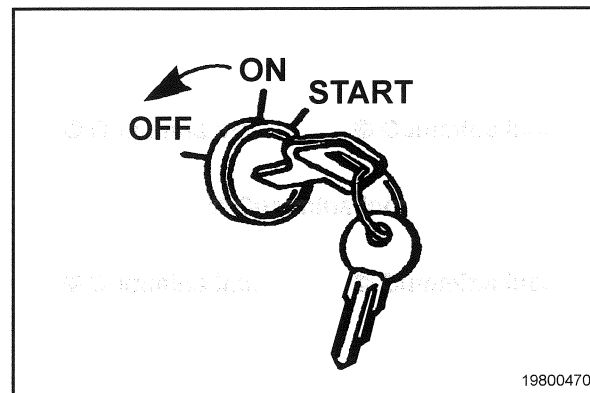
See the help section within INSITE™ electronic service tool for detailed ECM calibration procedures.

After an ECM is replaced or calibrated, the actual engine hours / distance **must** be entered correctly into the ECM.

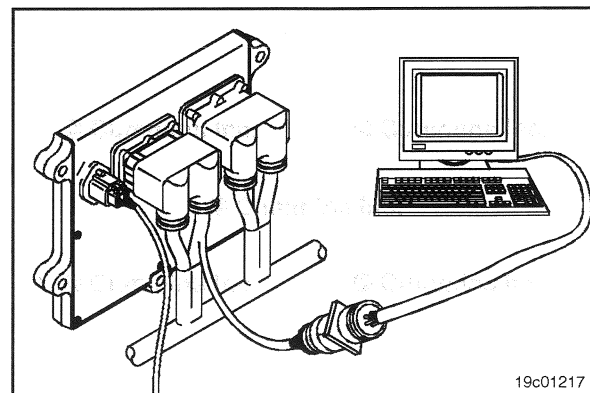
Input the values of ECM Distance Offset, ECM Time Offset, Engine Distance Offset, and Engine Time Offset prior to replacement or calibration of the ECM. These parameters can be found in the Trip Information section of Features and Parameters.



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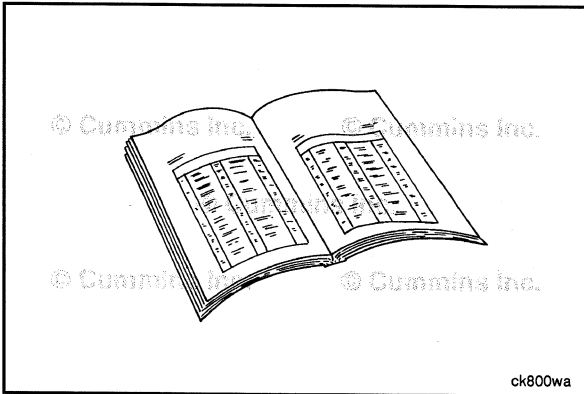


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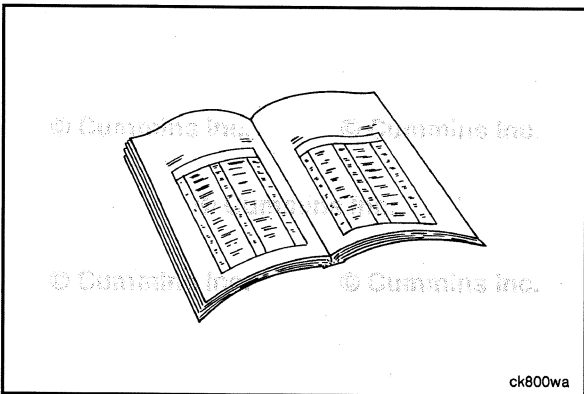




Following calibration download, if new fault codes or fault conditions exist, perform the following steps in order to understand if the calibration is working correctly and is the appropriate calibration for the application.

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.

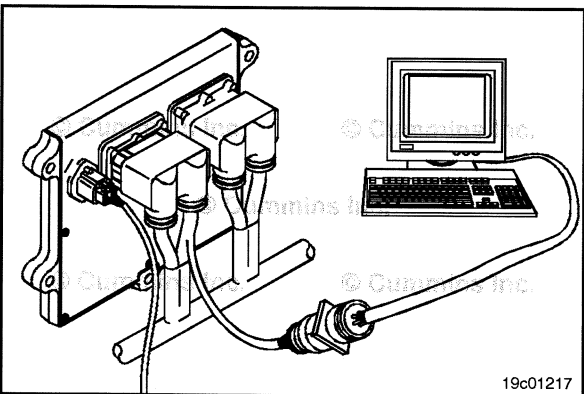
If no issues are found, no further action is required.



### 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.



**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.

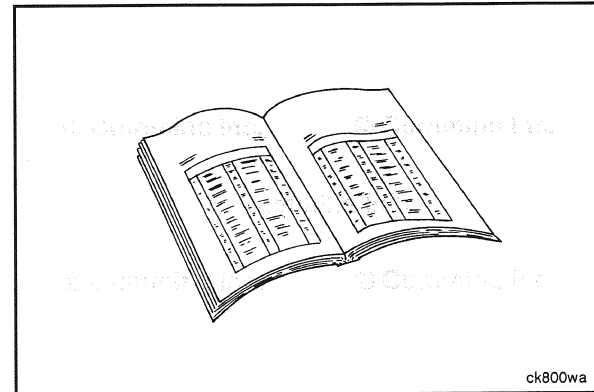
Review the INSITE™ electronic service tool help files "Adjustable Engine Features" section to determine if the suspected error is due to an incorrectly set adjustable engine feature.

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.



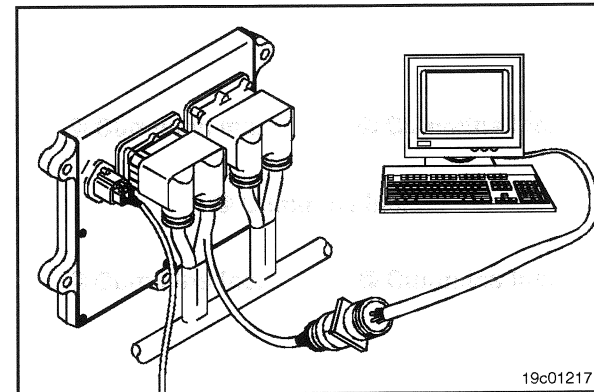
ck800wa

**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.).



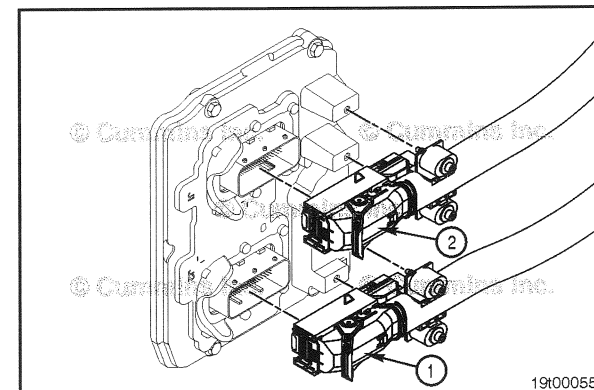
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## Engine Wiring Harness (019-043)

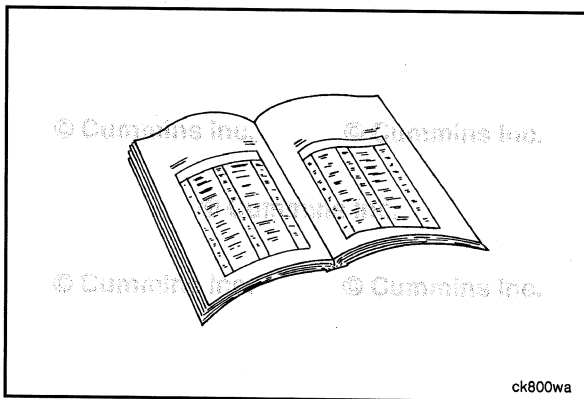
### General Information

The engine uses two separate wiring harnesses to control the engine and some of the vehicle operations. Shown are the engine control module (ECM) ports for the following connectors:

- 1 96-pin original equipment manufacturer (OEM) harness connector (J2)
- 2 96-pin engine harness connector (J1).



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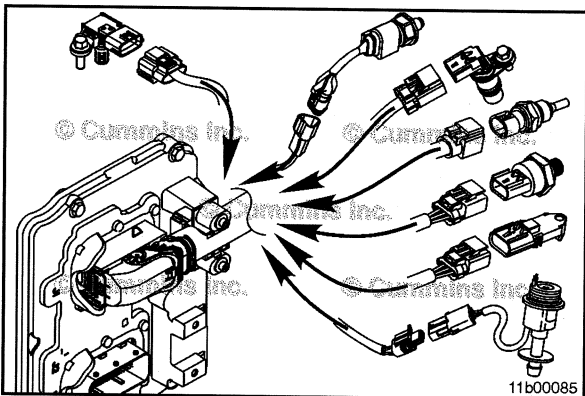
## Preparatory Steps

### ⚠ WARNING ⚠



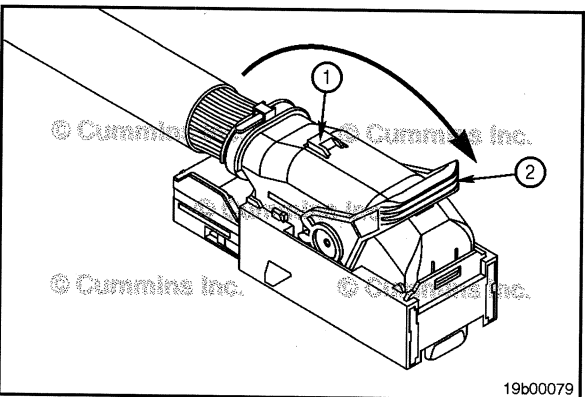
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries. See equipment manufacturer service information.
- Disconnect the 14-pin OEM crossover connector.



## Remove

Disconnect the engine harness from the sensors and the switches.



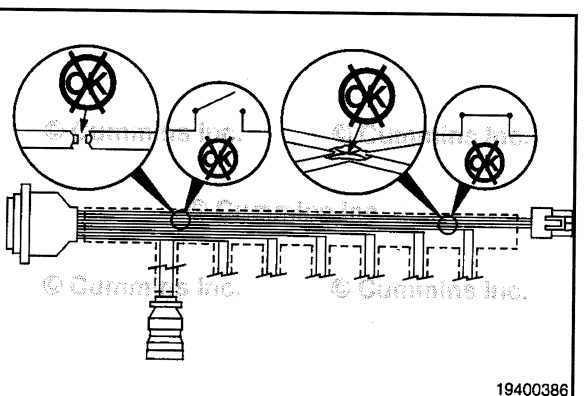
Remove the wire harness hold down clamps from the ECM.

**NOTE:** Do **not** remove the wire-ties attaching the hold down clamps to the wire harness.

Remove the OEM connector and the engine harness 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 to the connector.

Note the engine harness routing and location of the wire ties and mounting clips holding the engine harness before removal. It may be helpful to take photos and/or add tags to help route the harness properly during assembly.



## Inspect for Reuse

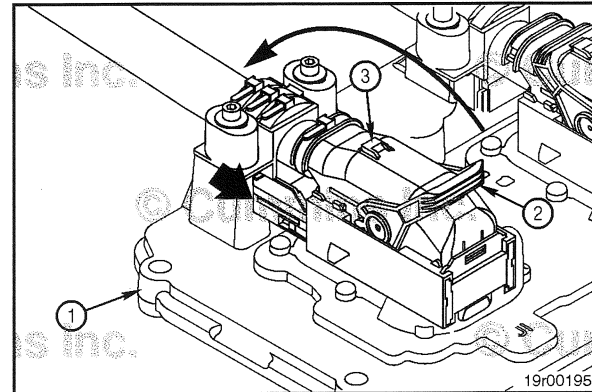
Inspect the engine wiring harness. If there is an open circuit or short circuit, determine the location of the damaged wiring.

**NOTE:** Wiring inside the protective covering can be repaired.

### Install

Install the connector to the ECM by placing the connector into the ECM receptacle (1) and pulling back on the locking lever (2) until the connector is fully seated and the lever locking tab (3) is engaged.

If the wire tie securing the wiring harness to the ECM connector backshell was removed, install a new wire tie.



### ⚠ CAUTION ⚠

Failure to correctly install the engine wiring harness hold-down clamp may lead to wiring harness failure.

**NOTE:** If the engine wiring harness hold-down clamp has been removed, install the hold-down clamp using the following steps.

Loosely attach the hold-down clamp to the wiring harness using wire ties. Do **not** tighten the wire ties at this time.

Install the harness hold-down clamp onto the ECM.

Tighten the capscrews.

**Torque Value:** 8 N•m [ 71 in-lb ]

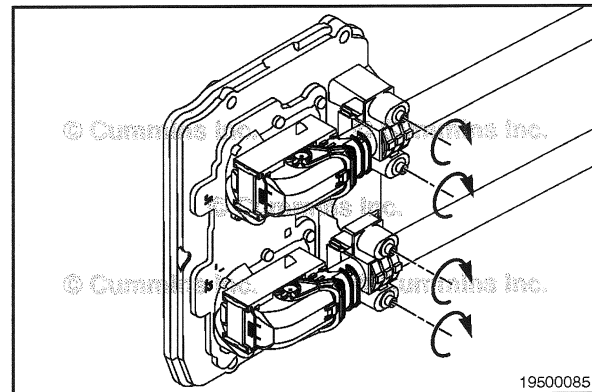
Orient the harness so there are no stretched or pinched wires.

Tighten the wire ties.

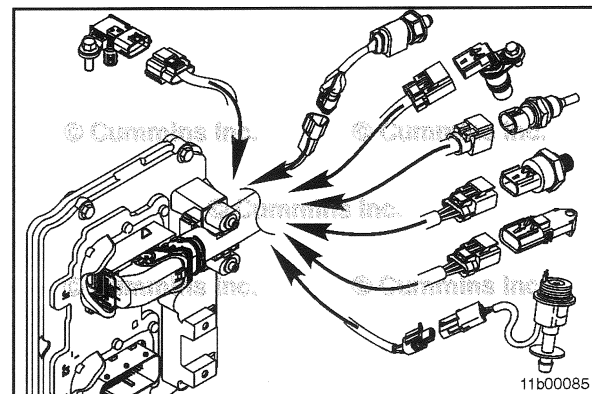
Trim any excess length from the wire ties.

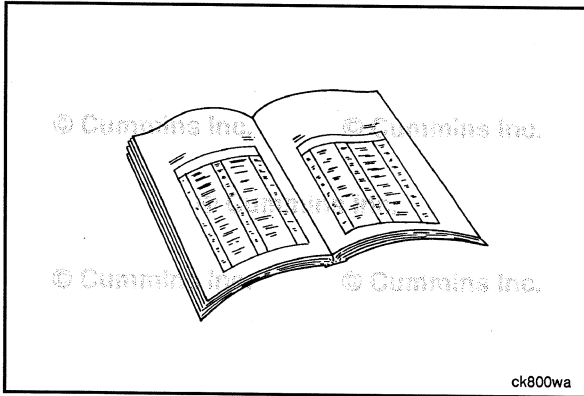
The harness should be routed as far away from hot components as possible.

Make sure all mounting clips and wire ties are reused or replaced to prevent the harness from rubbing on other components.



Connect the sensors and switches to the engine harness.





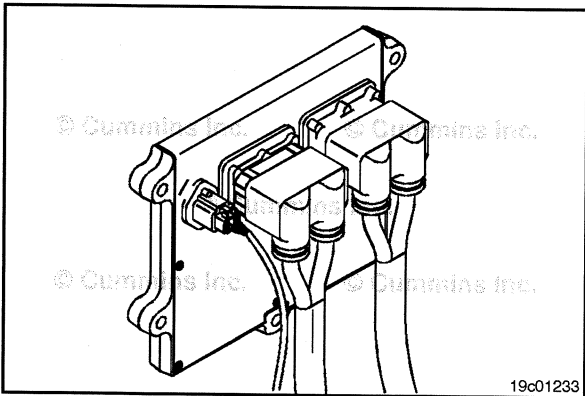
## Finishing Steps



### ▲ 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 14-pin OEM crossover connector.
- Connect the batteries. See equipment manufacturer service information.



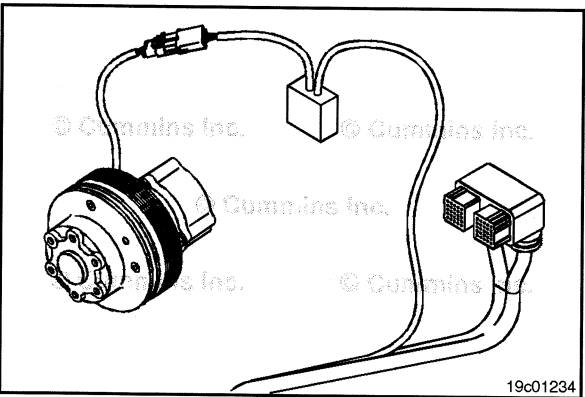
## Fan Control Circuit (019-045)

### General Information



The CM2350 electronic control system can control the fan clutch activation. The engine control module (ECM) energizes the air valve solenoid or an electric fan clutch.

Refer to the original equipment manufacturer (OEM) service manual for more information on the fan clutch wiring.



The fan control circuit resides in the 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 Cummins® Part Number 3822758, or equivalent. The connector will be damaged. The leads must fit tightly in the connector without expanding the pins of the connector.

Disconnect the OEM harness connector from the ECM connector. 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.

## 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.

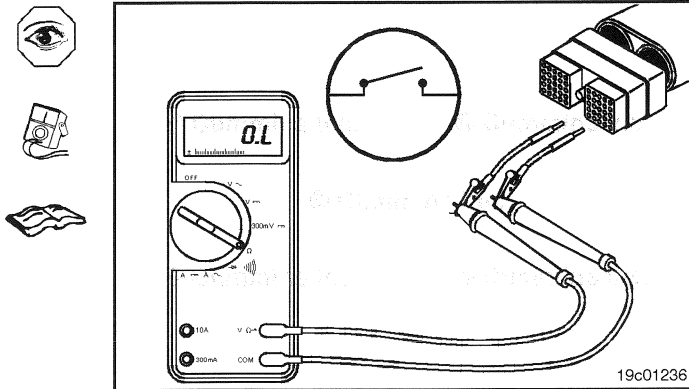
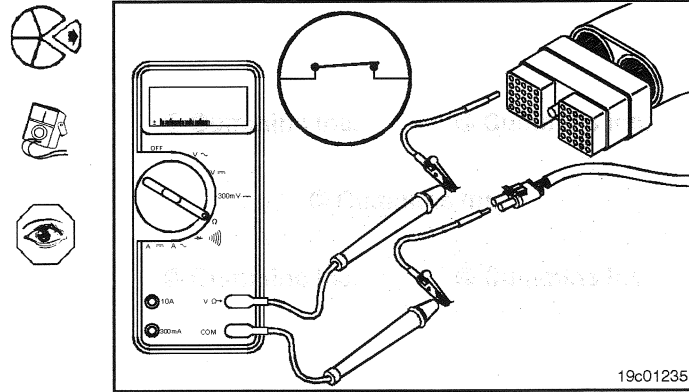
Measure the resistance.

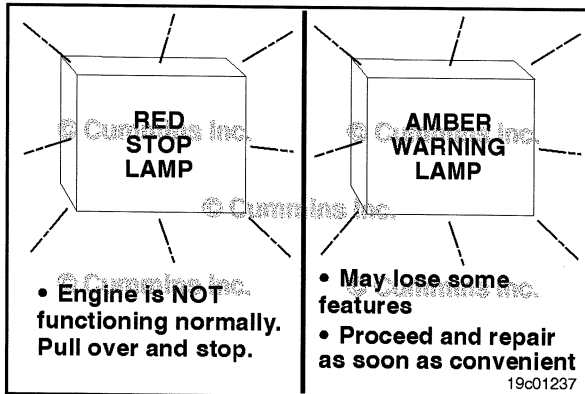
The multimeter **must** show an open circuit (greater than 100k ohms).

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 or engine wiring harnesses.

Refer to Procedure 019-043 in Section 019 or Refer to Procedure 019-071 in Section 19.

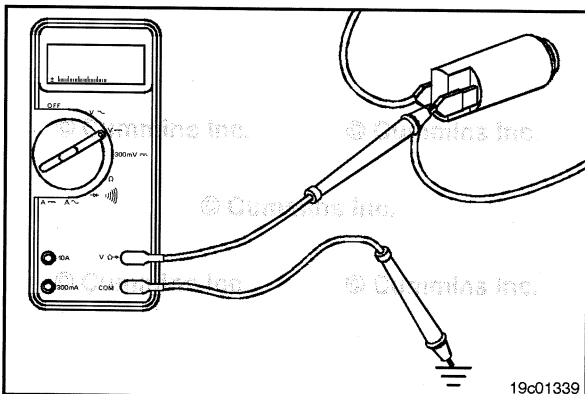




## Fault Lamp (019-046) General Information

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.



## 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 ⚠

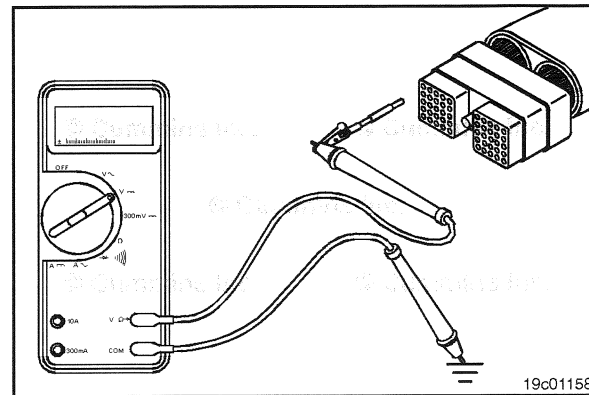
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

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.

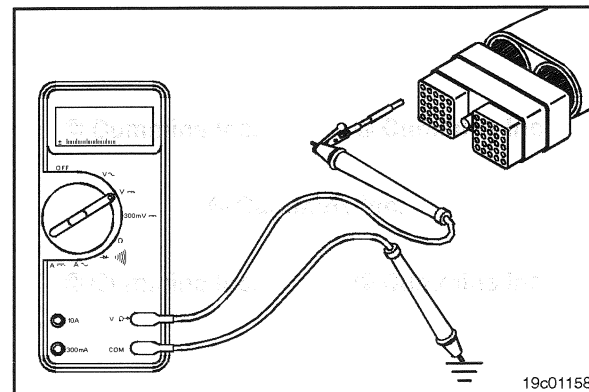


19c01158

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.

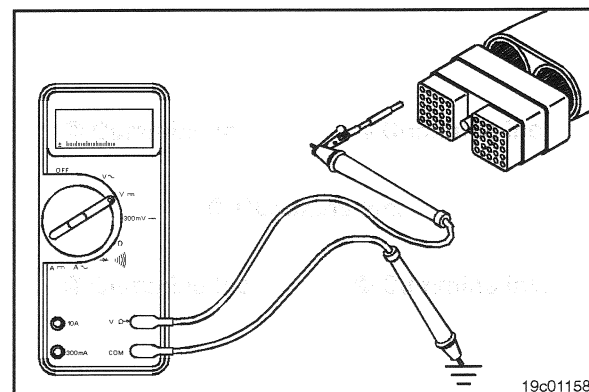


19c01158

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.

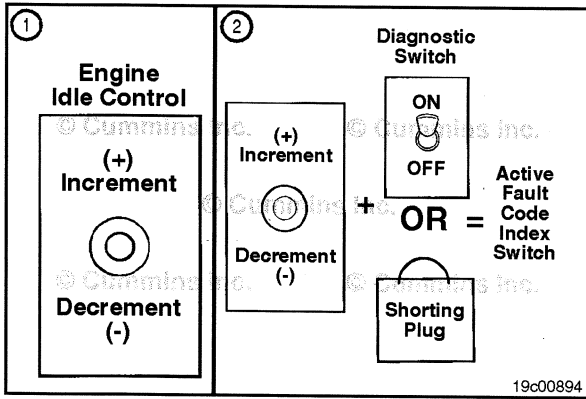
The multimeter **must** show battery voltage. If battery voltage is **not** present, there is a problem with the red stop lamp OEM harness wire, provided the red stop lamp has been previously checked. Refer to the OEM troubleshooting and repair manual for repair procedures.

Connect all components after completing the repair.



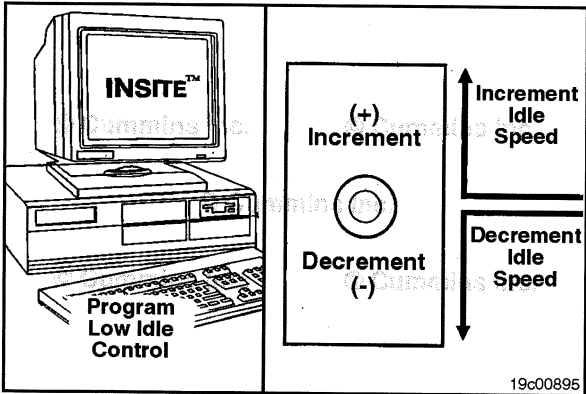
19c01158



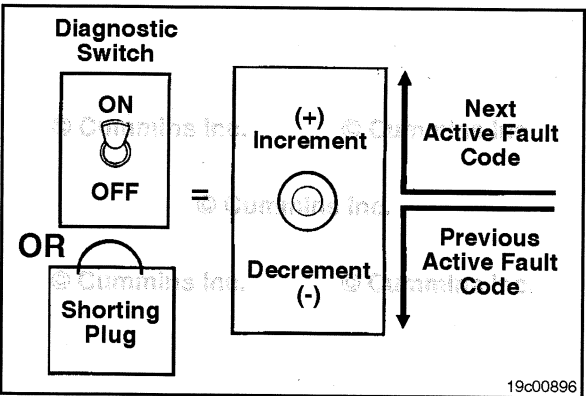


## Idle Adjust Switch (019-052) General Information

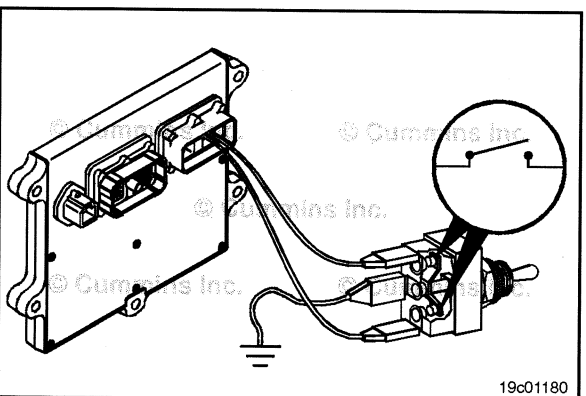
The idle adjustment feature is a part of the cruise control set/resume multi-functionality switch. Moving the switch to the set position increases the low idle speed and moving the switch to the resume position decreases the low idle speed.



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.

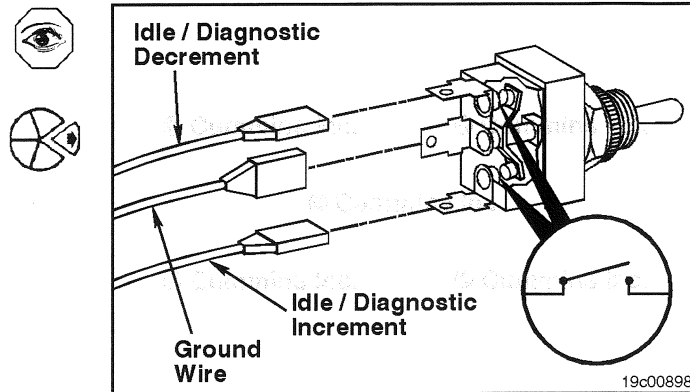


The idle adjust switch circuit consists of the idle/diagnostics increment signal, the idle/diagnostics decrement signal, the return wire, and the two-position switch located in the vehicle.

### Resistance Check

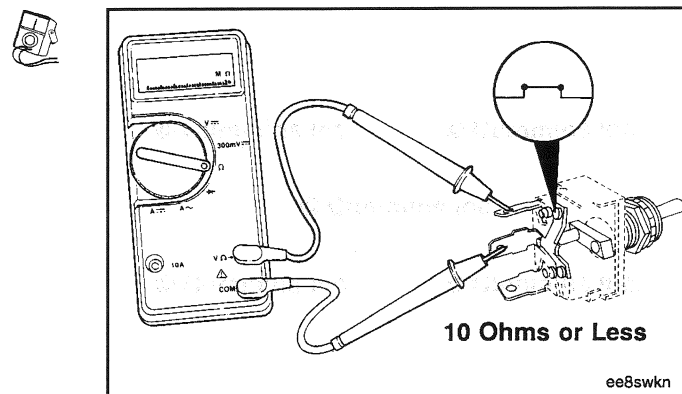
If INSITE™ is available, monitor the idle adjust switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Remove the three electrical connectors from the switch. Label the wires with the switch location and the circuit name.



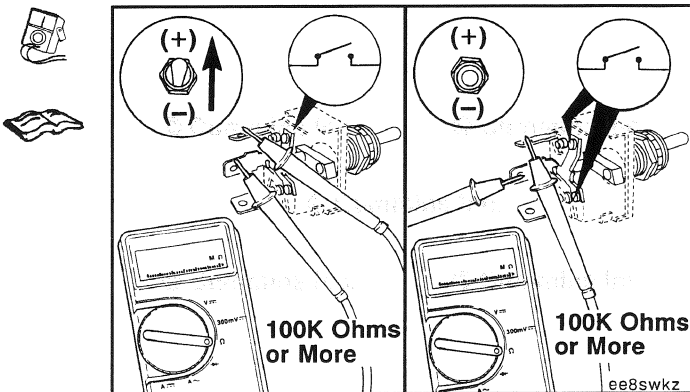
Touch one probe of the multimeter to the center terminal of the switch.

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.

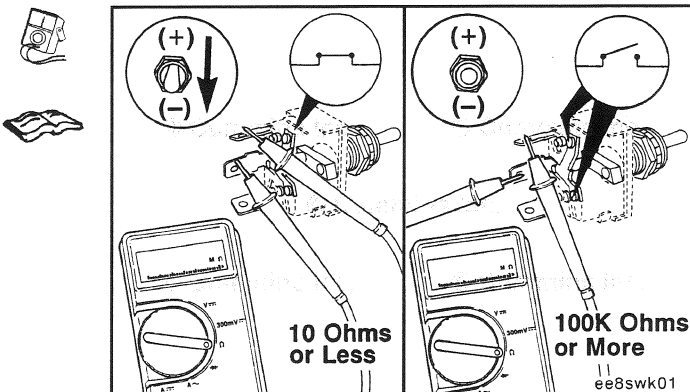
Refer to the OEM troubleshooting and repair manual for the replacement procedures.

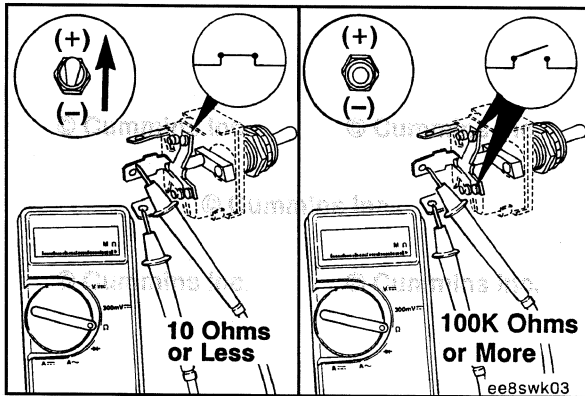



Hold the switch in the negative (-) decrement position. The multimeter **must** show a closed circuit (10 ohms or less) when the switch is held in the negative (-) decrement position.


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.



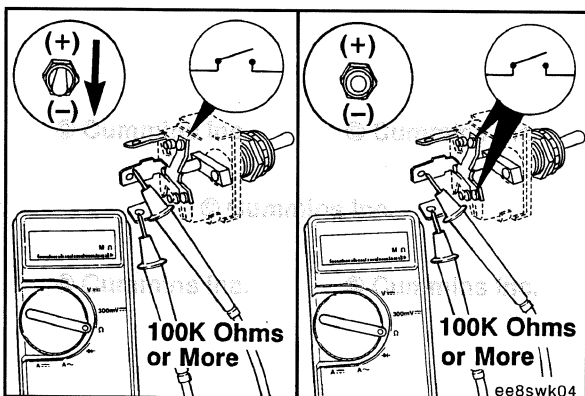



 Move the electrical lead from the cruise control/PTO resume/accelerate switch signal terminal to the cruise control/PTO set/coast switch signal terminal.

 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.

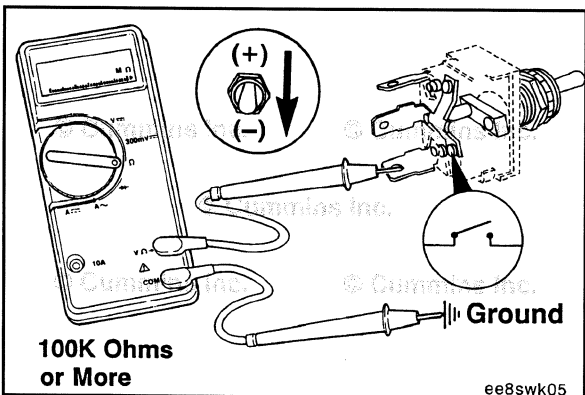
Refer to the OEM troubleshooting and repair manual for the replacement procedures.




 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.

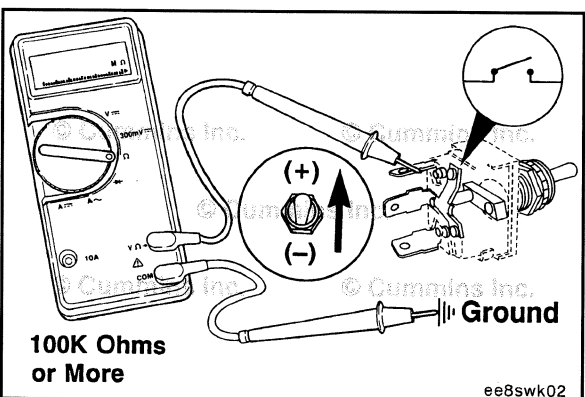
Refer to the OEM troubleshooting and repair manual for the replacement procedures.


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 INSITE™ electronic service tool is available, monitor the idle adjust switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.

Remove the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

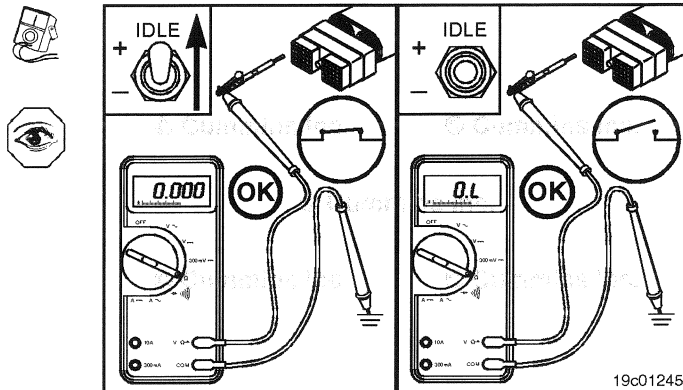
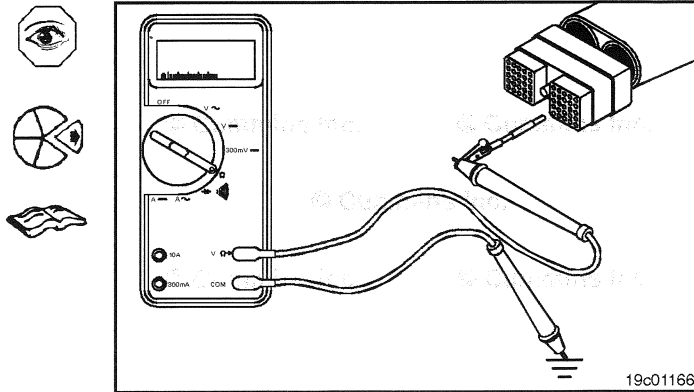
Insert the pin of the test lead into the cruise control/PTO set/coast switch signal in the OEM harness connector. Measure the resistance from the cruise control/PTO set/coast switch signal to the engine block.

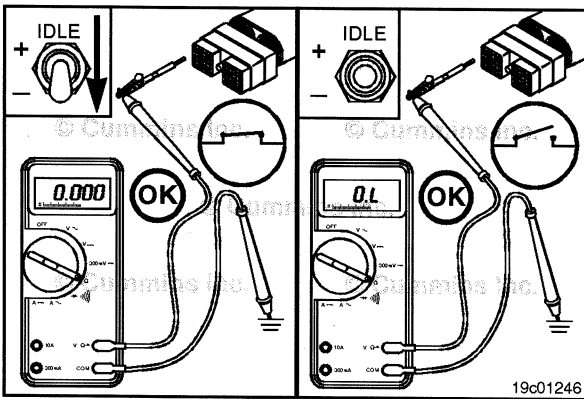
Hold the idle adjust switch in the positive (+) increment position.

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.



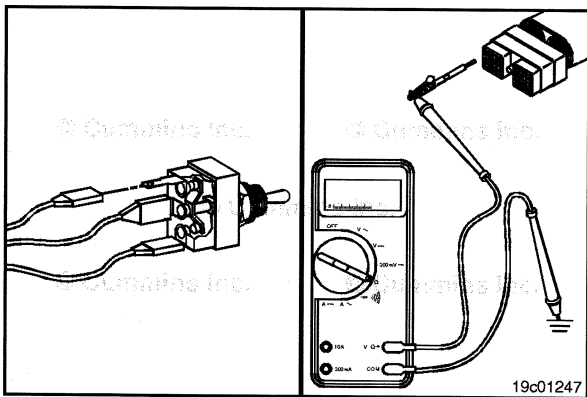


Remove the lead from the cruise control/PTO set/coast switch signal and insert it into the cruise control/PTO resume/accelerator switch signal.



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.

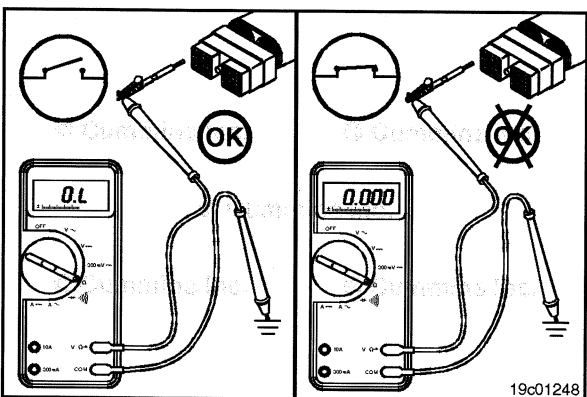
If the resistance values are **not** correct, make sure the cruise control/PTO resume/accelerator switch signal wire is properly installed on the idle adjust switch. If the cruise control/PTO resume/accelerator switch signal wire is properly installed on the idle adjust switch, inspect the cruise control/PTO 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 to the 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.

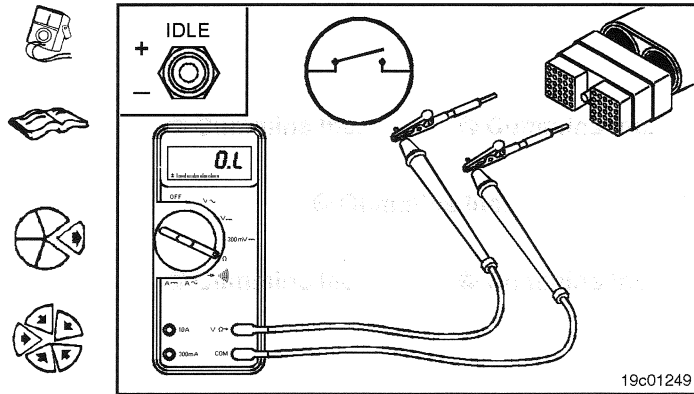
Repair or replace the wires in the OEM harness according to the vehicle manufacturer's instructions.

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.



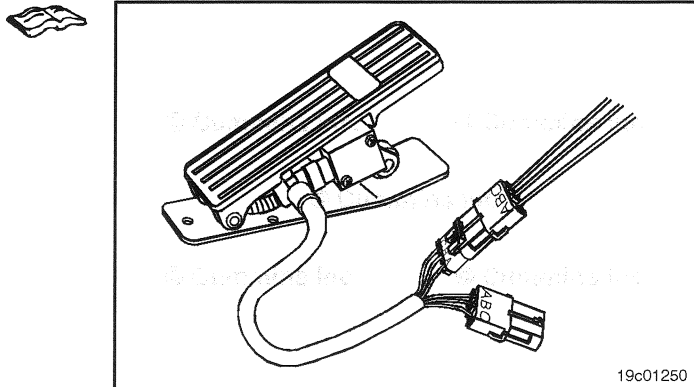
19c01249

### Idle Validation Switch (019-054)

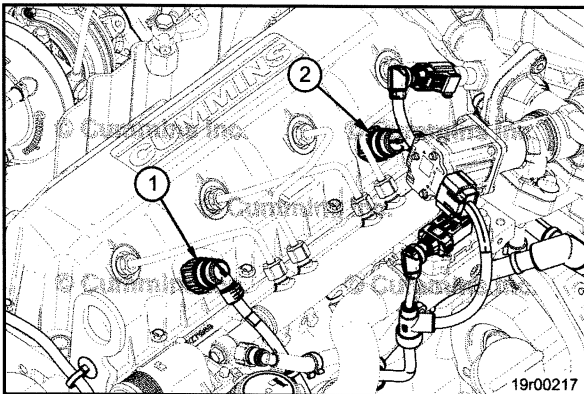
#### General Information

The idle validation switch will vary with OEM. Refer to vehicle manufacturer's manual for the specific troubleshooting and repair procedures.

The idle validation switch, on the accelerator pedal assembly, is used to detect when the accelerator pedal is at idle. The idle validation circuit consists of the idle validation switch, switch return wire, on-idle switch input, and off-idle switch input.



19c01250



## Internal Actuator Wiring Harness (019-063)



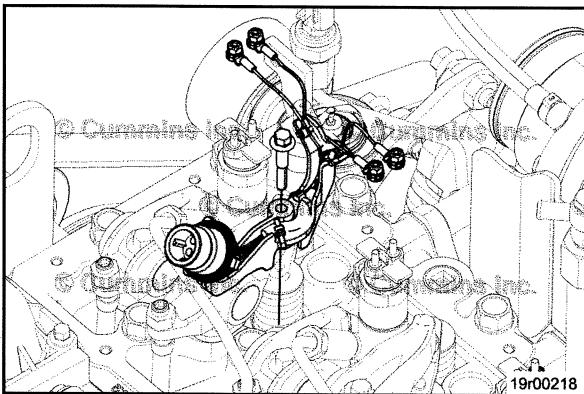
### Preparatory Steps

There are two different injector wiring harness connectors:

- Connector one (1) is for cylinders 1 and 2.
- Connector two (2) is for cylinders 3 and 4.

#### NOTE:

- Disconnect the connectors by rotating **counterclockwise** and pulling upward.
- Rotate the injector wiring harness lock ring **counterclockwise** and remove the ring.
- Remove the rocker cover. Refer to Procedure 003-011 in Section 3.

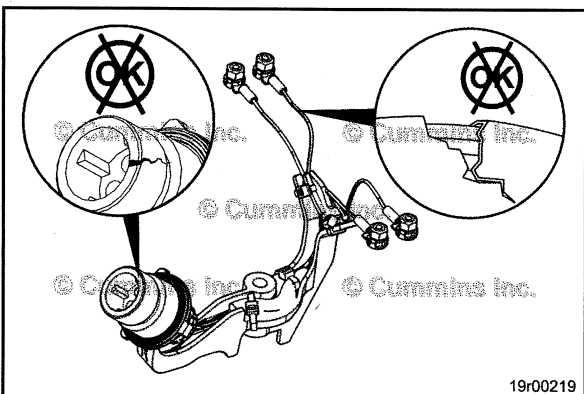


### Remove

Remove the pigtail capscrews from all injector solenoids.

Remove the internal injector harness and the brace assembly from the cylinder head.

**NOTE:** Do **not** remove the cable ties from the wiring brace.



### Inspect for Reuse

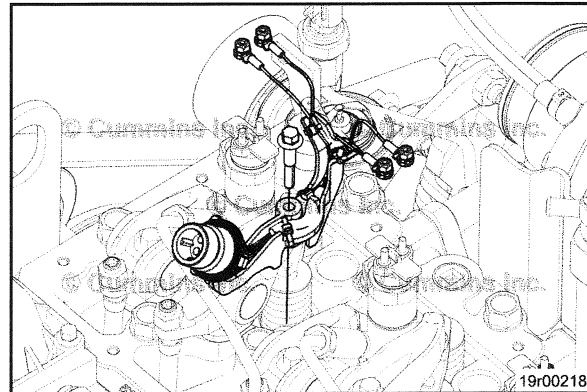
Inspect for damaged or exposed wires, bent or broken pins, or damaged connectors.

Replace, if necessary.

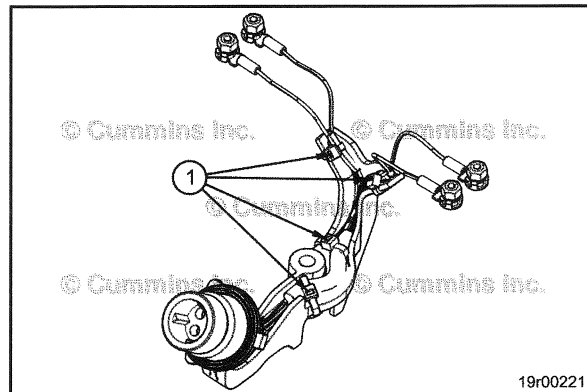
## Install

Install the internal injector wiring harness and support assemble onto the cylinder head.

**Torque Value:** 8 N•m [ 71 in-lb ]



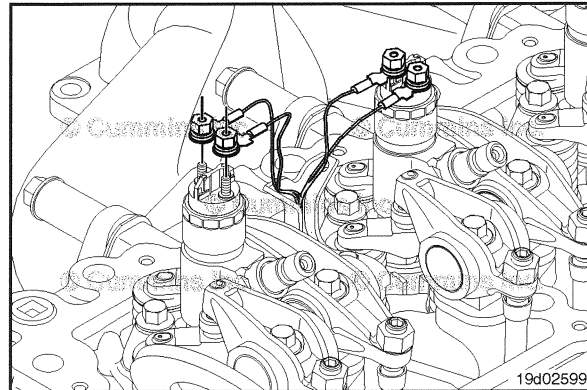
**NOTE:** There are four wire ties (1) that hold the injector wires to the support assembly. Make sure the wire ties are still intact and the wiring harness connector wires are engaged in the retaining clip.



**NOTE:** Injector wire to injector orientation is **not** significant.

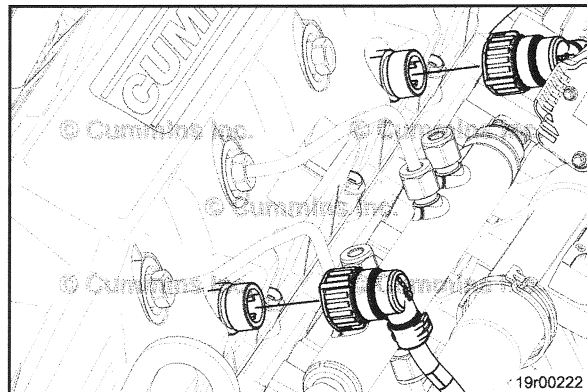
Install pigtail nuts on injectors.

**Torque Value:** 1.5 N•m [ 13 in-lb ]

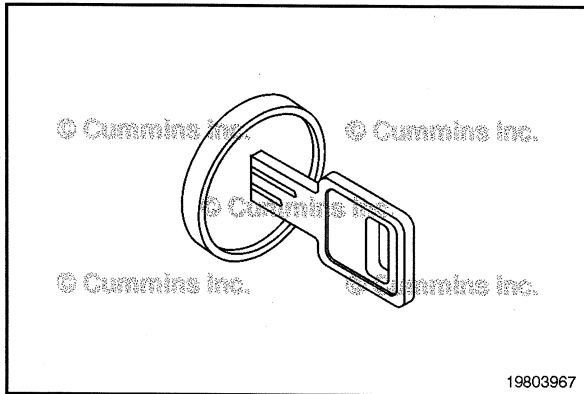


## Finishing Steps

- Install rocker lever cover. Refer to Procedure 003-011 in Section 3.
- Install the locking ring onto the injector wiring harness pass-through connector by rotating **clockwise** until a click is heard.
- Connect engine harness to pass-through connector by pushing in on the connector and rotating **clockwise** until a firm click is heard.
- Operate the engine and check for proper operation.



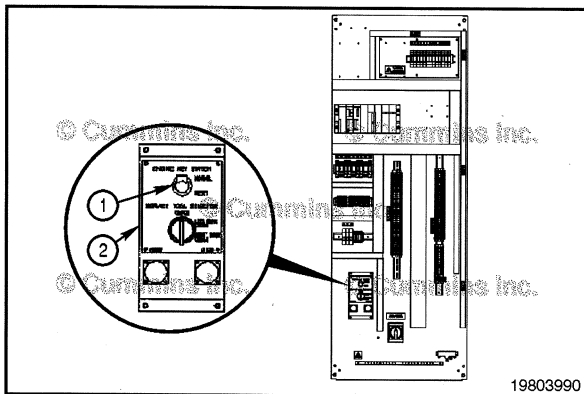




## Key Switch Battery Supply Circuit (019-064)

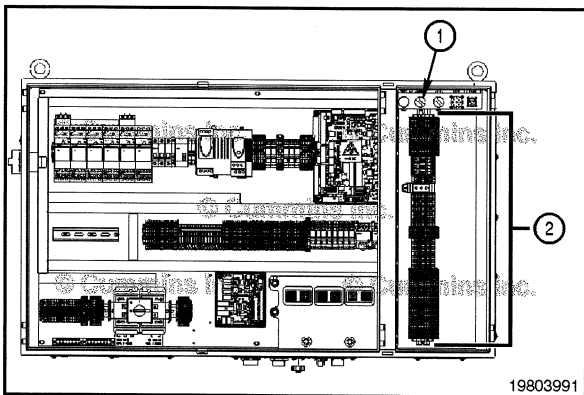
### Voltage Check

The vehicle keyswitch supplies an input signal to the electronic control module (ECM) which turns the ECM on or off.

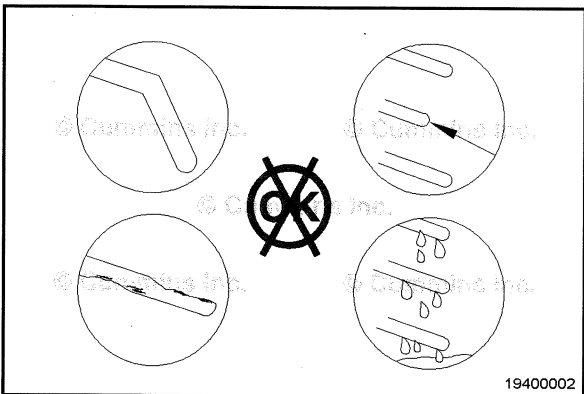


The Generator Set ECM Keyswitch supplies an input signal to all generator set electronic control modules (ECMs) which turns to ECM on or off.

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.

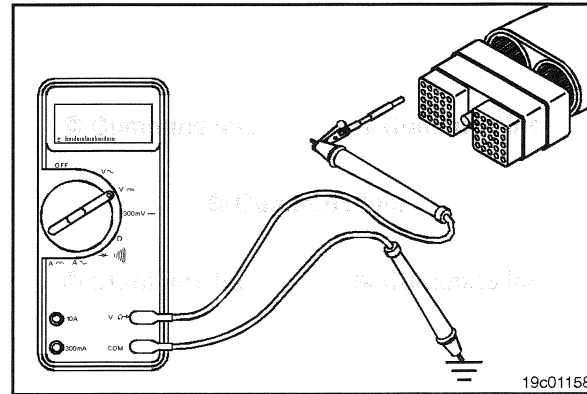
Repair or replace the wiring harness, keyswitch, or check the battery connections. Refer to the OEM troubleshooting and repair manual for the proper procedures.

**Engine Oil Pressure Sensor/Switch (019-066)**

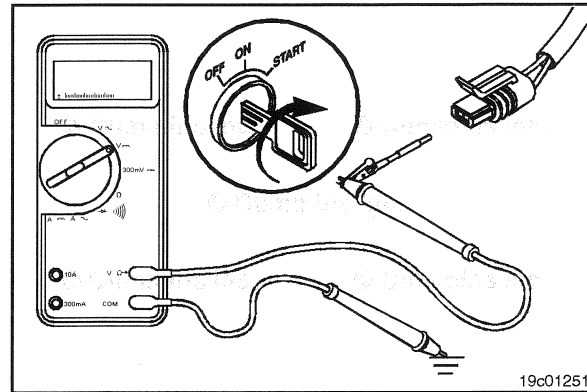
**Remove**

Disconnect the engine wiring harness from the engine oil pressure sensor.

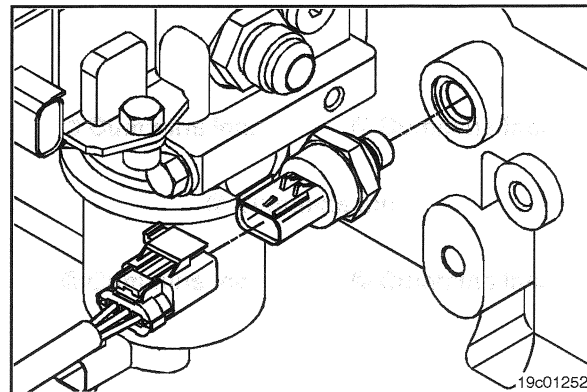
Remove the engine oil pressure sensor.



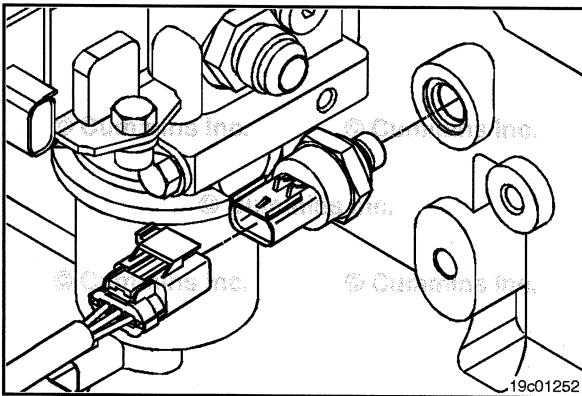
19c0115E



19c01251



19c01252



### Install

Verify the o-ring is installed on the sensor.

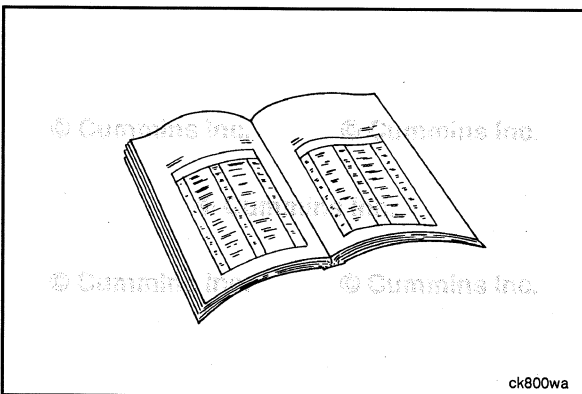


Install the engine oil pressure sensor.

**Torque Value:** 23 N·m [ 204 in-lb ]



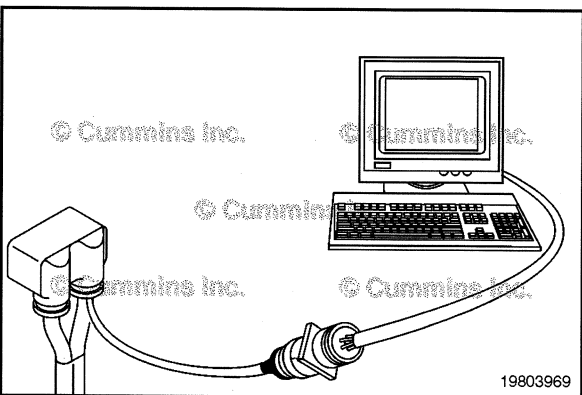
Connect the engine wiring harness to the engine oil pressure sensor. An audible click will be heard when the connector locks in place.



### OEM Wiring Harness (019-071)

#### General Information

The original equipment manufacturer (OEM) harness is supplied and installed by the vehicle manufacturer. Follow the vehicle manufacturer's procedures, if replacement is necessary. Refer to the vehicle manufacturer's troubleshooting and repair manual.



### 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.

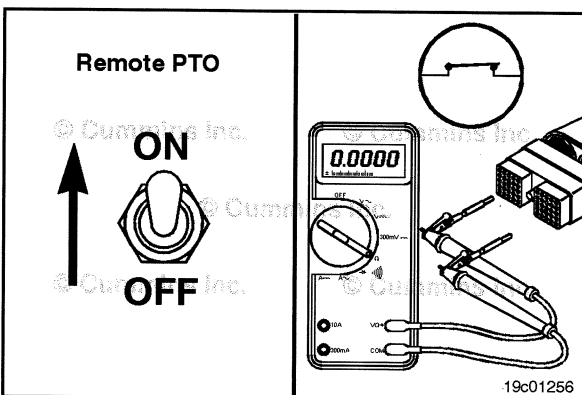
Consult the appropriate electronic service tool manual to adjust the parameters or features.

### 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.

Programmable Feature/Parameters Not Correct		
Symptom	Probable Cause	Correction
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 <b>not</b> correct or vehicle exceeding road speed governor set speed	Vehicle speed parameters <b>not</b> 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 <b>not</b> 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 <b>not</b> obtain maximum vehicle speed with semiautomatic transmission	The gear-down protection parameters are <b>not</b> correct.	Change the top gear ratio parameter to be equal to the first gear-down ratio, <b>not</b> 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 <b>must</b> 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 <b>not</b> shift into top gear	Top gear ratio setting does <b>not</b> 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 <b>not</b> turn on	Fan control feature is <b>not</b> set properly.	Verify all fan control feature parameters are properly set for the vehicle.
Fan will <b>not</b> turn off	Fan control feature is <b>not</b> set properly.	Verify all fan control feature parameters are properly set for the vehicle.
Fan control switch will <b>not</b> 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.
Unable to obtain maximum vehicle speed	Cruise control maximum vehicle speed or accelerator maximum vehicle speed <b>not</b> 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.

Programmable Feature/Parameters Not Correct		
Symptom	Probable Cause	Correction
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 <b>not</b> 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 <b>not</b> 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 <b>not</b> 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.



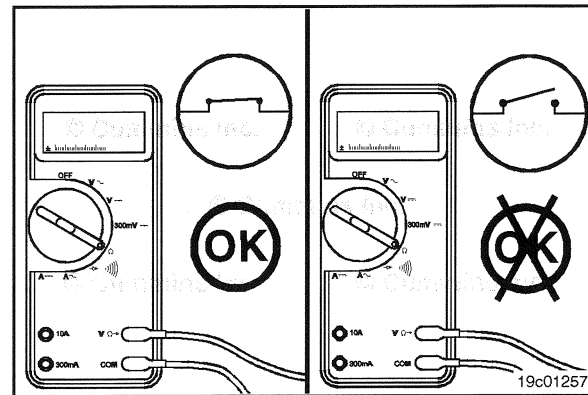
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

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.

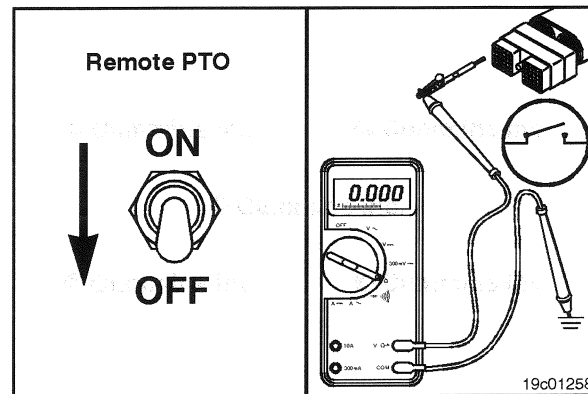
Disconnect the OEM harness from the ECM.

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.

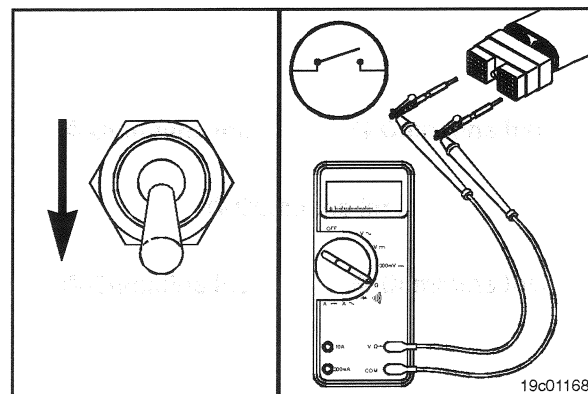
The multimeter **must** show an open circuit (100k ohms or more).

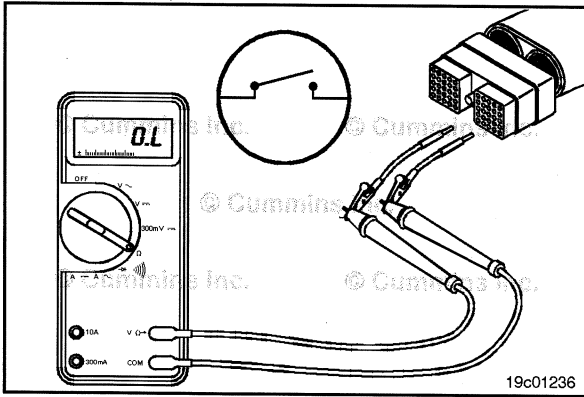
If the resistance values are **not** correct, make sure the remote PTO switch signal wire and the ground wire are properly installed on the switch. If both wires are correctly installed, inspect the wires for a short to ground circuit, provided the remote PTO switch has been previously checked.



### 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).



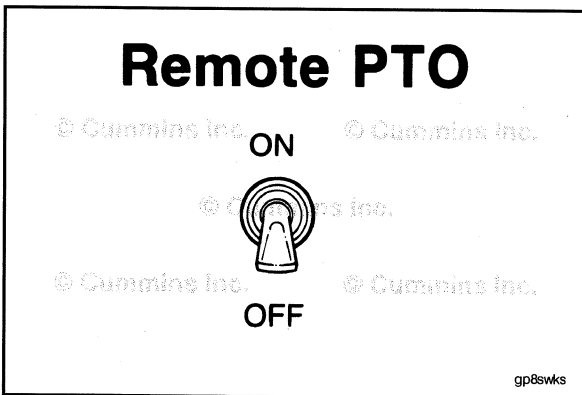


Remove the lead from the remote PTO switch return pin and insert it into the remote PTO switch signal pin of the harness connector. With the other test lead, check all other pins in the connector. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).



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.

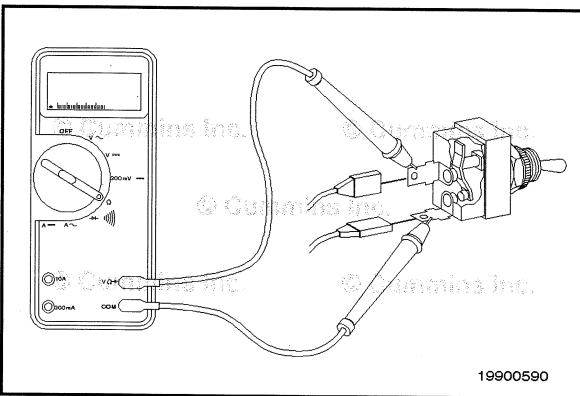
Connect all components after completing the repair.



## 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

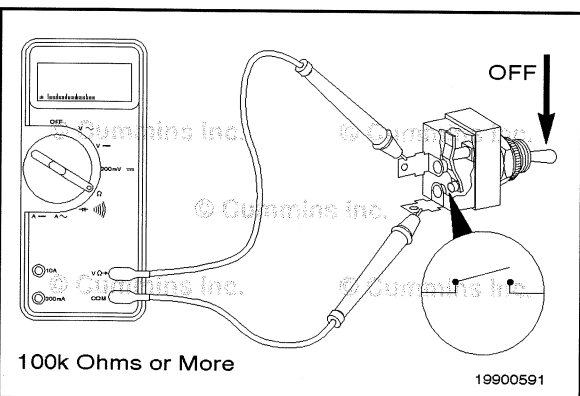
Locate the desired ON/OFF toggle switch.



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.



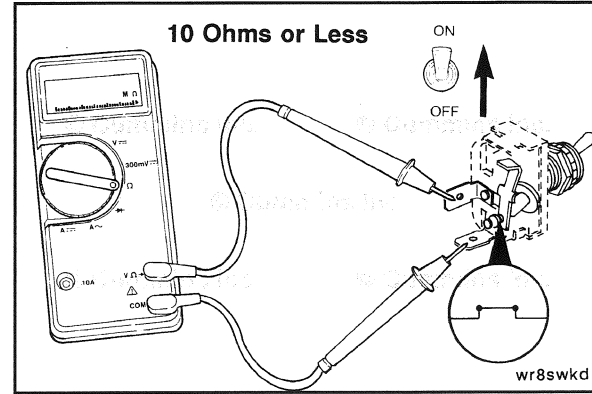
Replace the switch. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

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.



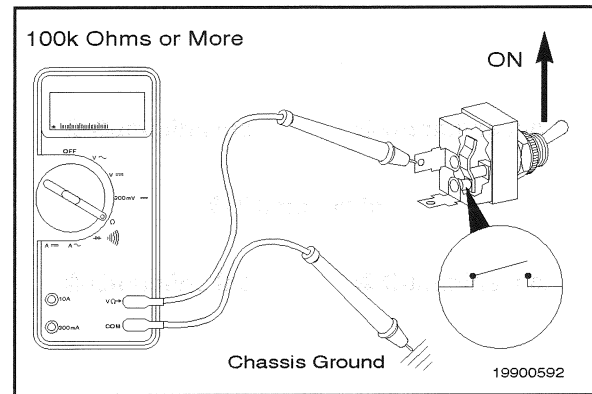
Replace the switch. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

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.

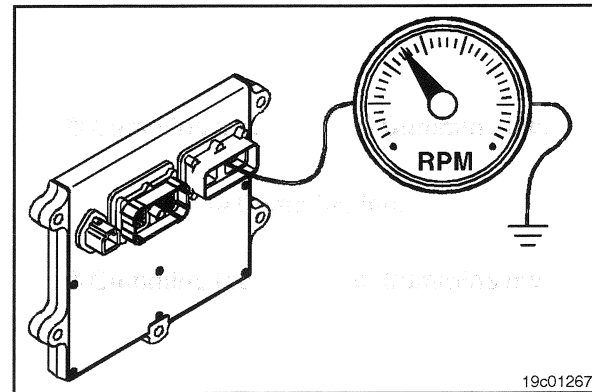


### Tachometer Circuit (019-083)

#### 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 wire in the original equipment manufacturer (OEM) harness.



### Resistance Check

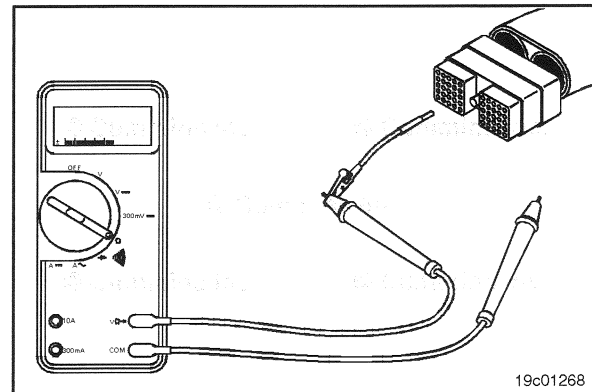
#### ⚠ CAUTION ⚠

Do not use probes or leads other than Cummins® Part Number 3822758. The connector will be damaged. The leads must fit tightly in the connector without expanding pins in the connector.

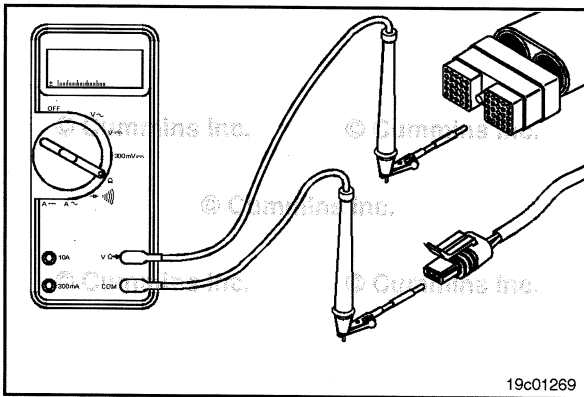
Disconnect the OEM harness from the ECM connector.

Disconnect the tachometer from the OEM harness.

Insert a test lead into the tachometer SIGNAL pin of the OEM harness connector and connect it to one of the multimeter probes.







Locate the tachometer connector of the OEM harness.

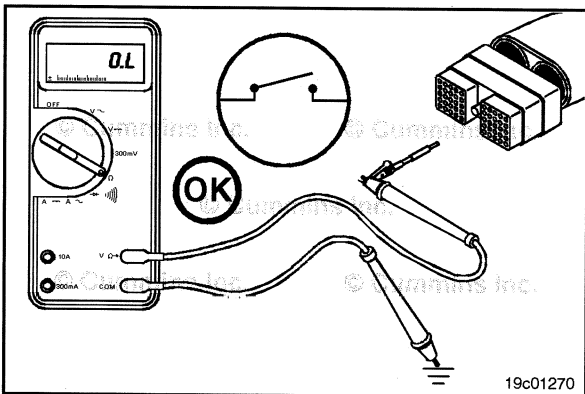


Insert another test lead into the tachometer SIGNAL pin of the tachometer connector that is coming from the engine ECM and connect it to the other multimeter probe. See equipment manufacturer service information for wiring schematics.

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 equipment manufacturer service information.



### Check for Short Circuit to Ground

Disconnect the tachometer from the OEM harness.



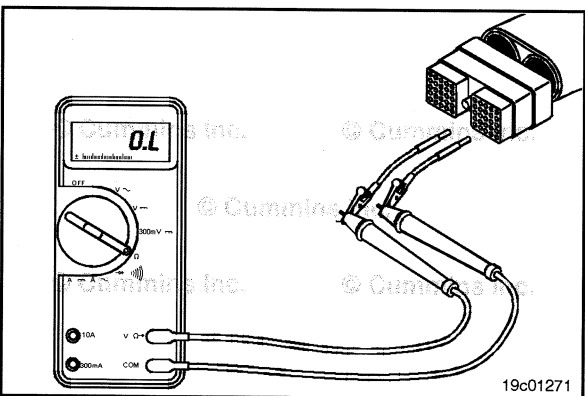
Insert the test lead into the tachometer SIGNAL pin of the OEM harness connector and connect it to the multimeter probe. Touch the other multimeter probe to the engine block ground.



Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or greater).

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 instructions.



### 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.

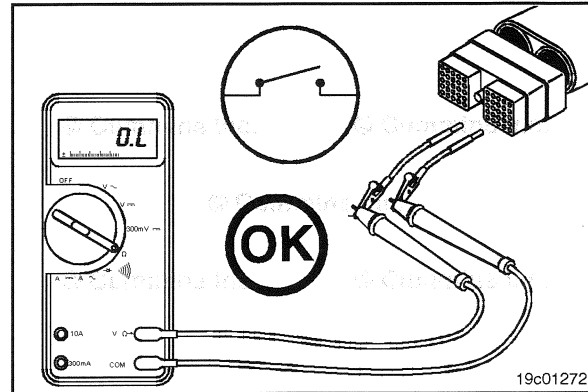
The multimeter **must** show an open circuit (100k ohms or greater).

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 and 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 greater) at all pins.

If any pin-to-pin check measures as **not** open, there is a short circuit between the tachometer SIGNAL pin and any other pin that measured a **not** open circuit. Repair or replace the OEM harness. Use the following procedure for information for harness replacement. Refer to Procedure 019-071 in Section 19.

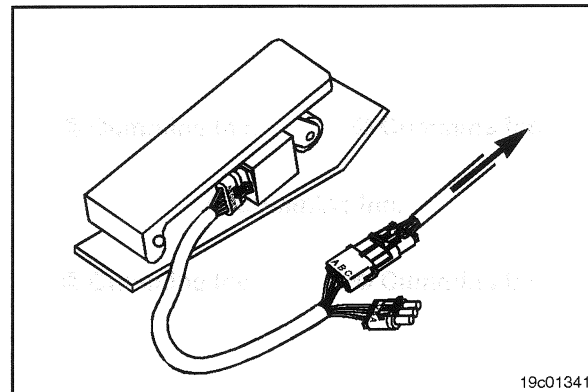


## Accelerator Pedal or Lever Position Sensor (019-085)

### 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.

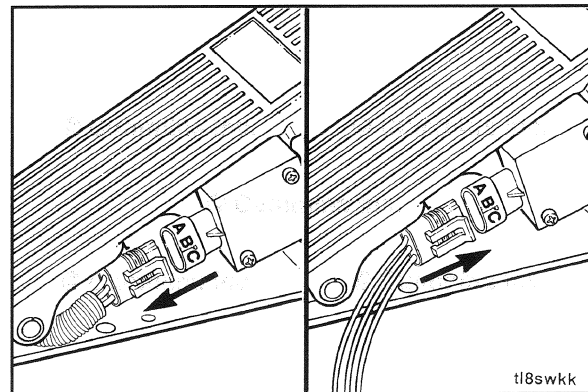


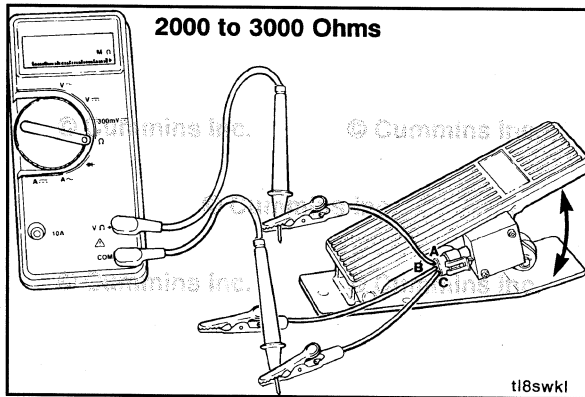
### Resistance Check

If INSITE™ 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.



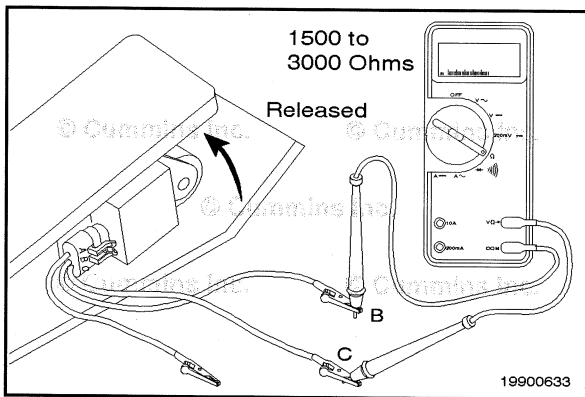


Connect the multimeter positive (+) test lead to the accelerator pedal/lever position +5 volt supply test connector wire. Connect the negative (-) multimeter test probe to the accelerator pedal/lever position return test connector wire.



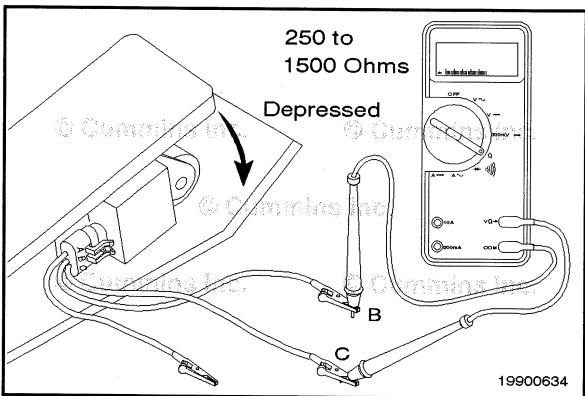
Measure the resistance. The multimeter **must** show between 2000 and 3000 ohms when the accelerator pedal is released (idle position) or depressed (full-fuel position).

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.

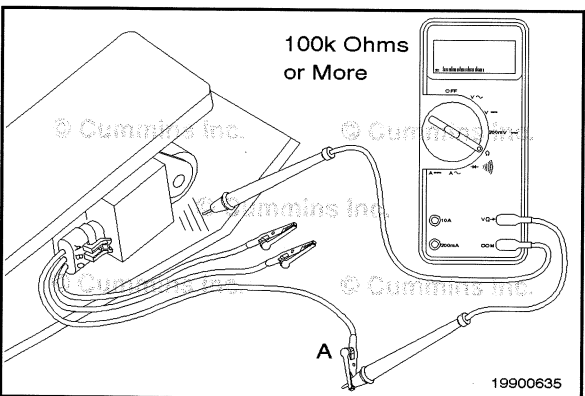


Remove the multimeter probe from the accelerator pedal/lever position +5 volt supply test connector wire and connect it to the accelerator pedal/lever position signal test connector wire.

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

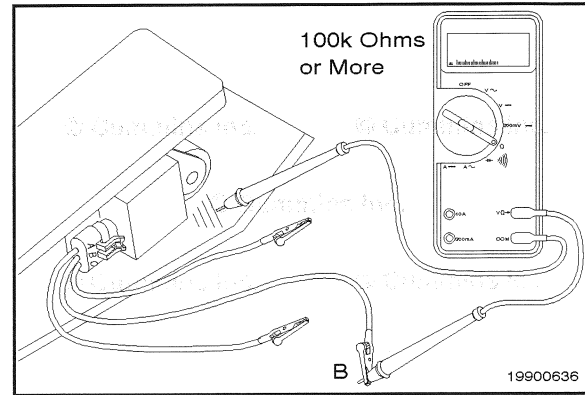
Connect the multimeter positive (+) probe to the accelerator pedal/lever position return test connector wire. Touch the negative (-) multimeter probe to the chassis ground and measure the resistance.

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).

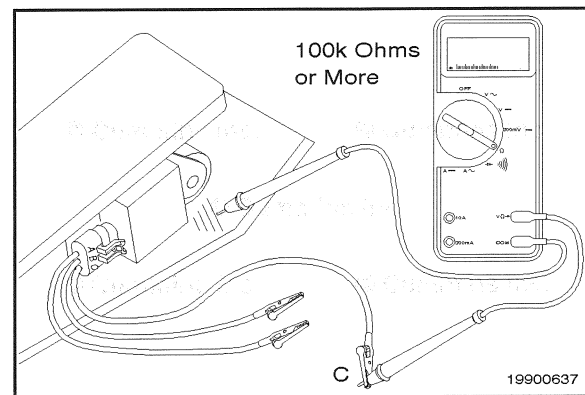


Remove the multimeter positive (+) probe from the accelerator pedal/lever position signal test connector wire and connect it to the accelerator pedal/lever position +5 volt supply test connector wire. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).



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

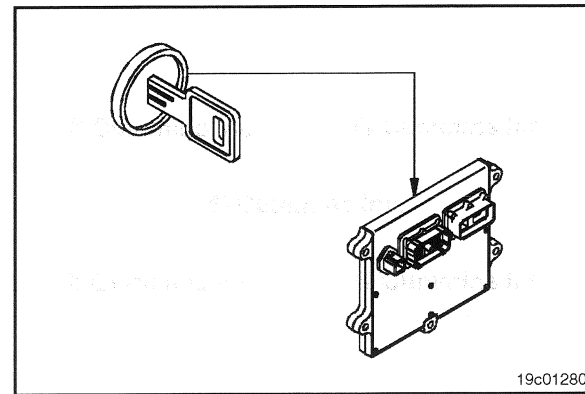


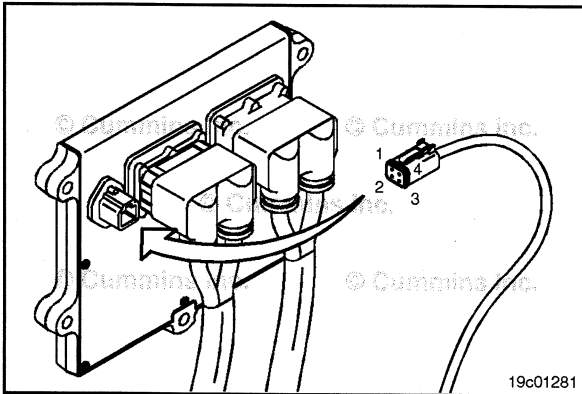
The engine control module (ECM) receives constant voltage from the batteries through the ECM battery positive (+) SUPPLY wire that is connected directly to the positive (+) battery post. There is one in-line 30-amp fuse in the ECM SUPPLY wire to protect the ECM. The ECM receives switched battery input through the keyswitch input signal when the vehicle keyswitch is turned ON. The ECM battery negative (-) SUPPLY wire is connected directly to the negative (-) battery post.

The ECM battery positive (+) SUPPLY wire and the ECM battery negative (-) SUPPLY wire are in the ECM power harness.

Always check the ECM battery supply fuse when troubleshooting the ECM and power supply circuit.

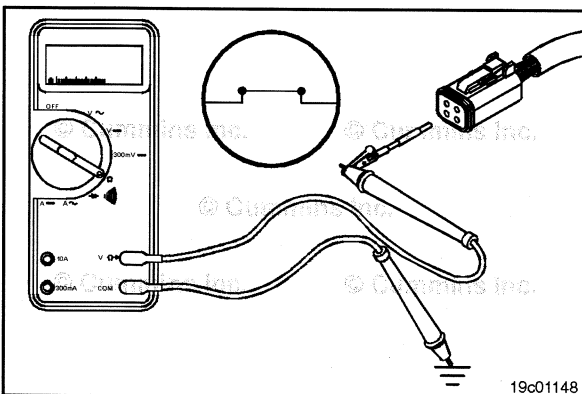
Check the battery voltage. Refer to Procedure 019-008 in Section 19.





### Resistance Check

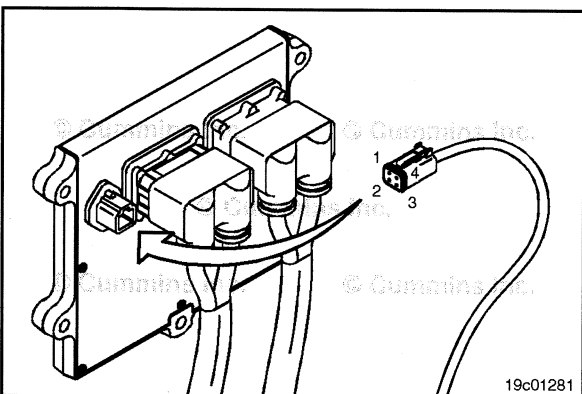
Disconnect the ECM power harness connector from the ECM connector.



Adjust the multimeter to measure resistance.

Insert a test lead into the ECM battery negative (-) SUPPLY pin of the ECM power 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 10 ohms or less.

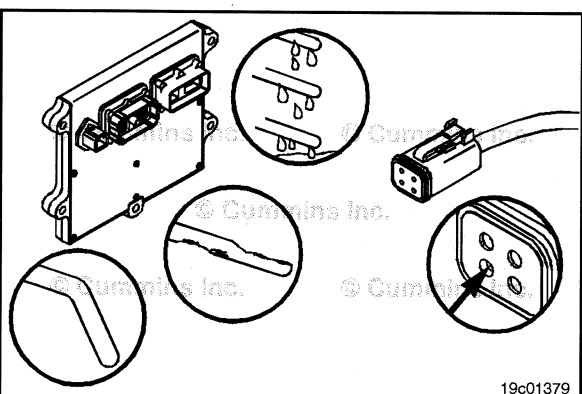


If the resistance value is **not** correct, check the ECM power harness.

Repair or replace the ECM power harness.



When the checks have been completed, connect the ECM power harness connector.



**NOTE:** Some original equipment manufacturer (OEM) applications have the ECM power harness with all 4 pins in the connector populated.



Check the battery RETURN wire in the ECM power harness for proper grounding.

Disconnect the harness from the ECM connector.

Check for damaged pins in the ECM and the harness.

Repair or replace any damaged pins.

## Voltage Check

Check the battery voltage supply at the ECM battery positive (+) SUPPLY pin of the ECM power connector.

Turn the keyswitch to the OFF position.

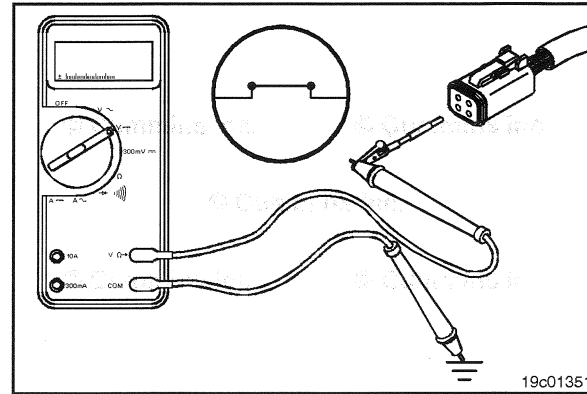
Disconnect the 4-pin ECM power harness connector from the ECM connector.

Set the multimeter to measure Volts of Direct Current (VDC).

Measure the voltage from the ECM battery positive (+) SUPPLY pin to ground.

The voltage **must** read battery voltage at this pin.

If the voltage is **not** correct, repair or replace the ECM power harness.



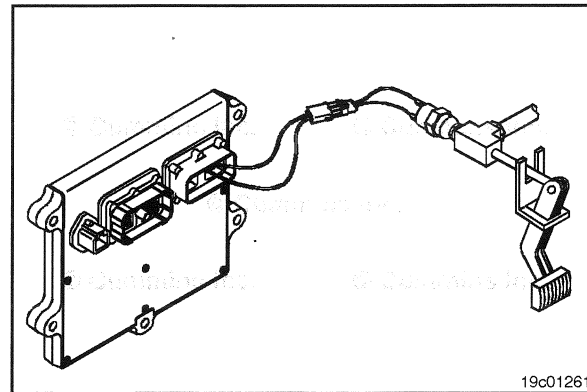
19c01351

## 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.



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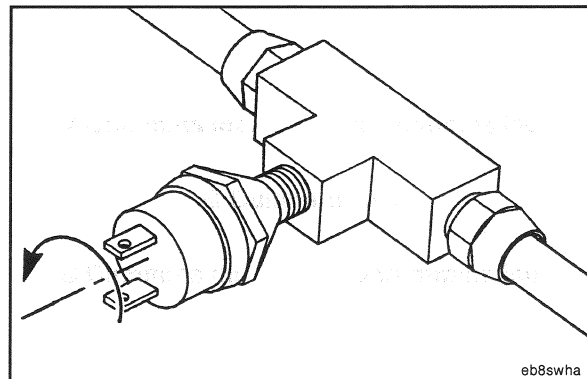
## Remove

### ⚠ WARNING ⚠

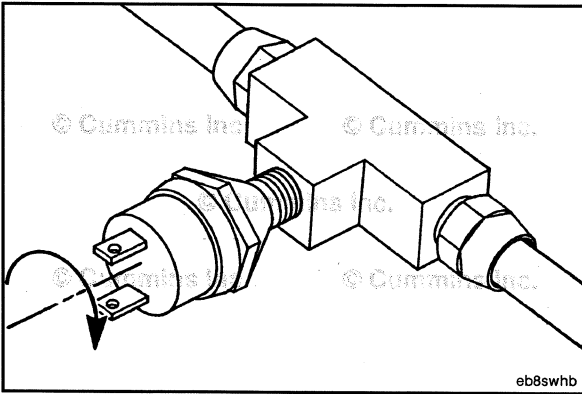
To avoid personal injury or death, do not apply the vehicle brakes when the switch is removed from the brake line fitting.

Disconnect the OEM harness from the brake pedal position switch.

Remove the brake pedal position switch from the fitting.

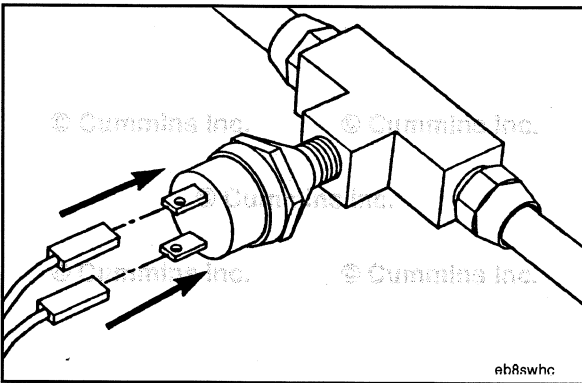


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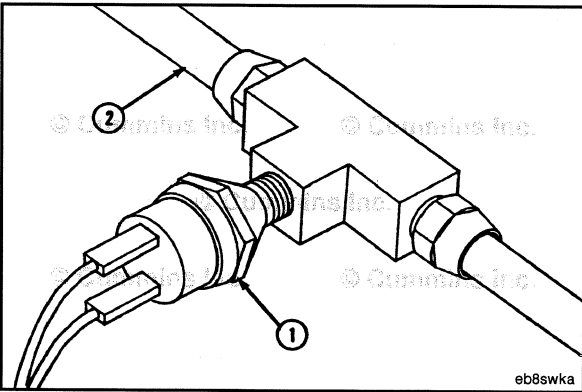


### Install

Install the new brake pedal position switch into the fitting according to the vehicle manufacturer's procedures.



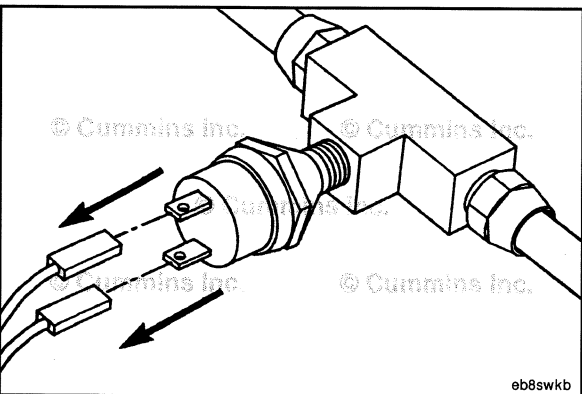
Connect the two wire connectors to the brake pedal position switch.



### Resistance Check

If INSITE™ 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.

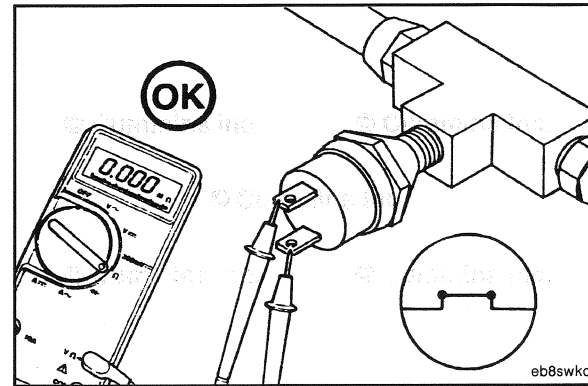


Disconnect the two wire connectors from the brake pedal position switch.

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.

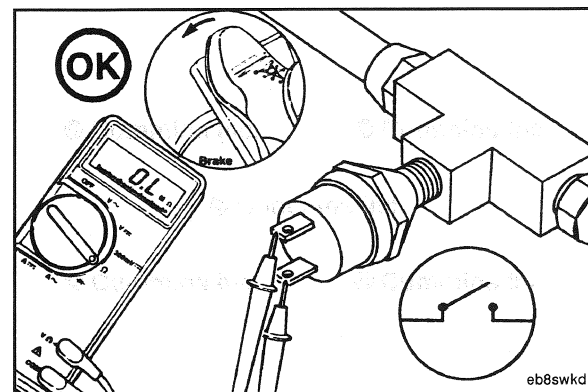


### ⚠ CAUTION ⚠

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.

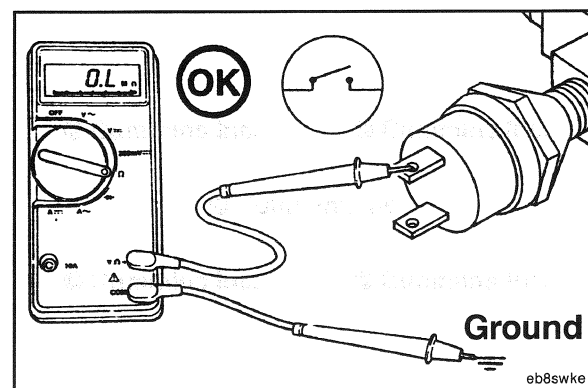
If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.



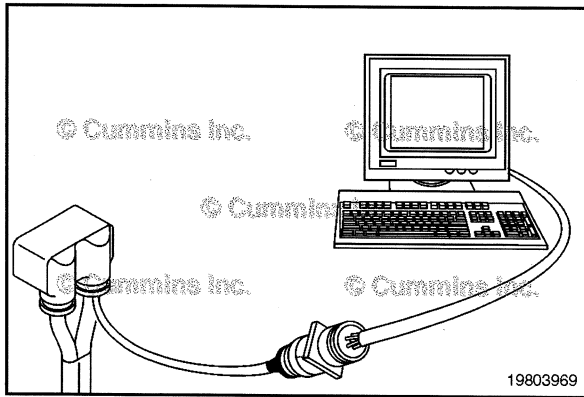
### Check for Short Circuit to Ground

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.







## Brake Pedal Position Switch Circuit (019-089)



### Resistance Check



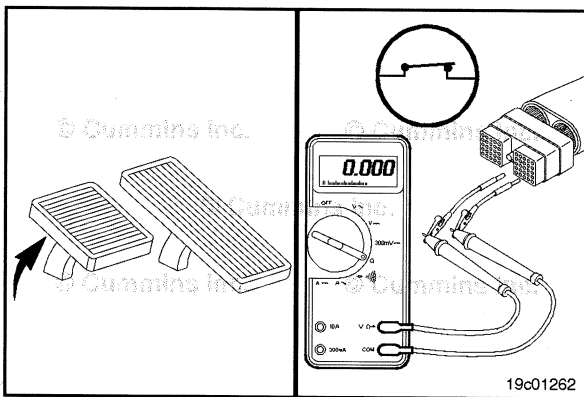
#### ⚠CAUTION⚠

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 INSITE™ 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 connector from the electronic control module (ECM).

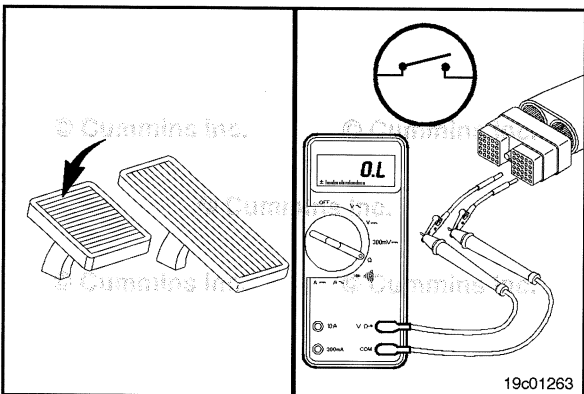


Make sure the brake pedal position switch is connected to the circuit.



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.

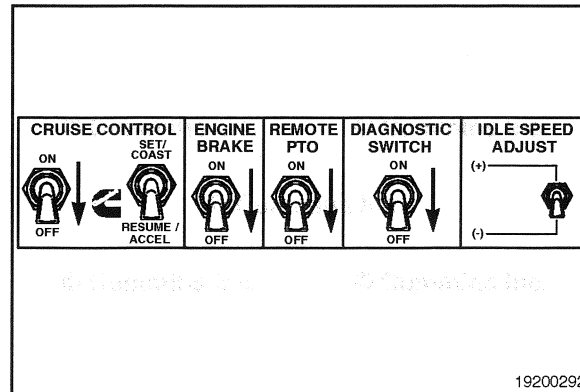
### Check for Short Circuit to Ground

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.

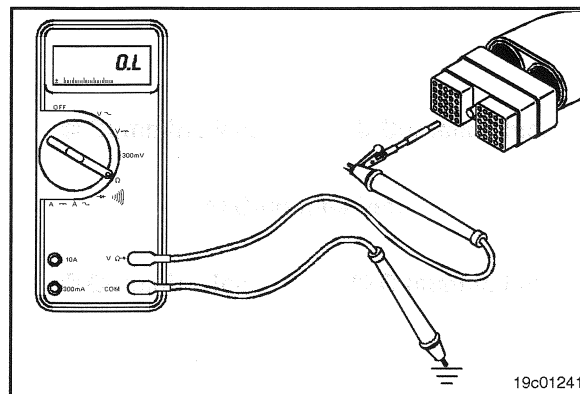
Set the service brake using the trailer brake hand valve.

Disconnect the clutch pedal position switch, accelerator position switch and the idle validation on/off switch.



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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.



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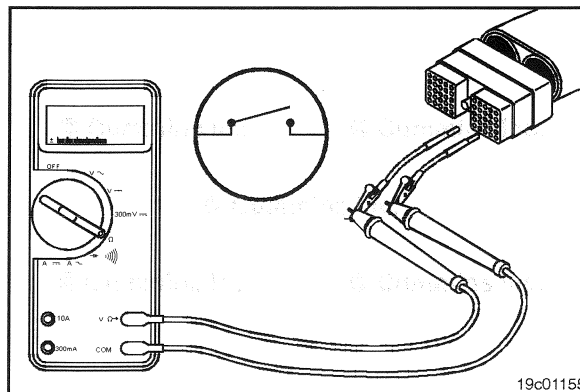
The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the brake pedal position switch signal wire, provided that the switch has been previously checked.

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

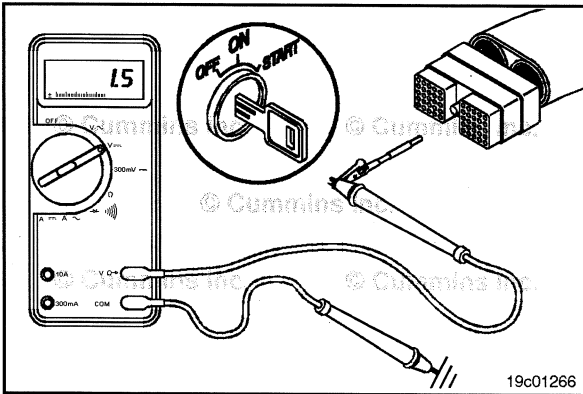
Isolate the brake pedal position switch circuit by disconnecting the brake pedal position switch connector and the OEM harness connector at the ECM. Insert a test lead into the brake pedal position switch signal pin of the OEM harness connector. Insert the other test lead into the switch return pin of 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).



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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



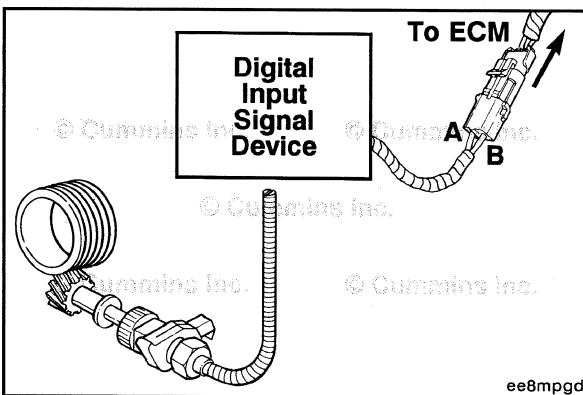
Disconnect the brake pedal position switch from the OEM harness and disconnect the OEM harness from the ECM. Turn the vehicle keyswitch to the ON position. Adjust the multimeter to measure VDC. Insert a test lead into the brake pedal position switch signal pin and connect it to the positive multimeter 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**

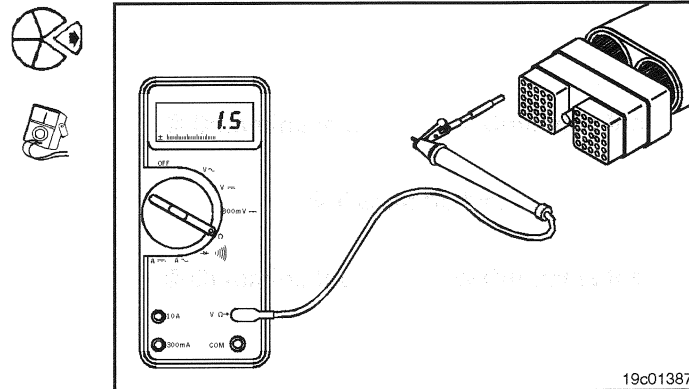
**⚠ CAUTION ⚠**

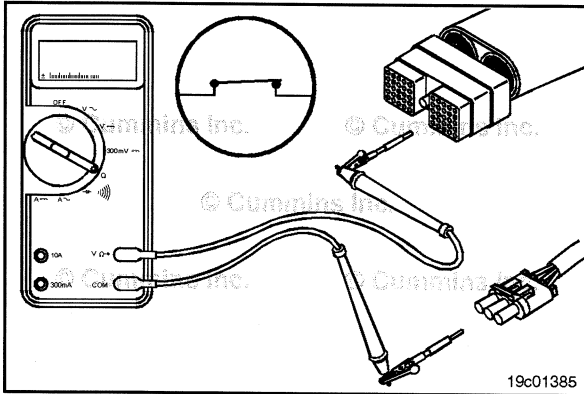
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the OEM harness connector from the ECM connector.

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 OEM harness connector from the ECM.

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.

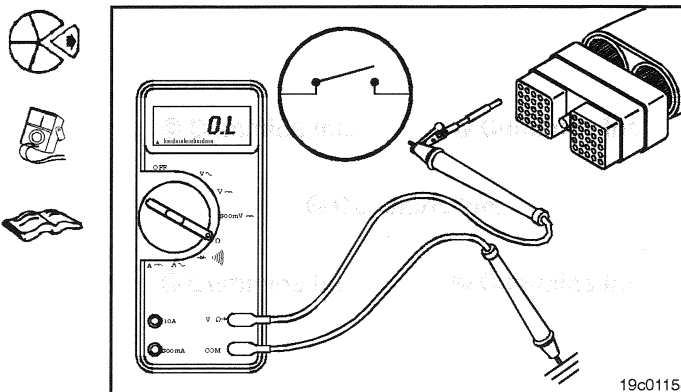
The multimeter **must** show an open circuit (100k ohms or more).

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.

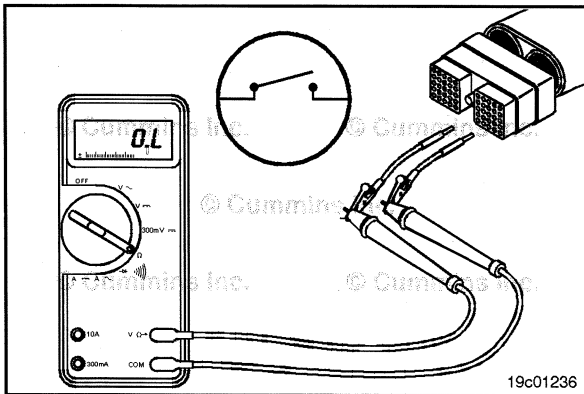
The multimeter **must** show an open circuit (100k ohms or more).

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.



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### Check for Short Circuit from Pin to Pin

Disconnect the vehicle speed sensor from the OEM harness.

Disconnect the OEM harness connector from the ECM connector.

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 pin.

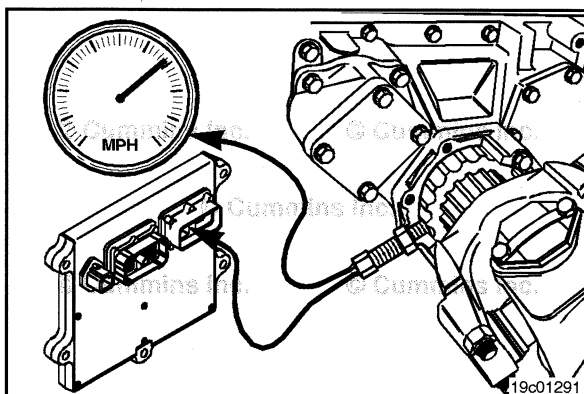
Use the other test lead to check all pins in the connector. Measure the resistance.

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, Magnetic Pick Up (019-091)

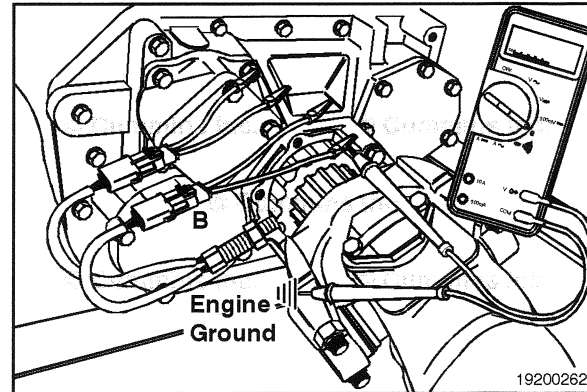
#### General Information

The vehicle speed sensor (VSS) senses the speed of the output shaft of the transmission. The vehicle's road speed is computed from this data by the electronic control module (ECM). The ECM uses programmed gearing and tire size data to compute the road speed.

The vehicle speed sensor is located in the rear of the transmission housing.

The vehicle speed sensor has two coils. One coil is connected to the ECM and the other coil is connected to the vehicle speedometer, or some other vehicle device.

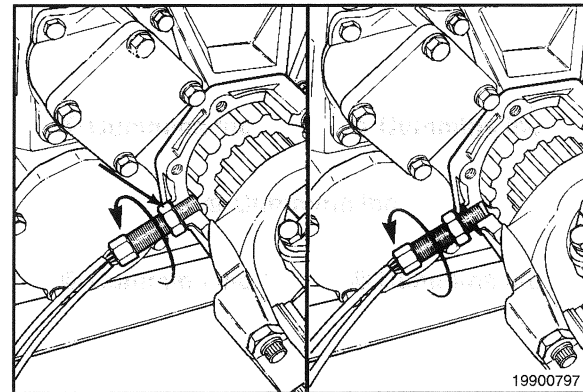
**NOTE:** Vehicle speed sensor design varies with the application. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual to understand which type of vehicle speed sensor is being used in a given location.



### Remove

Disconnect the engine harness from the vehicle speed sensor.

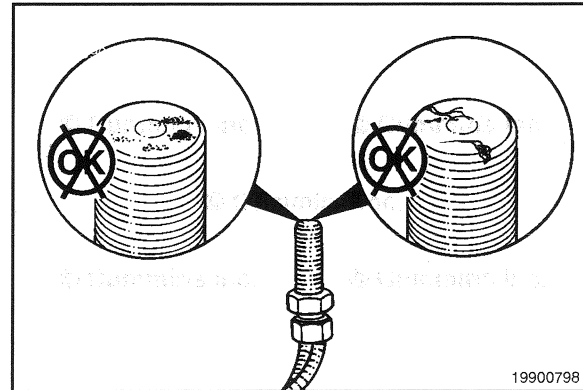
Loosen the locknut. Turn the vehicle speed sensor out of the transmission housing.



### Inspect for Reuse

Inspect the tip of the vehicle speed sensor for dirt, debris, or physical damage (cracked potting, and so forth).

Clean the tip if dirty, or replace the vehicle speed sensor if damaged.

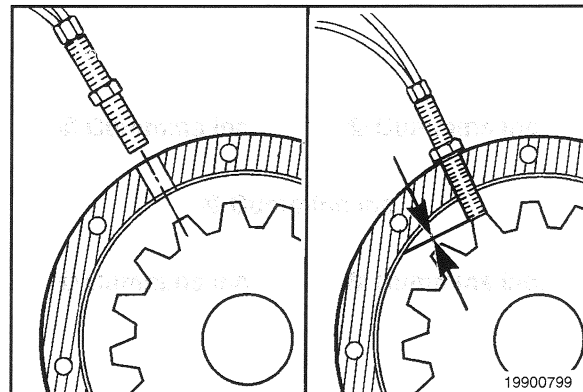


### Install

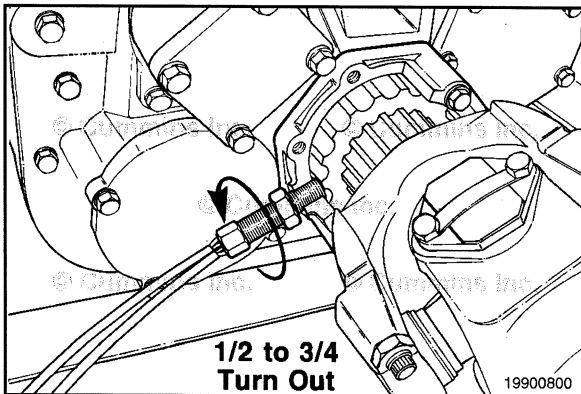
#### ⚠ CAUTION ⚠

**Make sure a gear tooth is aligned with the hole in the housing. Install the vehicle speed sensor into the hole until it touches the gear tooth.**

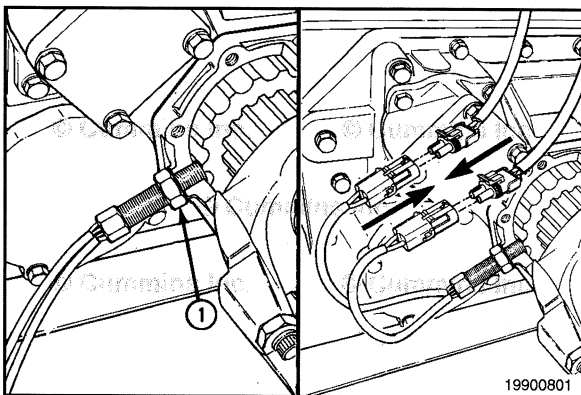
**NOTE:** If the vehicle speed sensor does **not** turn in with finger pressure, check the transmission hole threads and the sensor threads for dirt or damage.







Turn the vehicle speed sensor out 1/2 to 3/4 of a turn.

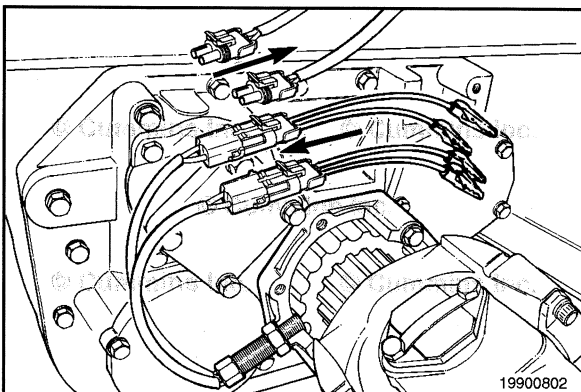


Tighten the locknut against the transmission housing.

Torque the sensor according to the OEM or transmission specifications. Refer to the OEM troubleshooting and repair manual for detailed procedures.



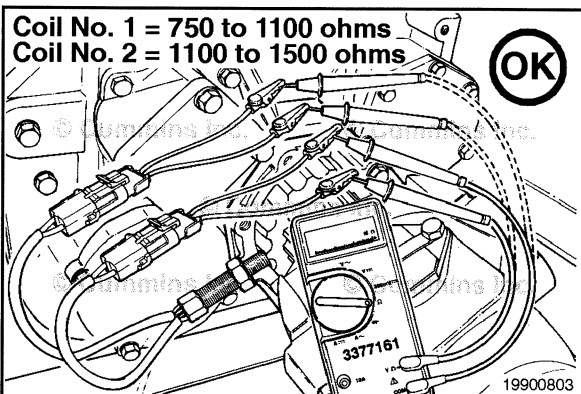
Install both of the connectors together until connectors "snap" into position. The connectors can be interchanged with each other without changing the performance of the system.



### Resistance Check

Lift the tab on the connectors and pull them apart.

**NOTE:** When measuring the resistance value of the vehicle speed sensor coils, use two female test leads. This will allow the electrical leads of the sensor to be softly flexed to check for damaged or partially broken wire strands under the insulation.

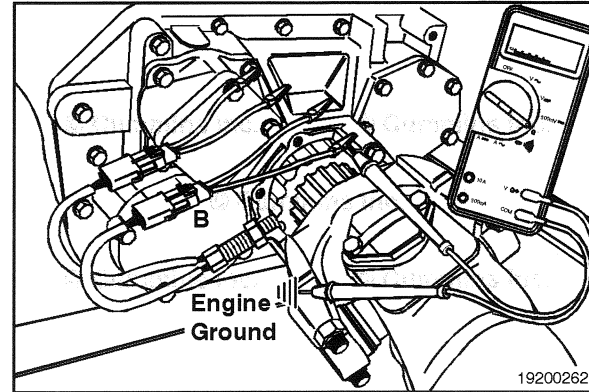


Use a multimeter to measure the resistance between the two pins of each connector on the vehicle speed sensor. Refer to the OEM troubleshooting and repair manual for detailed procedures. If the resistance is **not** correct, replace the vehicle speed sensor. If the resistance value is correct, the vehicle speed sensor **must** still be checked for a short circuit to ground and a short circuit between coils.

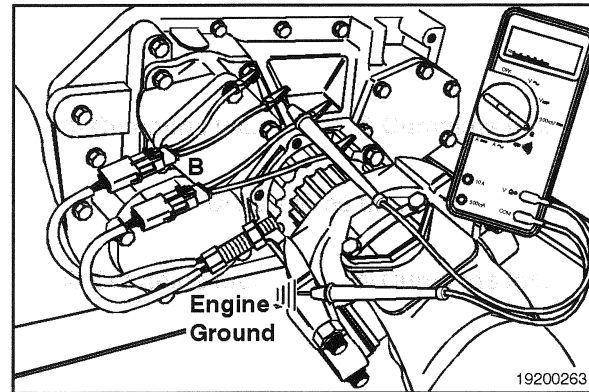


### Check for Short Circuit to Ground

Measure the resistance between the magnetic vehicle speed sensor signal negative (-) pin of one of the connectors and the engine block. Refer to the OEM troubleshooting and repair manual for detailed procedures.

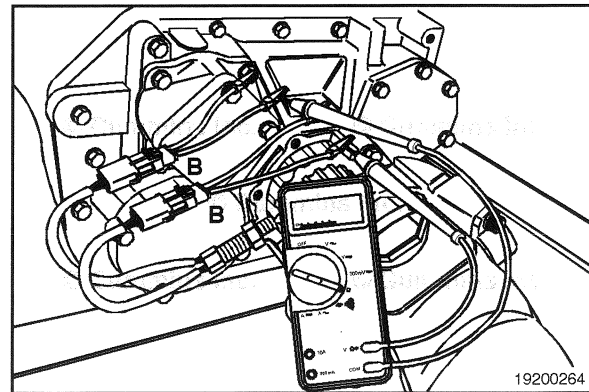


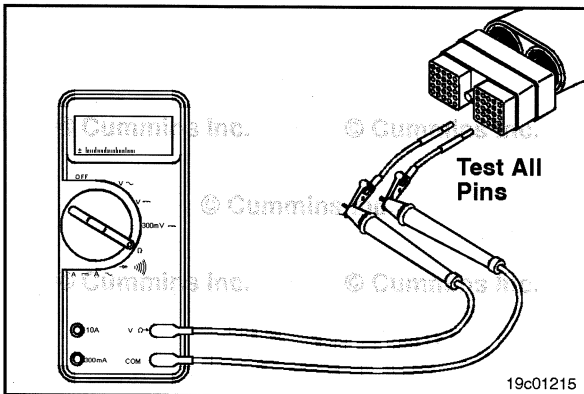
Measure the resistance between the magnetic vehicle speed sensor signal negative (-) pin of the other connector and the engine block. Refer to the OEM troubleshooting and repair manual for detailed procedures.



### Check for a short circuit between coils

Use a multimeter to measure the resistance between the magnetic vehicle speed sensor signal negative (-) pin of one of the connectors and the magnetic vehicle speed sensor signal (-) pin of the other connector. Refer to the OEM troubleshooting and repair manual for detailed 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.



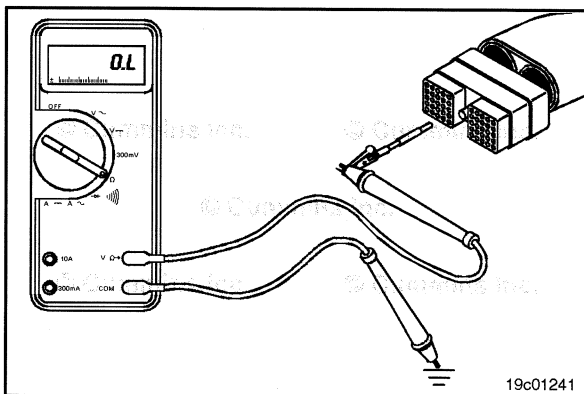
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). Make sure the vehicle speed sensor is connected to the OEM harness.

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).

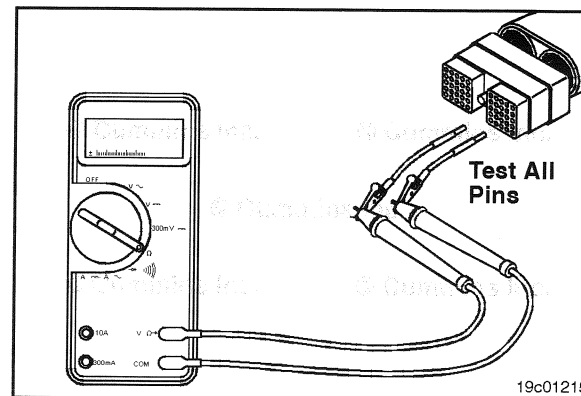
If the circuit is **not** open, there is a short circuit to ground in the vehicle speed sensor circuit in the engine harness or OEM harness.

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).



## Rail Fuel Pressure Sensor (019-115)

### General Information

The fuel pressure sensor is located on the fuel rail, which is mounted just above the intake manifold.

### Preparatory Steps

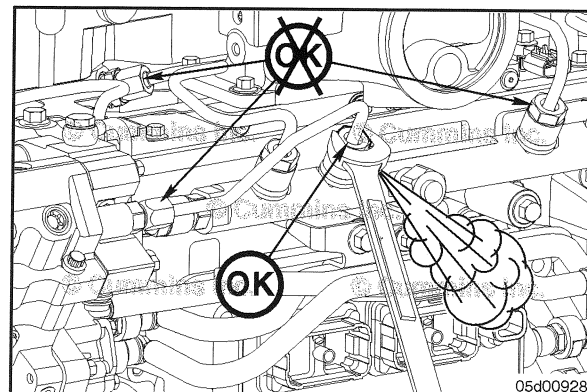
#### ▲ WARNING ▲

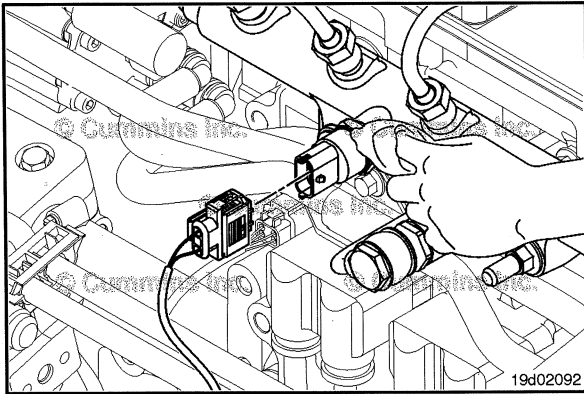
The fuel pump, high-pressure fuel lines, and fuel rail contain fuel under pressure sufficient to penetrate the skin and cause serious personal injury. Do not loosen any fittings while the engine is operating. Wait at least 10 minutes after shutting down the engine before loosening any fittings in the high-pressure fuel system to allow pressure to decrease to a lower level.

- 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 the fuel rail nut.

**Torque Value:** 65 N•m [ 48 ft-lb ]

**NOTE:** A machined slot in this fitting directs the fuel spray towards the engine block.



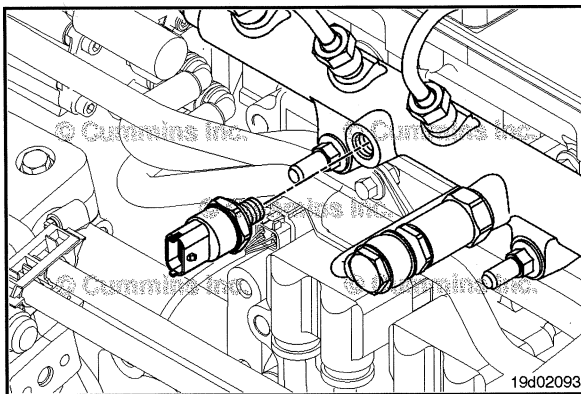


### Remove

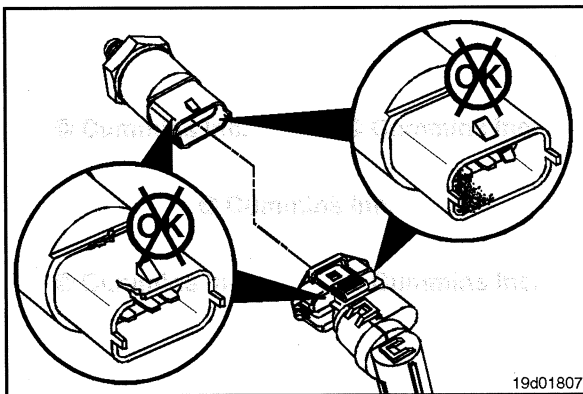
Clean the area around the fuel pressure sensor.



Disconnect the pressure sensor connector from the engine harness.



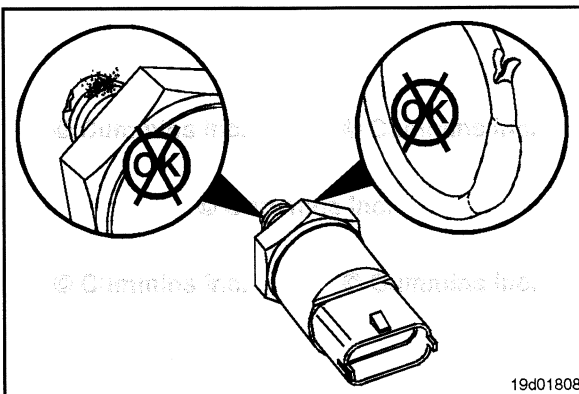
Remove the fuel pressure sensor.



### Inspect for Reuse

Inspect the engine harness connector and the fuel pressure 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.



Inspect the fuel pressure sensor for the following:

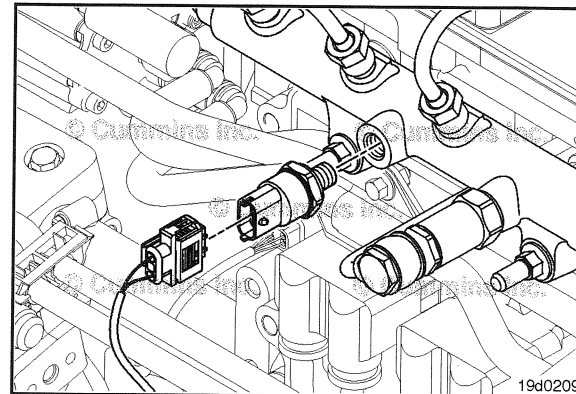
- Damaged seal surface in the rail.
- Damaged seal surface on the sensor.
- Thread damage.

## Install

Install a new fuel pressure sensor.

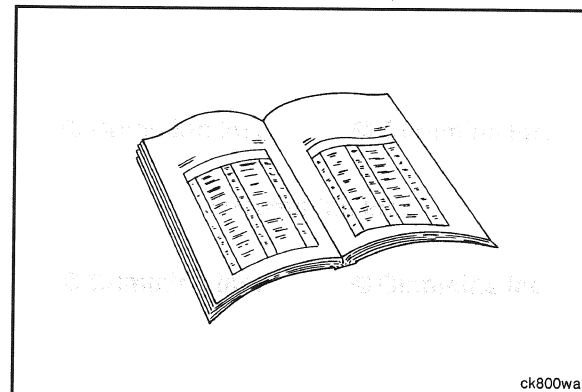
**Torque Value:** 70 N•m [ 52 ft-lb ]

Connect the engine harness to the fuel pressure sensor.



## Finishing Steps

Start the engine and check for leaks.



## Fuel Pump Actuator (019-117)

### Preparatory Steps

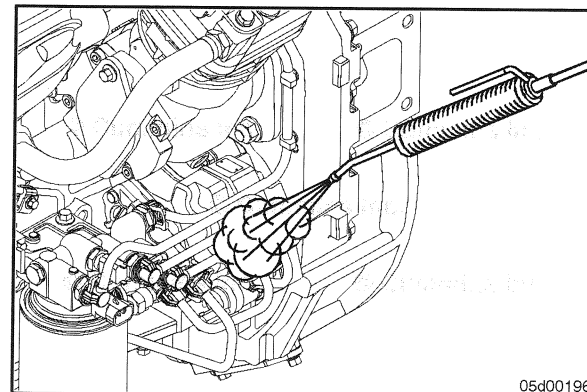
#### ⚠ WARNING ⚠

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

#### ⚠ WARNING ⚠

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

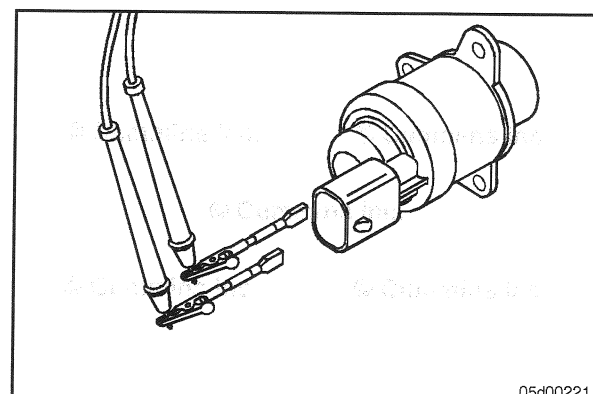
- Steam clean the fuel pump and the area around the fuel pump. Dry with compressed air.

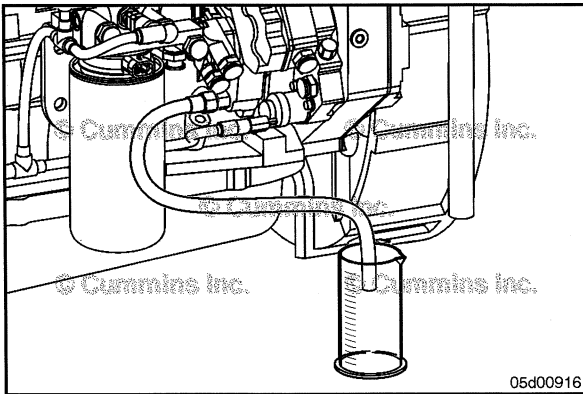


## Measure

Measure the resistance of the fuel pump actuator valve. The maximum resistance is 5 ohms.

Install the electrical connection after measurement.





With the keyswitch ON and the engine cranking, check the high pressure injection pump.

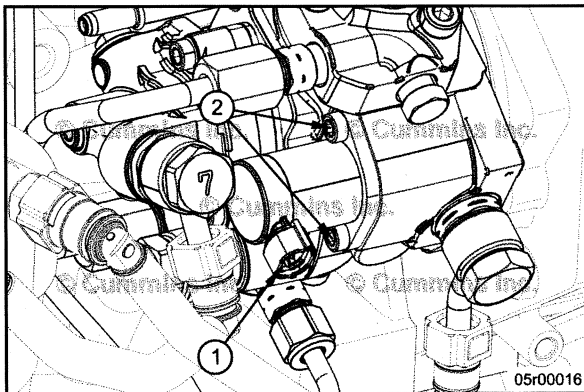
Check the high pressure injection pump fuel flow as follows:

- Disconnect the high pressure fuel line to the fuel rail from the high pressure injection pump.
- Connect a clear hose to the outlet of the high pressure injection pump
- Place the high pressure fuel clear hose into an empty bucket
- Crank the engine for 30 seconds and measure the fuel pump flow.

Minimum fuel pump flow is 50 ml [1.69 oz] in 30 seconds at 120 rpm.

If the minimum fuel flow is **not** achieved, the high-pressure injection pump is damaged. Refer to Procedure 005-016 in Section 5.

If the minimum fuel flow is achieved, the fuel pump actuator is damaged.



### Remove

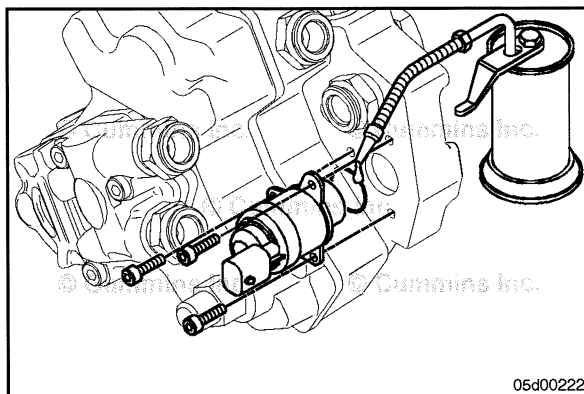
Disconnect the electrical connector (1).



Use a 5 mm hexagon wrench to remove the two mounting capscrews (2).

Remove the fuel pump actuator by pulling straight outward.

Remove and discard the fuel pump actuator o-ring.



### Install

**NOTE:** Lubricate the new fuel pump actuator housing o-ring with clean oil before installation.



Install a new o-ring on the fuel pump actuator.

Install guide pins in the actuator valve mounting capscrew holes. The pins will align the actuator to prevent damage to the o-ring during installation.

**⚠ CAUTION ⚠**

To reduce the possibility of damage to the actuator valve, be sure to orient the electrical connector to the outside of the pump.

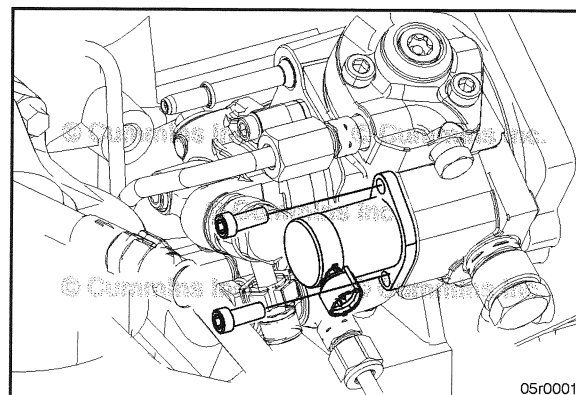
Slide the fuel pump actuator valve onto the guide pins, orienting the electrical connector to the outside of the pump. Push the actuator valve until the flange is flush with the mounting surface.

Remove the guide pins and install the two mounting capscrews. Tighten the capscrews in two steps.

**Torque Value:**

Step 1	4 N•m	[ 35 in-lb ]
Step 2	9 N•m	[ 80 in-lb ]

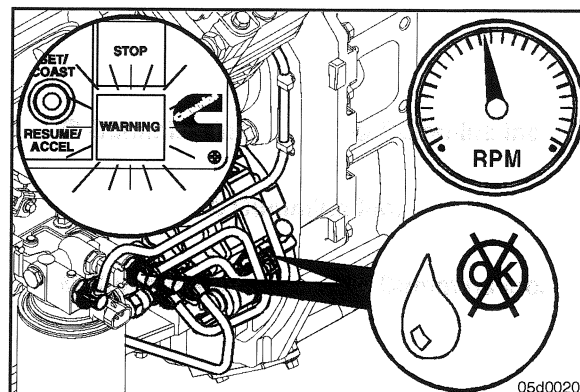
Connect the electrical connector.



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**Finishing Steps**

- Operate the engine and check for leaks or fault codes.

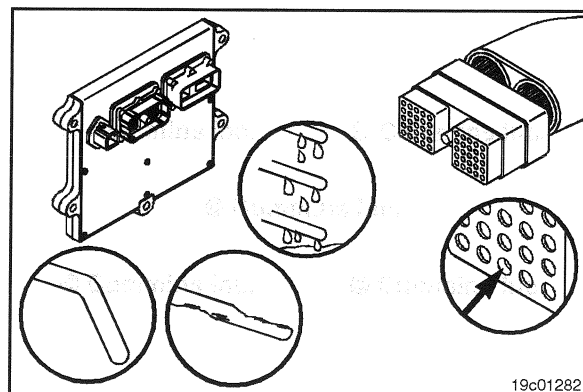


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**Water in Fuel Sensor (019-127)**

**General Information**

The water-in-fuel sensor separator is located at the base of the 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.



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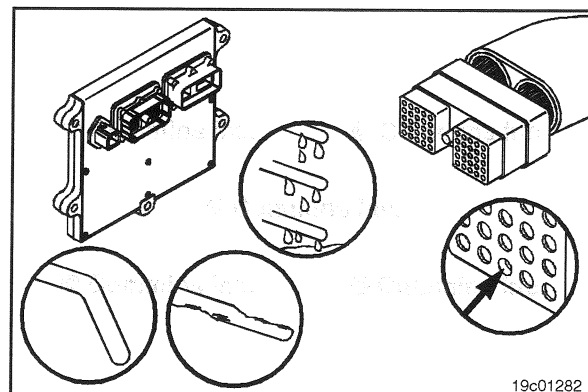
**Resistance Check**

**NOTE:** The water-in-fuel sensor is the water-in-fuel SIGNAL wire and the water-in-fuel RETURN wire in the engine harness connector.

Disconnect the engine harness from the ECM.

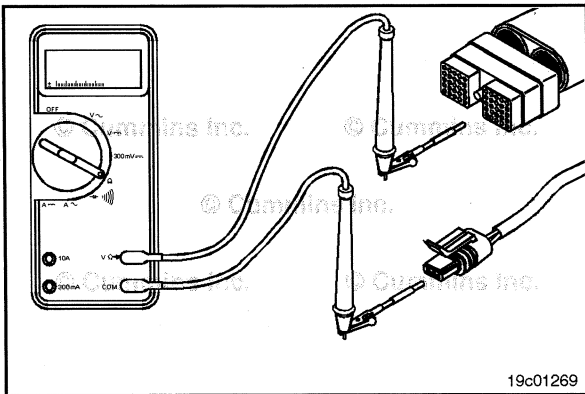
Check for damaged pins.

Disconnect the water-in-fuel sensor from the engine harness.



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### ⚠ CAUTION ⚠

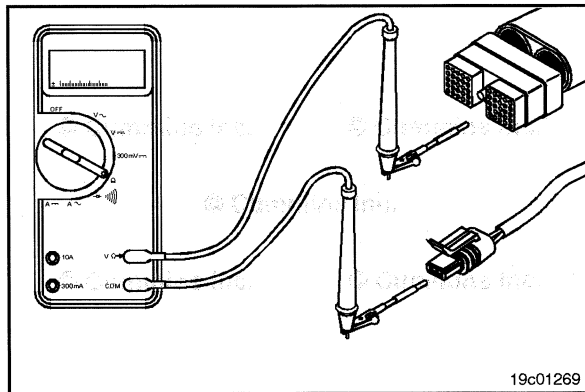
To reduce the possibility of pin and connector damage, use test lead, Cummins® Part Number 3822758, when taking a measurement.

#### RETURN Wire Resistance - Checking

- Insert the test lead into sensor RETURN pin (common return) of the engine harness connector. Connect the alligator clip to the multimeter probe. Touch the other multimeter probe to water-in-fuel RETURN pin of the water-in-fuel sensor, harness side.

#### Measure the resistance

- 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. Repair the wire, or replace the engine harness.

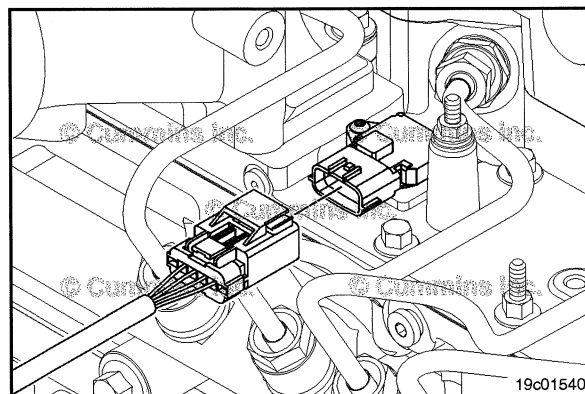


#### SIGNAL Wire Resistance - Checking

- Insert the test lead into the water-in-fuel SIGNAL pin of the engine harness connector. Connect the alligator clip to the multimeter probe. Touch the other multimeter probe to the SIGNAL wire pin of the water-in-fuel sensor, harness side.

#### Measure the resistance

- 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. Repair the wire, or replace the engine harness.



## Intake Manifold Pressure/Temperature Sensor (019-159)

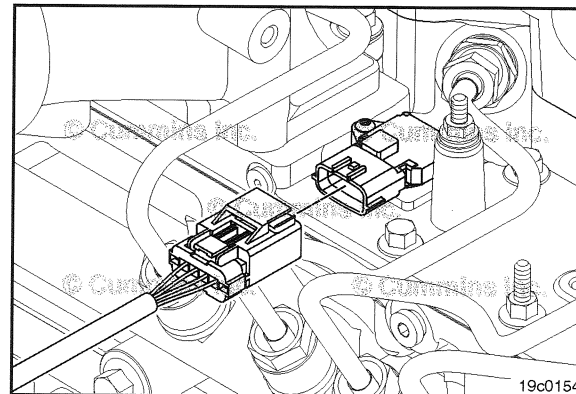
### General Information

The intake manifold temperature sensor and intake manifold pressure sensors are combined into a single sensor. The sensor is located in the intake manifold. Use the following procedure for a detailed component location. Refer to Procedure 100-002 in Section E.

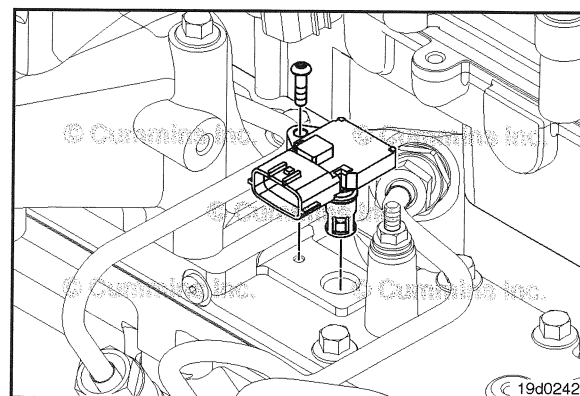
## Remove

Lift up on the locking tab and pull the electrical connectors apart.

Remove the capscrew.



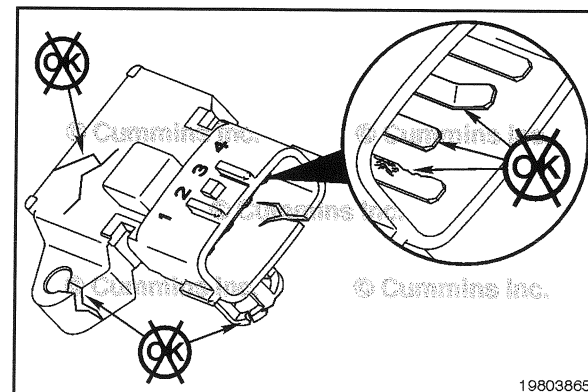
Remove the sensor from the engine by pulling straight up on the sensor. Be careful **not** to damage the o-ring seal or the plastic cage surrounding the sensor tip when removing the sensor. Do **not** pry the sensor, as damage to the plastic cage can occur.



## Inspect for Reuse

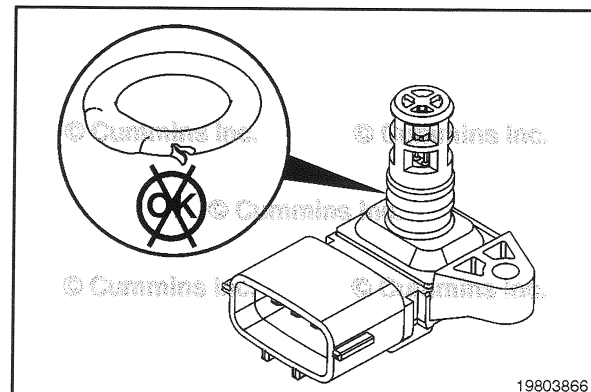
Inspect the engine harness connector and the intake manifold pressure/temperature sensor for the following:

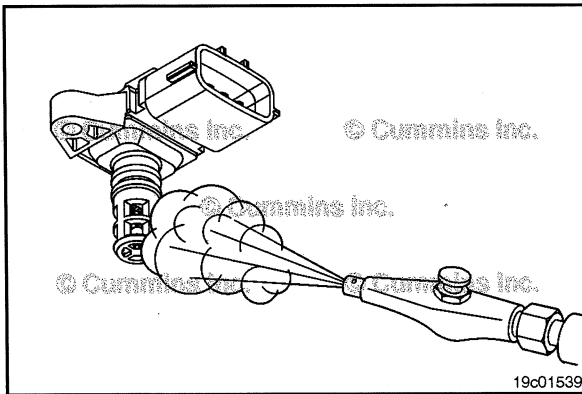
- Cracked or broken shell.
- Missing or damaged connector seals.
- Dirt, debris, or moisture in or on the connector pins.
- Corroded, bent, broken, pushed back, or expanded pins.



Inspect the intake manifold pressure/temperature sensor for the following:

- Swollen o-ring.
- Nicks or cuts in or on the o-ring.





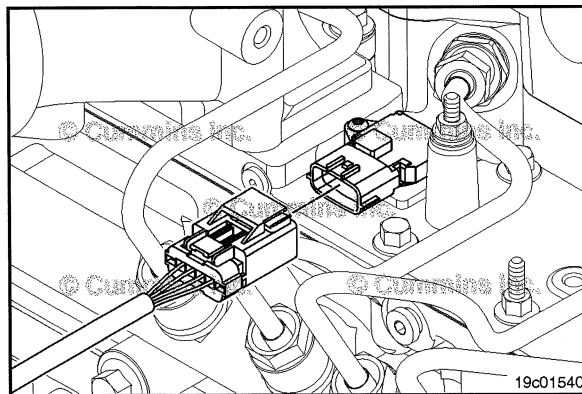
### ▲ WARNING ▲

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

Inspect the tip of the sensor for soot and carbon buildup.

Use compressed air to remove the soot from the sensor, if necessary.

Do **not** replace the sensor for soot in the sensor.



### Install

Make sure the new sensor has an o-ring.



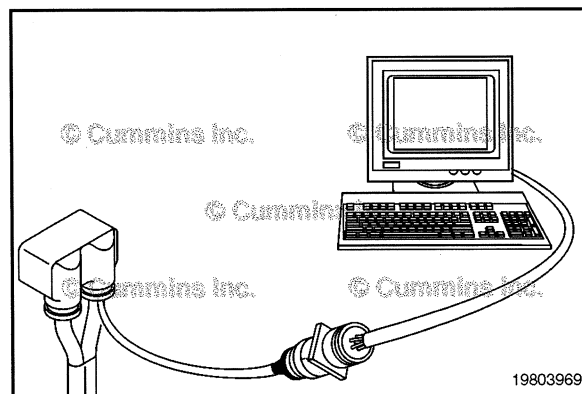
Lubricate the o-ring with 15W-40 lubricating oil.

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 INSITE™ electronic service tool is accomplished by a 9-pin datalink connector (1), Part Number 3162848.

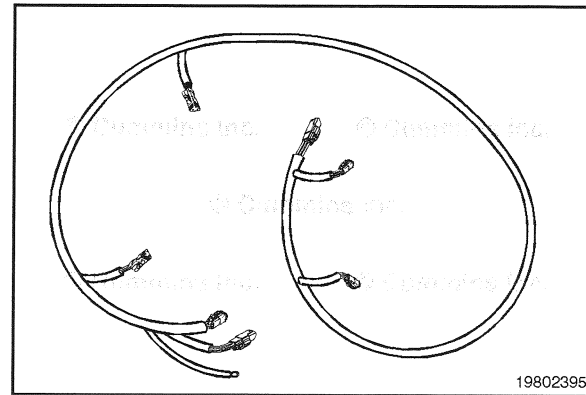
**NOTE:** Some OEM's place a 9-pin connector in the cab, but do **not** connect all of the pins to support J1939 protocol.

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.

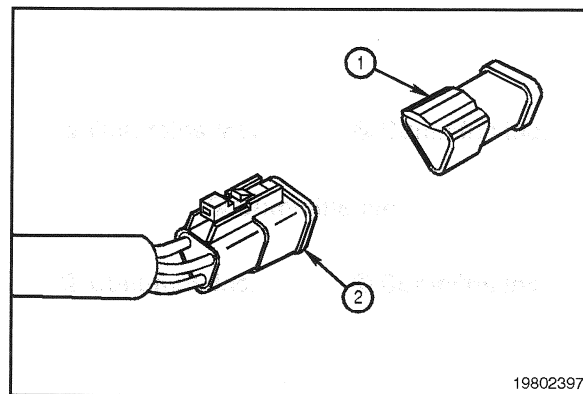
The multimeter **must** read between 50 and 65 ohms for the INSITE™ electronic service tool to be able to establish communication.

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.

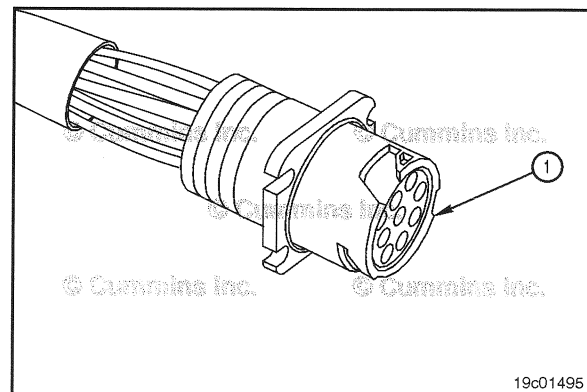
**NOTE:** The typical SAE J1939 connector will be a 9-pin connector.



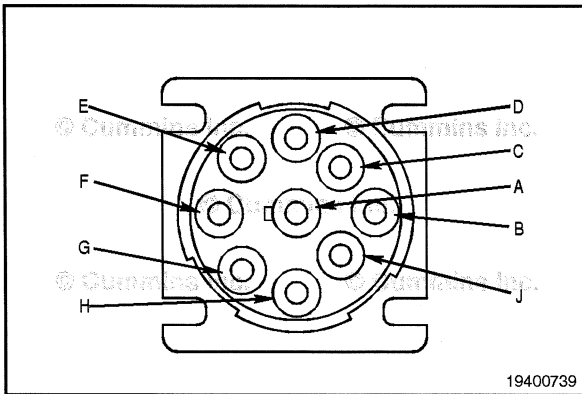
19802395



19802397



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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.

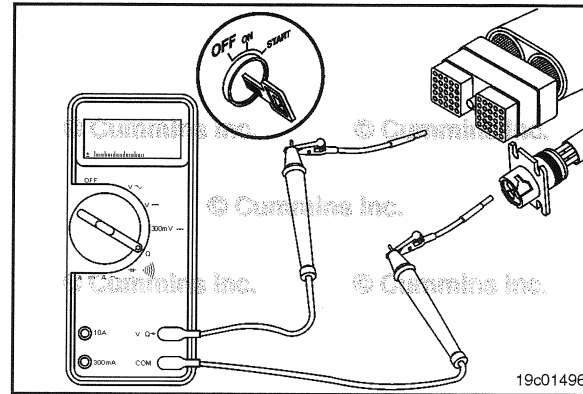
If the shield pin is provided, measure the resistance from the SAE J1939 datalink (shield) pin of the OEM harness connector to the SAE J1939 datalink (shield) pin of the 9-pin Deutsch™ connector.

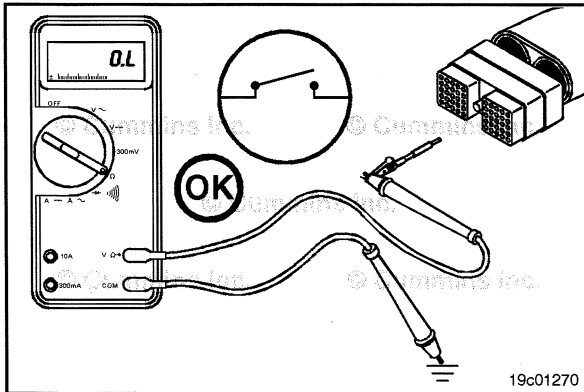
The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual for the procedures.

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.

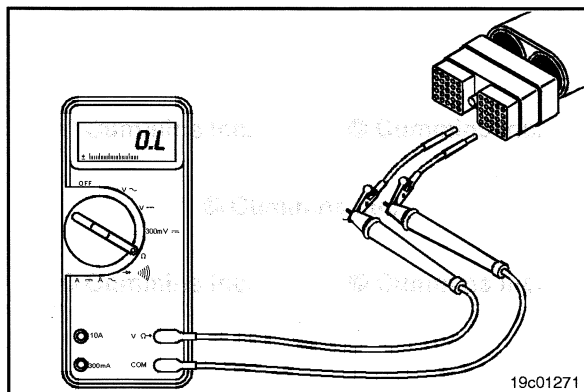
Disconnect the OEM harness connector from the ECU. Insert a test lead into the SAE J1939 datalink positive (+) pin of the OEM harness connector and connect it to a multimeter probe. Touch the other multimeter probe to the engine block or chassis ground.

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 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 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).

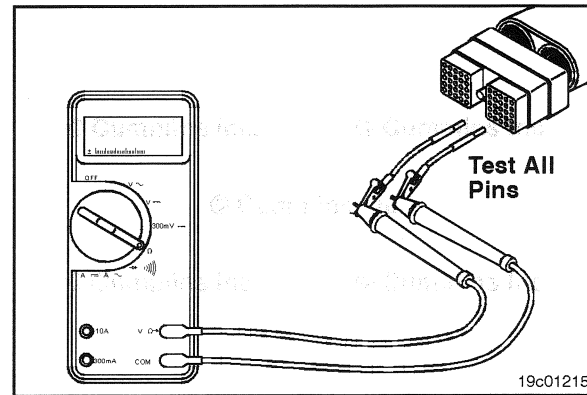
If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

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.



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

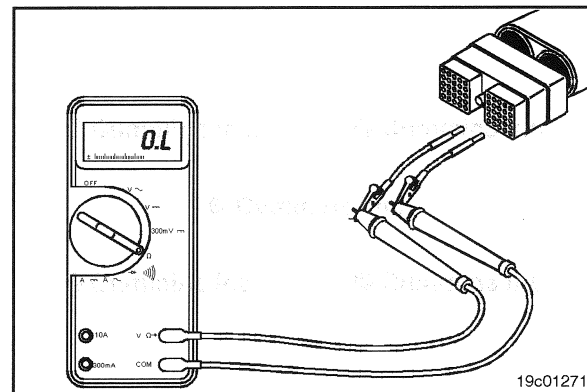


**NOTE:** If the J1939 datalink circuit is an unshielded twisted pair (UTP), the (shield) pin will **not** be provided. If the shield pin is **not** provided, the datalink negative (-) pin **must** still be checked for a short circuit to the other pins.

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).

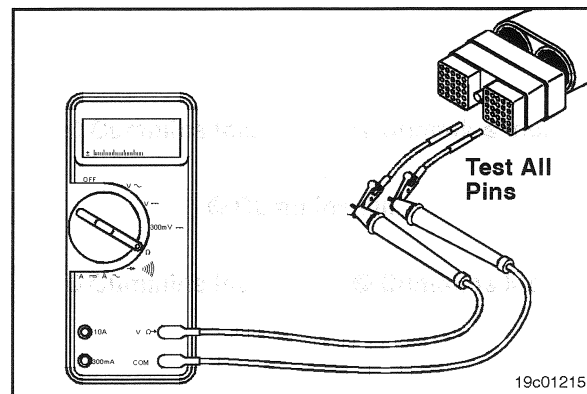
If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



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.

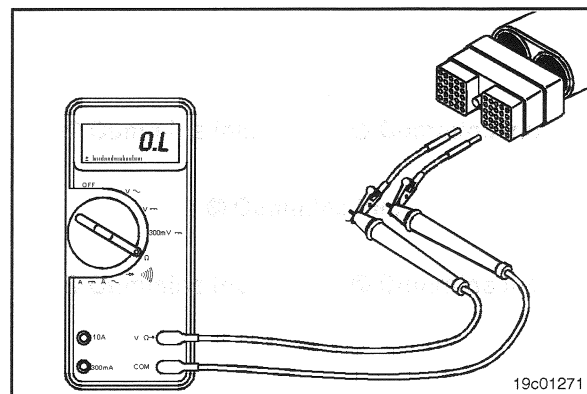


Remove the test lead from the SAE J1939 datalink (shield) pin and insert it into the SAE J1939 datalink negative (-) pin of the OEM harness connector. Insert the other test lead into another pin in the connector. Measure the resistance.

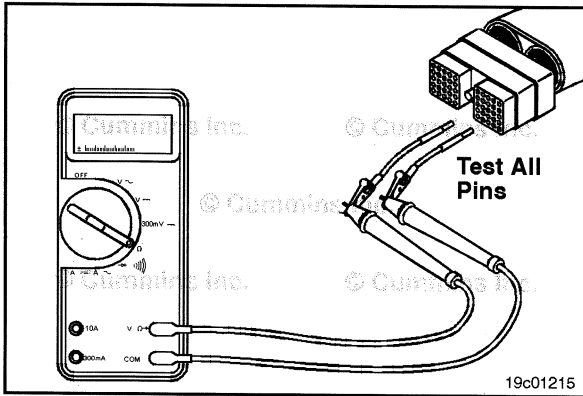


The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.







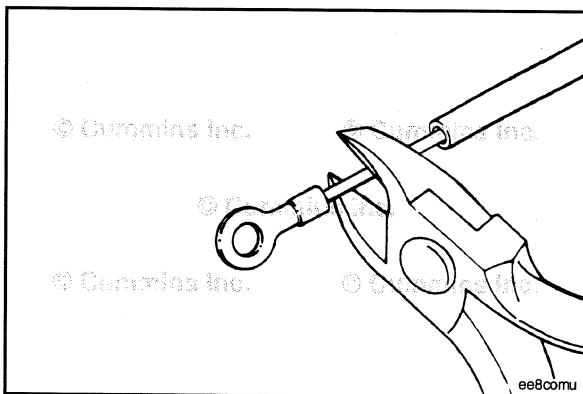
Measure the resistance from the SAE J1939 datalink negative (-) pin of the OEM harness connector to all other pins in the connector. The multimeter **must** show an open circuit (100k ohms or more) at all pins, except the J1939 datalink positive (+) pin.

If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

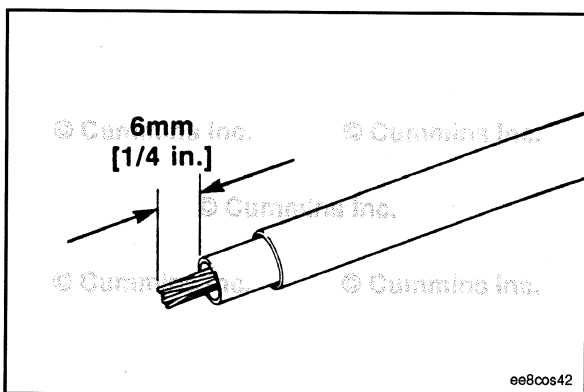
Connect all the components after the repair is complete.

## Ring Terminal (019-197) Connector Replacement

Terminals are used for various connections including grounds and fuel shutoff valve supply.



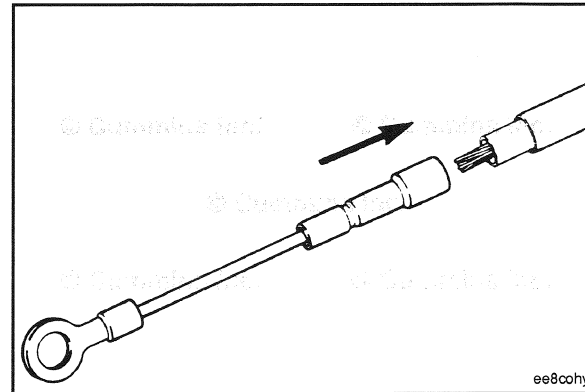
Use wire crimp tool, Part Number 3822930, to cut and remove the ring terminal connector as shown.



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



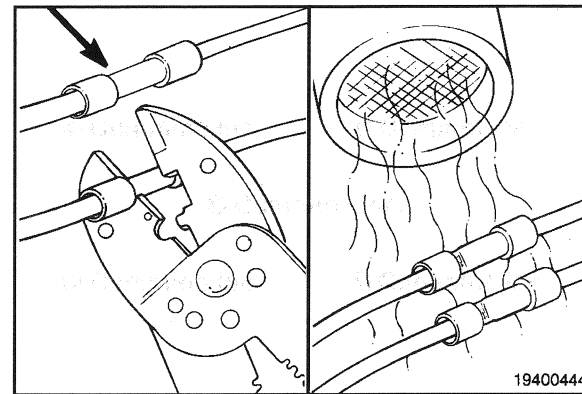
ee8cohj

**⚠ 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.

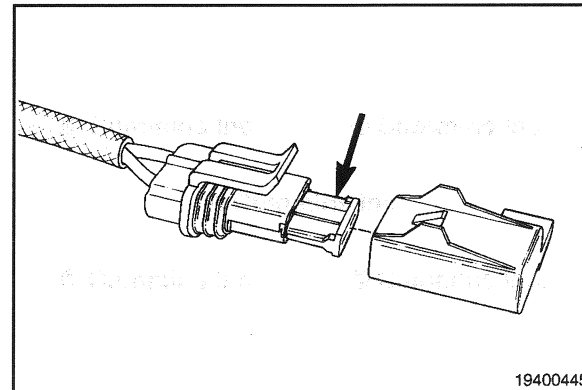


19400444

**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.



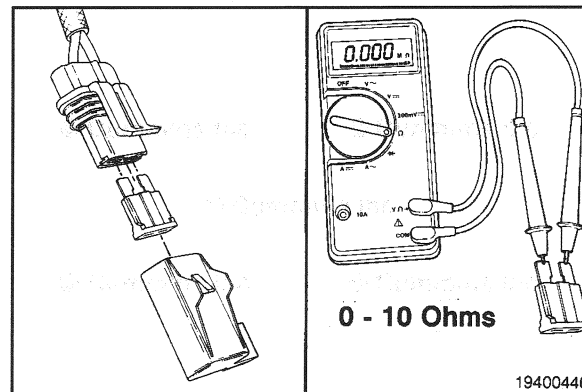
19400445

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.



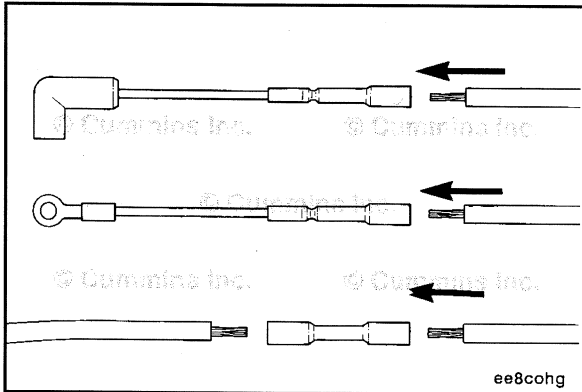
19400446

## Connector, Butt Splice (019-199)

### Select Service Tools

The following Cummins Service Tools or equivalent are required to complete this procedure:

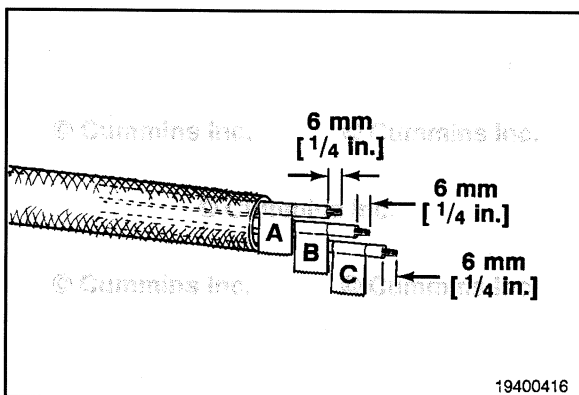
- 1 Wire Stripping Tool, Part Number 3400045, or equivalent.
- 2 Wire Crimping Tool, Part Number 3163109, or equivalent.
- 3 Heat shrink tube installer (butane), Part Number 5298996, or equivalent.



### General Information

Butt splice connectors are used when repairing wiring harnesses or damaged wires.

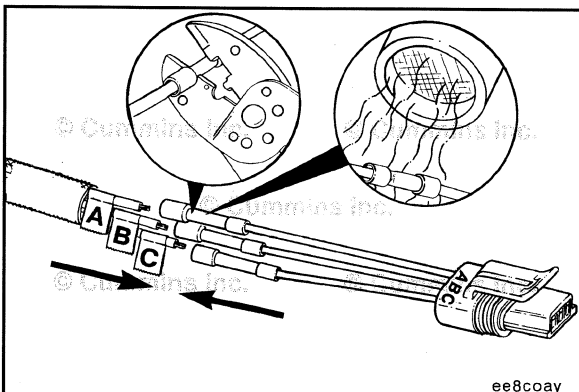
This procedure **only** covers butt splice connectors provided by Cummins Inc. Installation procedures for other butt splice connectors may be different.



### Repair

#### Crimp Splice

Strip 6 mm [ $\frac{1}{4}$  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.

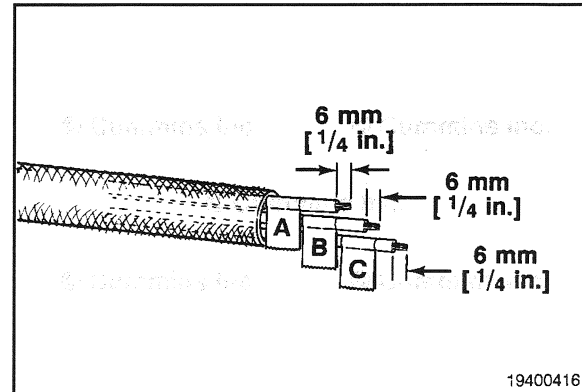
Heat the butt splice connector. Use Cummins® service tool, Part Number 5298996, heat shrink tube installer (butane) or equivalent.

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 [ $\frac{1}{4}$  in.] of insulation from the end of the wires.  
Use Cummins® service tool, Part Number 3400045, wire stripping tool or equivalent.



### ⚠ CAUTION ⚠

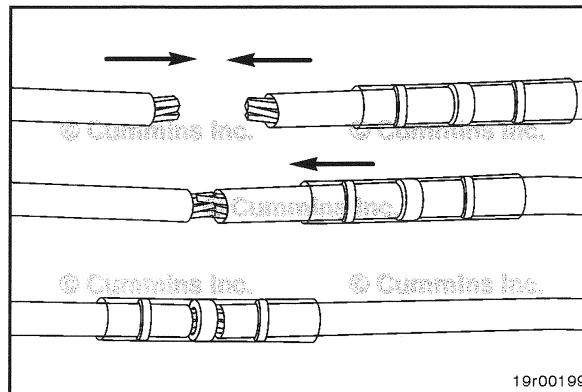
Connect the repair connector wires to the correct harness wires or electrical problems will occur.

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.



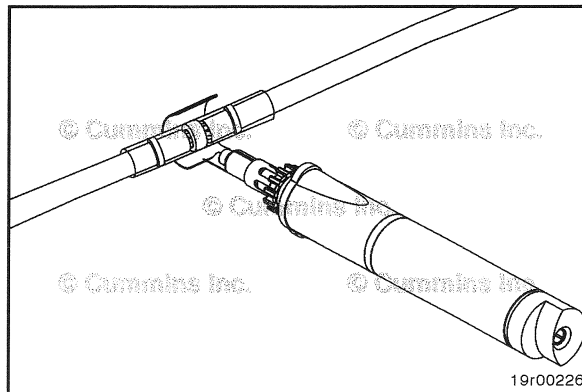
### ⚠ WARNING ⚠

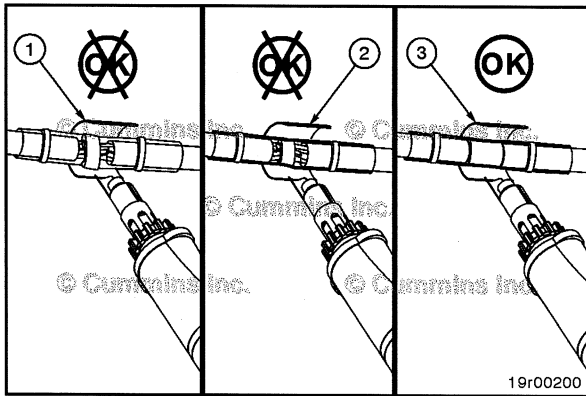
To reduce the possibility of personal injury, wear goggles and protective clothing.

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.

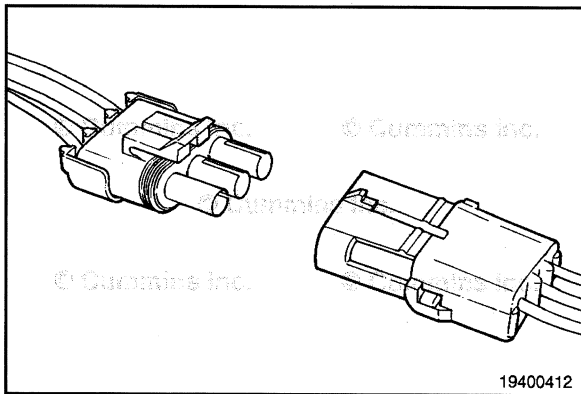
Apply heat until the solder of the butt splice connector has flowed into the wire strands.





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.



## Weather Pack Connector Series (019-201)



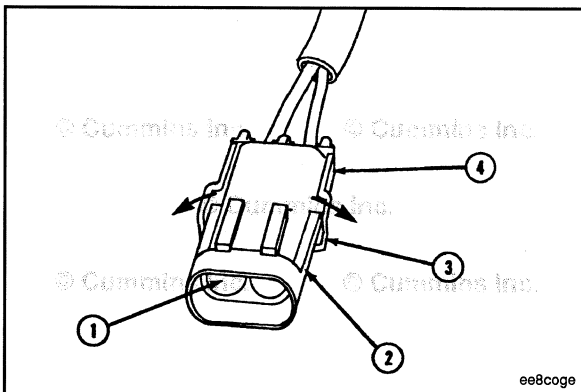
### Pin Replacement

This connector is used to connect many different components to the engine, or other devices. The connector can have many different pin configurations. All types of connectors are repaired in the same manner. The two-way connector is displayed in this procedure.

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.

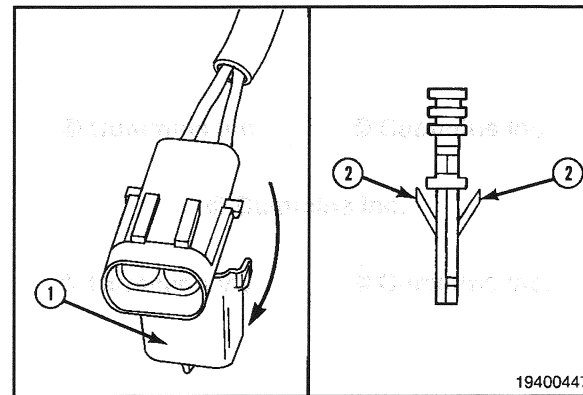
Refer to the wiring diagram in Section E for pin locations.



To replace the Weather-Pack terminal (1), pull the locking tabs (3) apart on the wire lock (4).

**NOTE:** The wire is held in the connector body by the wire lock (1) and two locking lances (2) on the terminal.

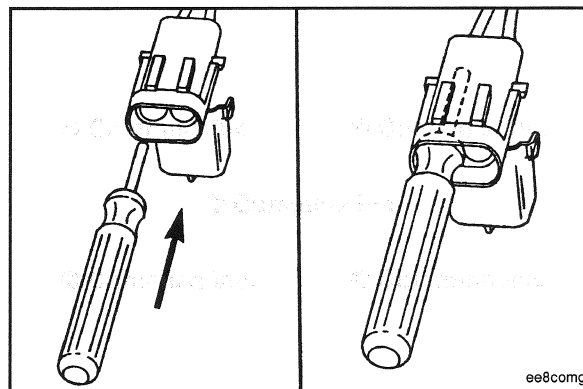
Open the wire lock.



**⚠ CAUTION ⚠**

This tool can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

Insert the Weather-Pack extraction tool, Part Number 3822608, over the terminal. Use a twisting motion to push the tool to the bottom of the cavity.



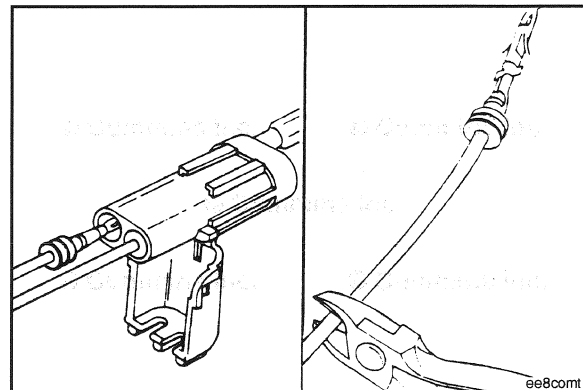
**⚠ CAUTION ⚠**

If more than one wire is being repaired, tag each wire and install it in the original location. Electrical problems can occur if wires are switched.

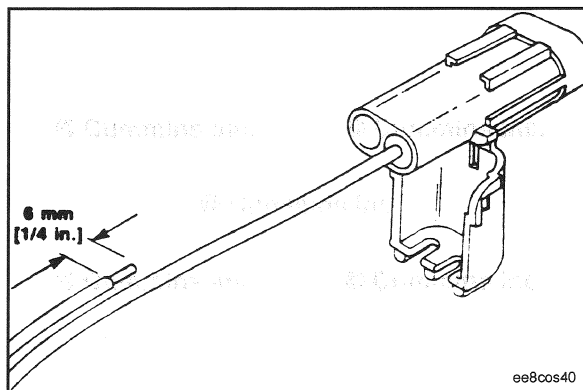
Pull the wire and the terminal out of the connector body.

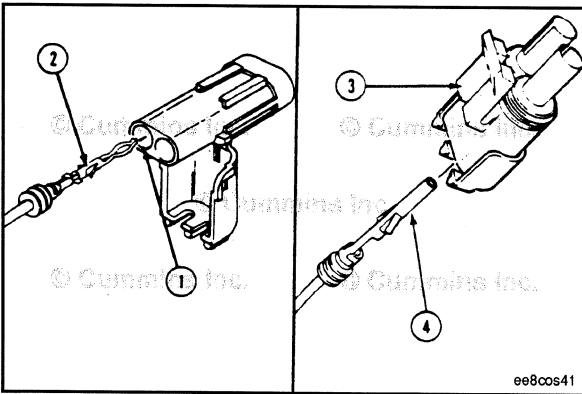
**NOTE:** The repair wire and the terminal is 127 mm [5 in] long.

Use crimping tool, Part Number 3822930, to cut 127 mm [5 in] of the terminal wire.



Use wire crimping tool, Part Number 3822930, to remove approximately 6 mm [1/4 in] of insulation from the wire.





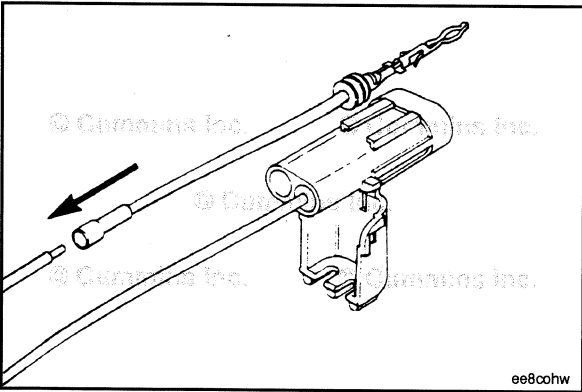
**NOTE:** The shroud connector bodies (1) use pin terminals (2). The tower connector bodies (3) use socket terminals (4).



Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

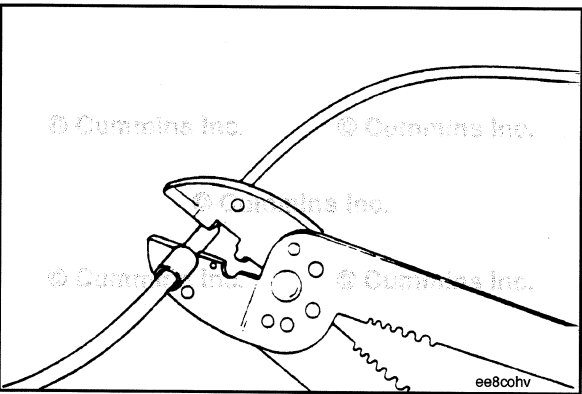
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire. Replace one contact wire at a time. If more than one wire needs to be replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

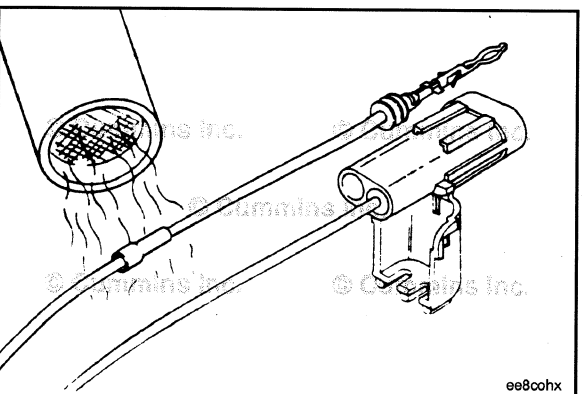


Install the correct repair wire on the bare wire.

Make sure that the bare wire extends into the insulated butt splice connector.



Use wire crimping tool, Part Number 3822930, to crimp the repair wire on the bare wire.

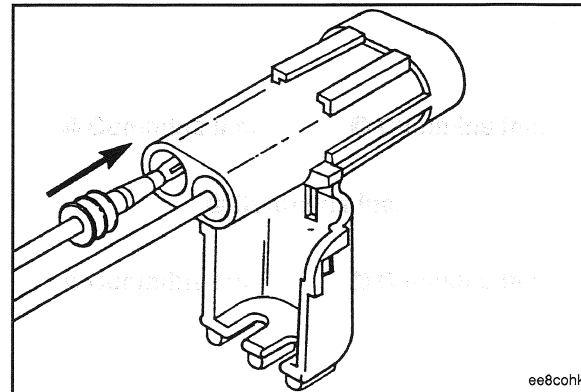


Use heat gun, Part Number 3822860, to heat the shrink tubing. The tubing will shrink and make the connection waterproof.

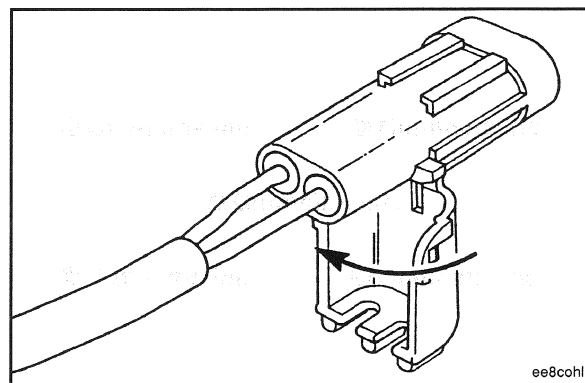
**⚠ CAUTION ⚠**

If more than one wire is repaired or if the connector body is replaced, make sure to insert the wires into the same locations as they were in. Electrical problems can occur if wires are switched.

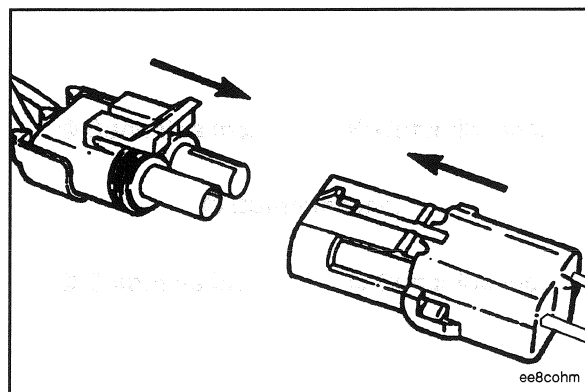
Insert the terminal into the connector body. The terminal locking lances **must** click and hold the terminal in the body.



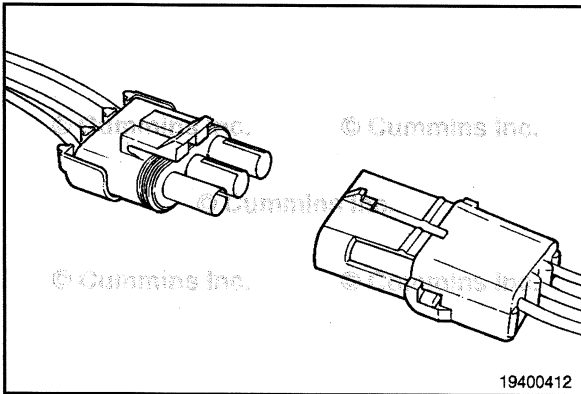
Close and latch the wire on the connector body.



Insert the two connector halves together.







## Connector Replacement

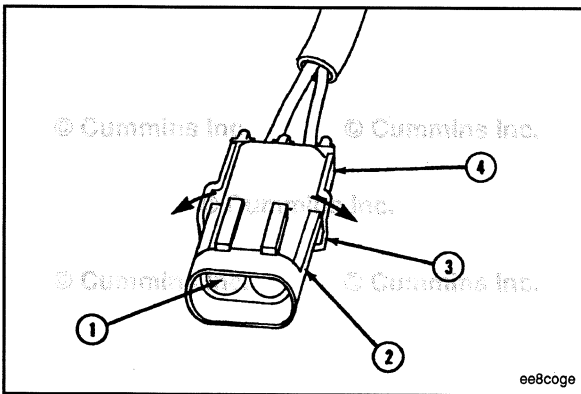
The connector is used to connect many different components to the engine, or other devices. The connector can have many different pin configurations. All types of connectors are repaired in the same manner. The two-way connector is displayed in this procedure.

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

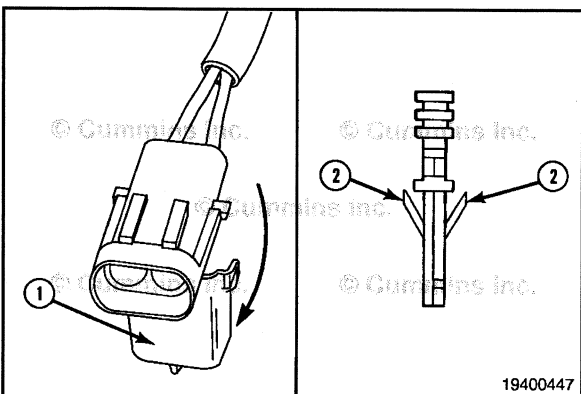
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.

Replace one contact wire at a time. If more than one wire needs to be replaced, attach a lettered tag to each wire removed.



To replace the Weather-Pack connector body (2), pull the locking tabs (3) apart on the wire lock (4).



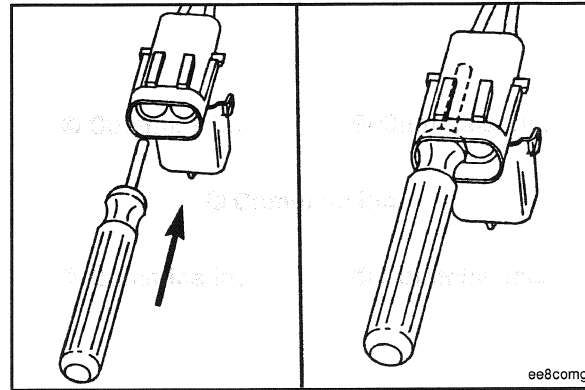
The wire is held in the connector body by the wire lock (1) and two locking lances (2) on the terminal.

Open the wire lock.

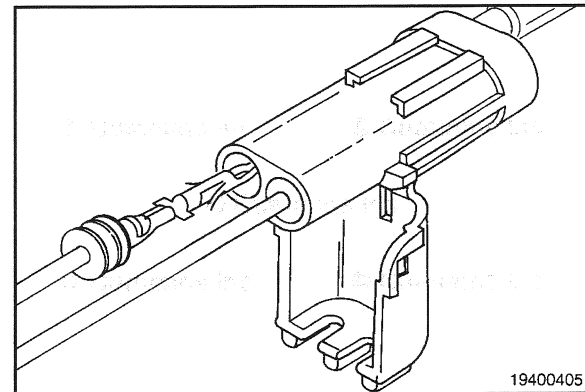
**⚠ CAUTION ⚠**

This tool can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

Insert Weather-Pack extraction tool, Part Number 3822608, over the terminal. Use a twisting motion to push the tool to the bottom of the cavity.



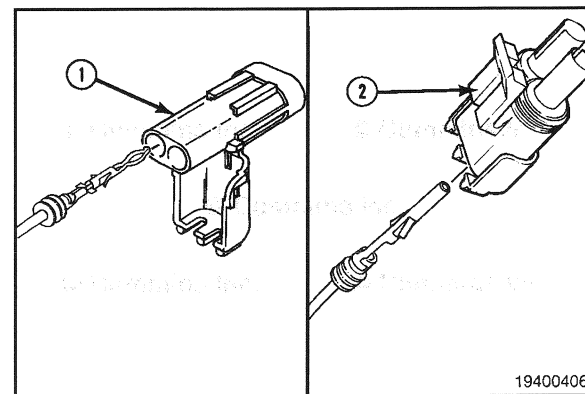
Pull the wire and the terminal out of the connector body.



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.

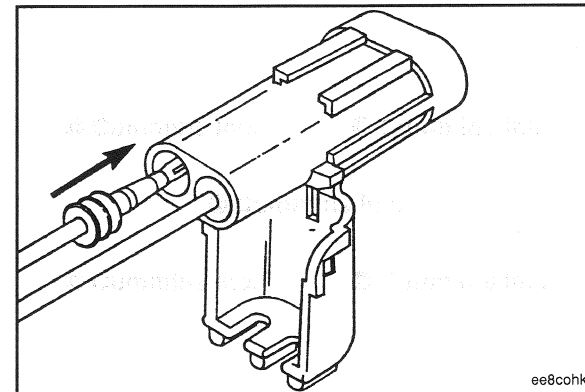
Replace one contact wire at a time. If more than one wire needs replaced, attached a lettered tag to each wire removed.

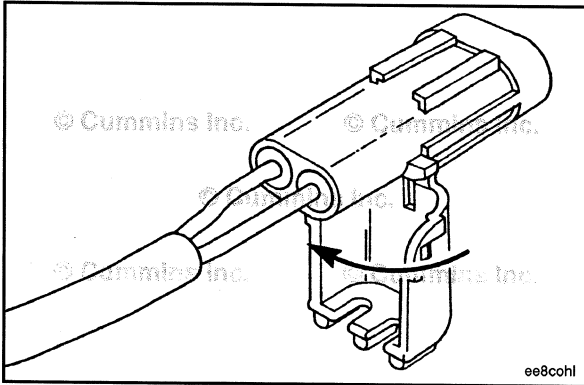


**⚠ CAUTION ⚠**

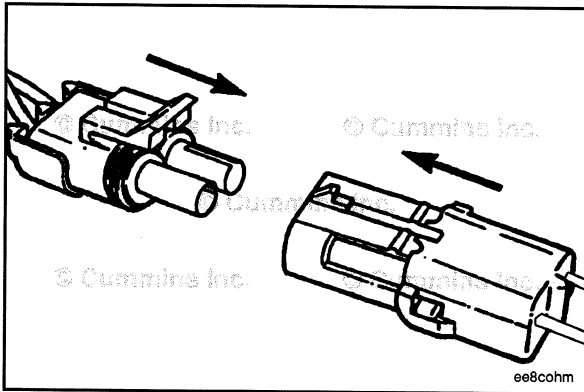
If more than one wire is repaired or if the connector body is replaced, make sure to insert the wires into the same locations as they were in. Electrical problems can occur if wires are switched.

Insert the terminal into the connector body. The terminal locking lances **must** click and hold the terminal in the body.

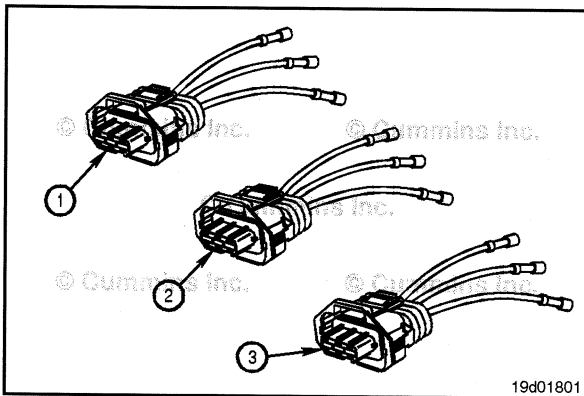




Close and latch the wire lock on the connector body.

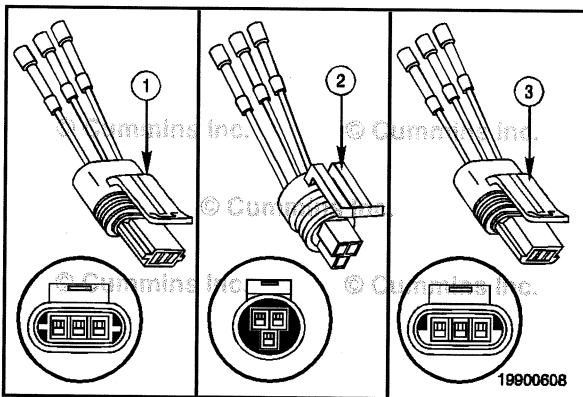


Insert the two connector halves together.



### Metripack Connector Series (019-202) Pin Replacement

The connector can have multiple pin configurations. All types of connectors are repaired in the same manner.

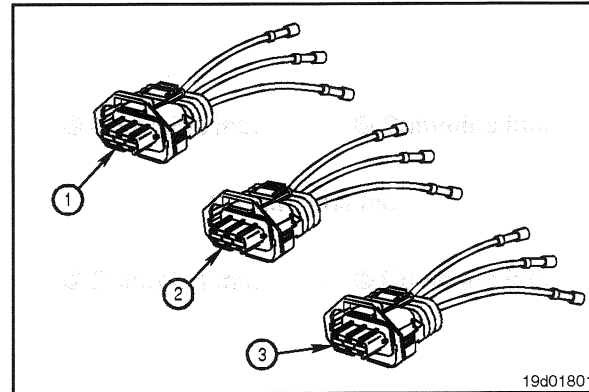


The connector pins can **not** be repaired or replaced. The connector **must** be replaced as a unit.

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.

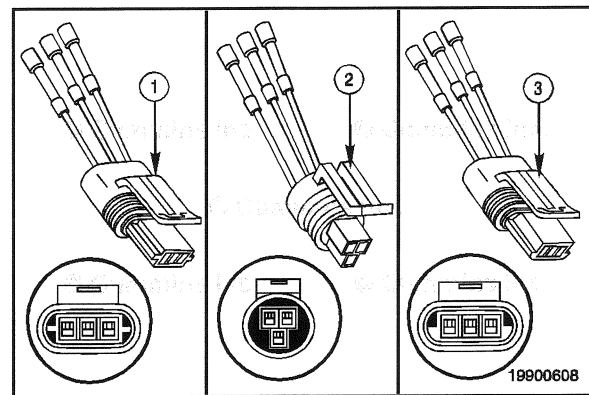


Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

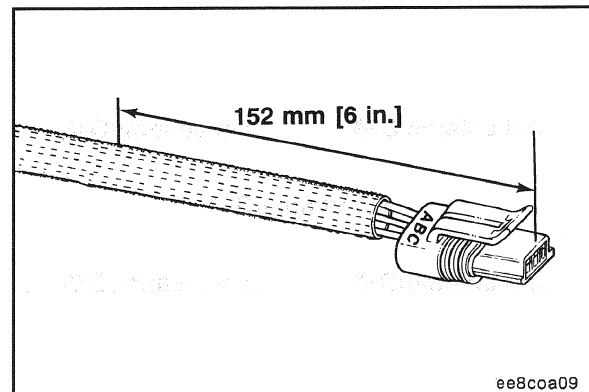
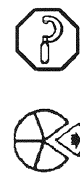
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

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.

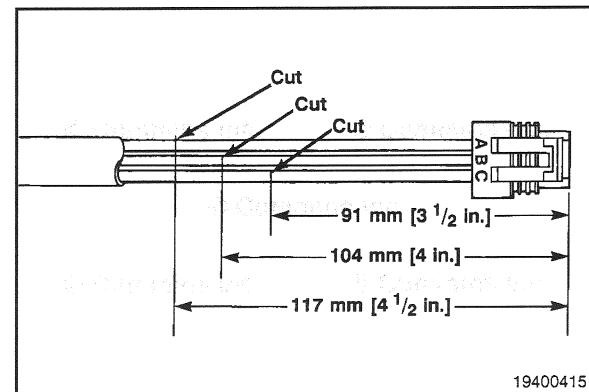


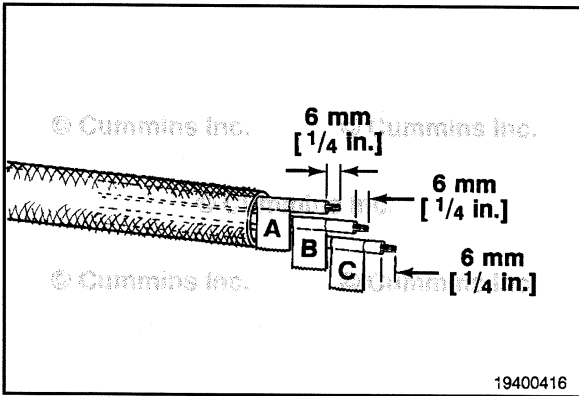
Before cutting the wires, measure and tag the wires.

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 [1/4 in.] of insulation from all electrical wires.

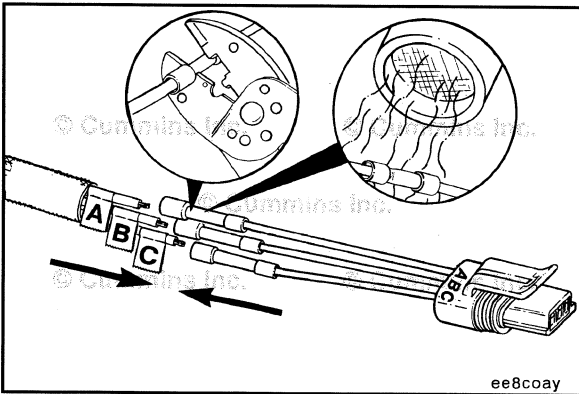


Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

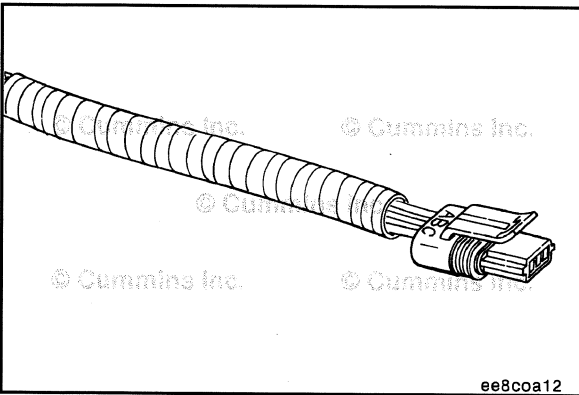
Refer to Section E for pin locations.

Replace one contact at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

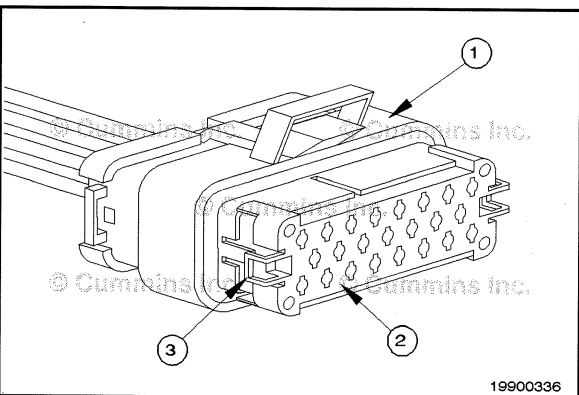


Install the terminal repair wires on the bare wires and use wire crimping tool, Part Number 3822930, to crimp the terminals.

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.



## AMP Connector Series (019-203) Pin Replacement

### ⚠CAUTION⚠

Use care in handling the AMP connectors. They are very fragile and easily damaged. Follow the steps outlined in this procedure to avoid damage.

Check to be sure the connector wedge lock is in the open position.

**NOTE:** The connector assembly is shipped in one piece, with the wedge lock in the open position. It is possible that during adverse shipping conditions that some wedge locks can get bumped into the closed position.

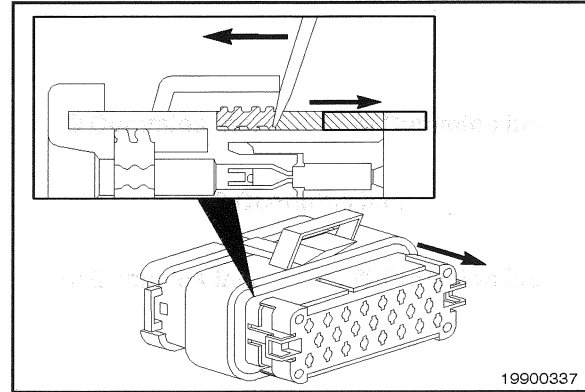
If the wedge lock is closed, perform the following:

Insert screwdriver blade (flat) between the matting seal and one of the red wedge lock tabs.

Depress the lock tabs (Item 3 in the figure in the previous step).

Pry open the wedge lock to the open position.

**NOTE:** The wedge lock **must not** be removed from the housing for insertion or removal of the contacts.



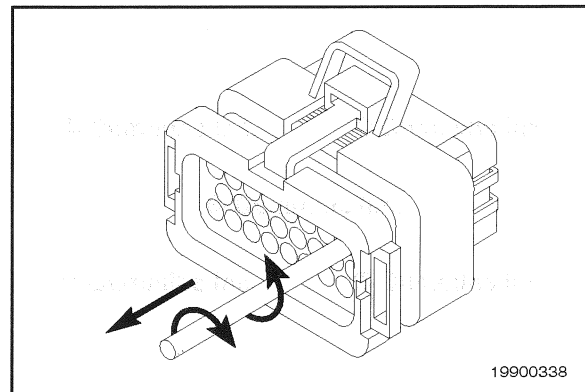
19900337

Remove the damaged contacts, rotate the contact wire back and forth over a half turn ( $\frac{1}{4}$  turn in each direction). Gently pull the wire until the contact is removed.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

**NOTE:** 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.



19900338

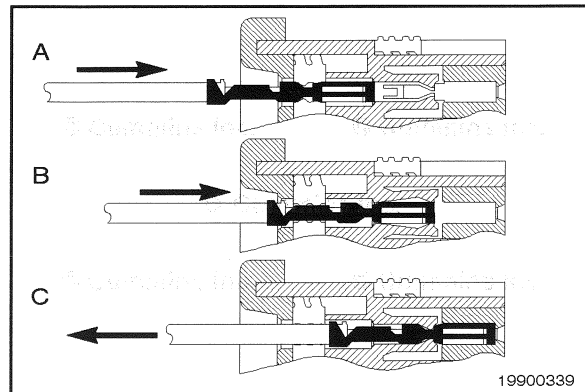
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

Install a new wire and contact.

Insert wire straight into the appropriate circuit cavity.

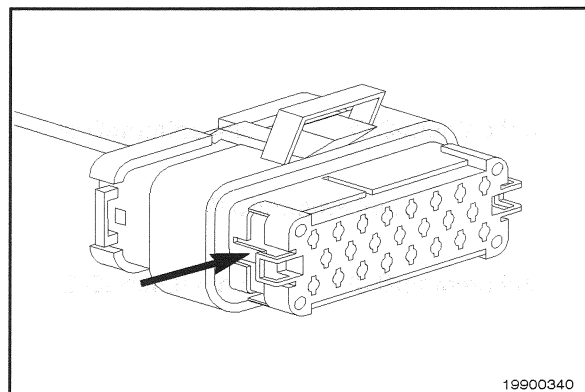
Insert the wire until the pin bottoms out.

Pull back gently to be sure the retention fingers are holding the contact.

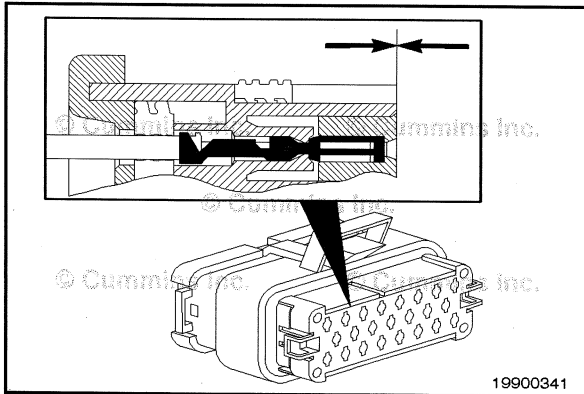


19900339

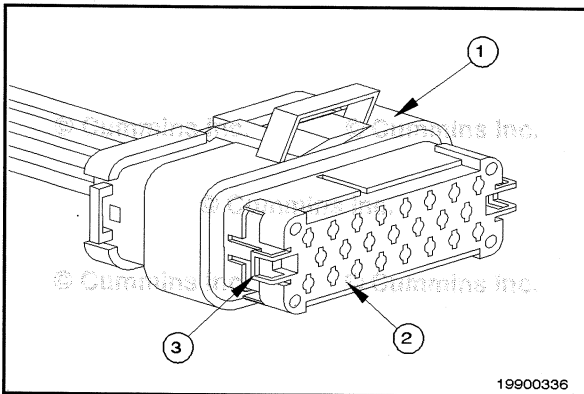
After all of the required contacts have been replaced, the wedge lock **must** be closed to its LOCKED position. Release the locking latches by squeezing them inward.



19900340



Slide the wedge lock into the housing until it is flush with the housing.



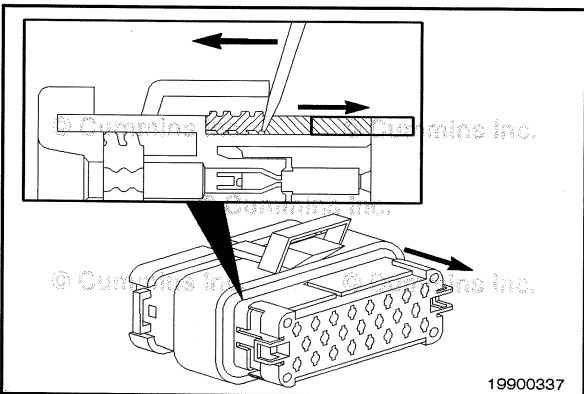
### Connector Replacement

#### ⚠ CAUTION ⚠

Use care in handling the AMP connectors. They are very fragile and easily damaged. Follow the steps outlined in this procedure to avoid damage.

**NOTE:** The connector assembly is shipped in one piece, with the wedge lock in the open position. It is possible that during adverse shipping conditions that some wedge locks can get bumped into the closed position.

Check to be sure the connector wedge lock is in the open position.



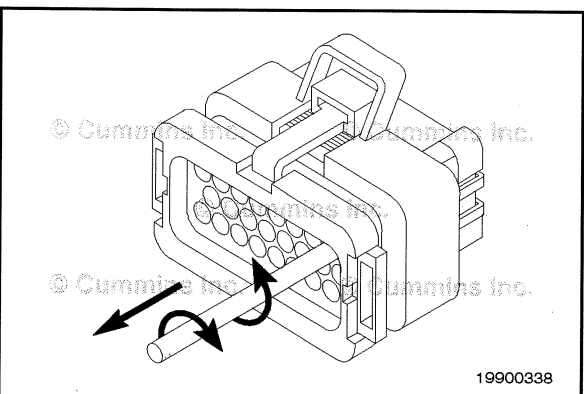
**NOTE:** The wedge lock **must not** be removed from the housing for insertion or removal of the contacts.

If the wedge lock is closed, perform the following:

Insert screwdriver blade (flat) between the matting seal and one of the red wedge lock tabs.

Depress the lock tabs (Item 3 in the figure in the previous step).

Pry open the wedge lock to the open position.



Replace one contact wire at a time. Attach a lettered tag to each wire removed.



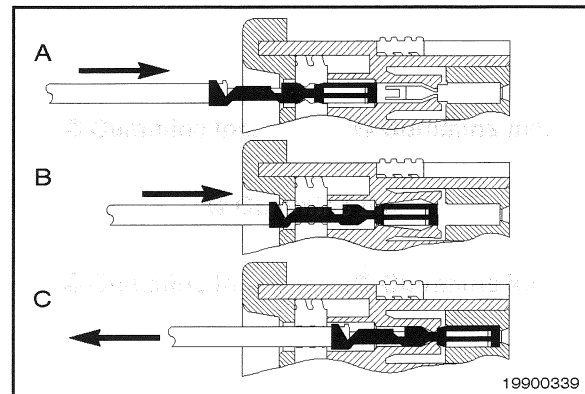
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Remove all of the contacts. Rotate the contact wires back and forth over a half turn ( $\frac{1}{2}$  turn in each direction). Gently pull the wire until the contact is removed.

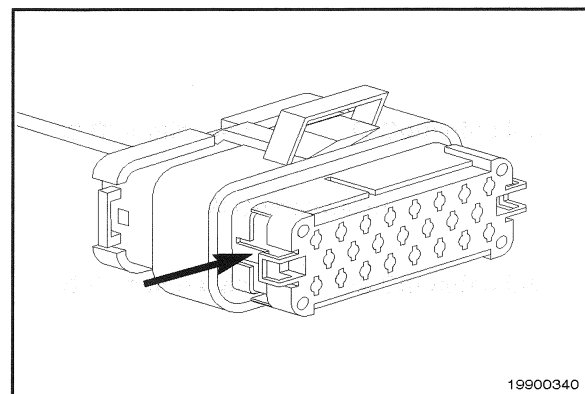
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.

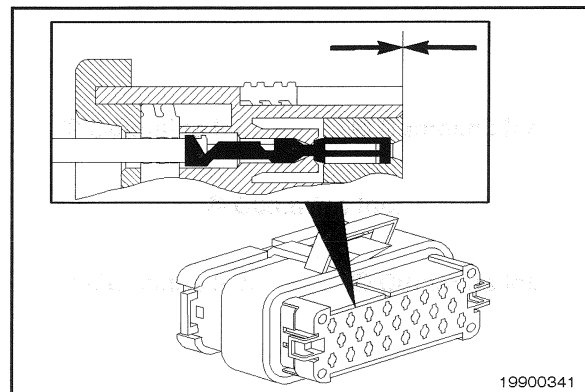
Install a new wire and contact by:  
Insert wire straight into the appropriate circuit cavity.  
Insert the wire until the pin bottoms out.  
Pull back gently to be sure the retention fingers are holding the contact.



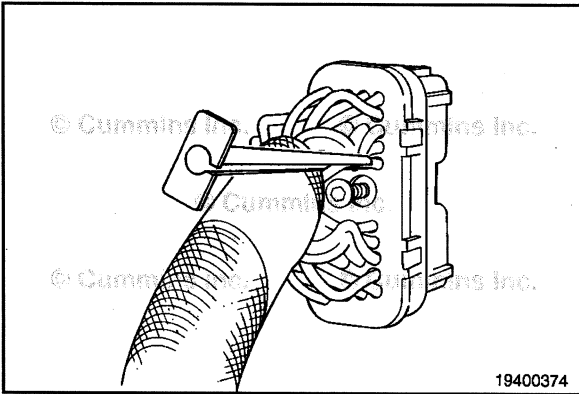
After all of the required contacts have been replaced, the wedge lock **must** be closed to its LOCKED position. Release the locking latches by squeezing them inward.



Slide the wedge lock into the housing until it is flush with the housing.







## Deutsch DRC Connector Series (019-204)

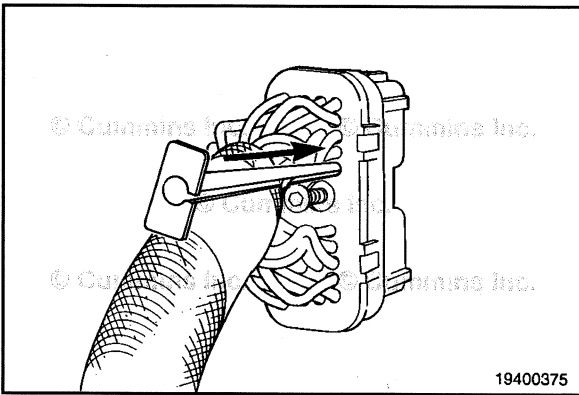
### Pin Replacement

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

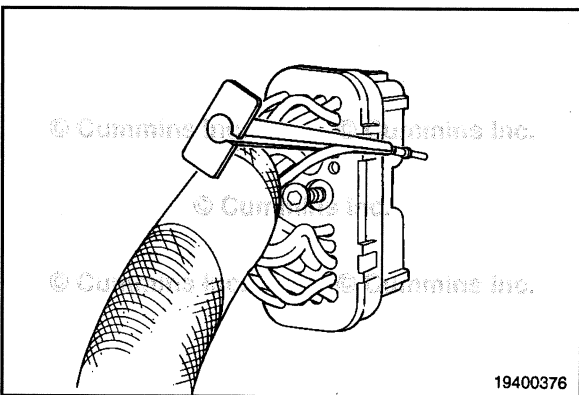
Refer to the wiring diagram for pin locations.

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



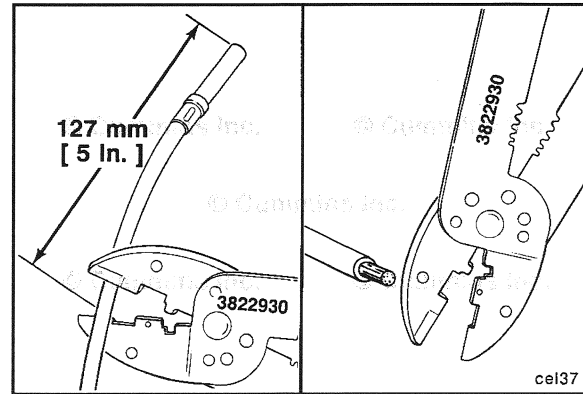
Push the tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange.



Hold the tool on the terminal flange and pull the wire and connecting pin out of the connector. Note and record the hole from which the pin is removed.

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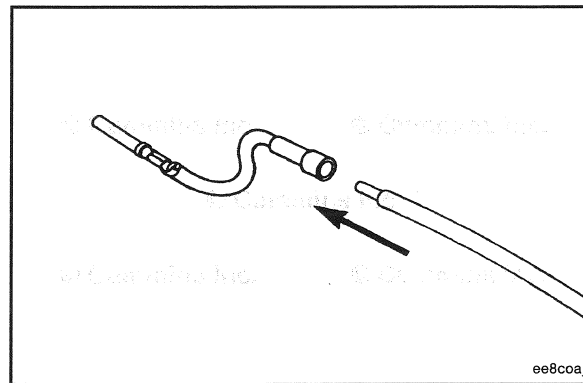
**NOTE:** The repair wire is 127 mm [5 in] long.  
Use wire crimping tool, Part Number 3822930, to cut 127 mm [5 in] off the wire and pin.  
Use the crimping tool to remove 6 mm [ $\frac{1}{4}$  in] of insulation from the wire.



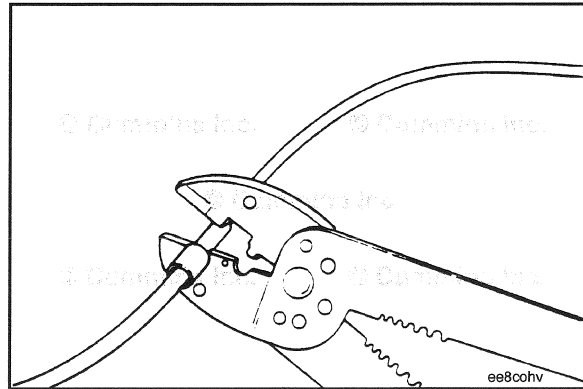
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.



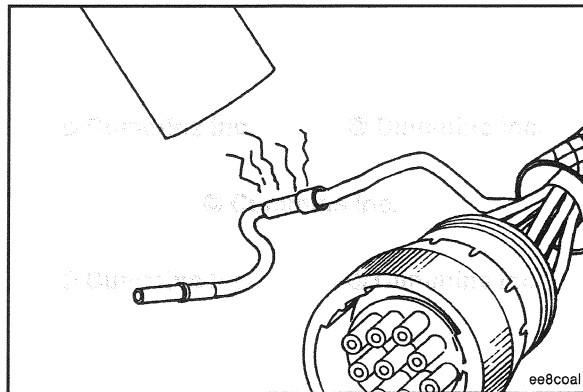
Install the correct repair wire on the bare wire, make sure that the bare wire extends into the splice connector.

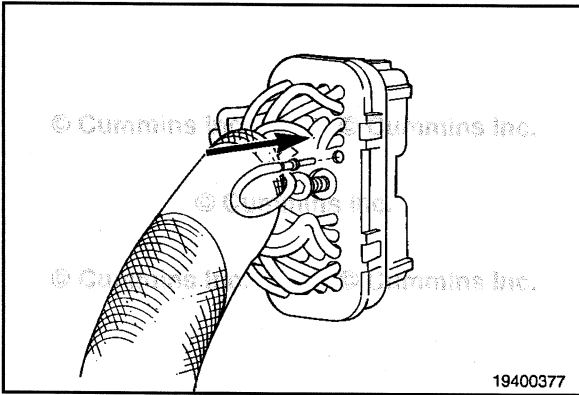


Use the wire crimping tool to crimp the repair wire onto the bare wire.



Use heat gun, Part Number 3822860, or an open flame to heat the shrink tubing around the wire. The tubing will shrink and make the connector waterproof.

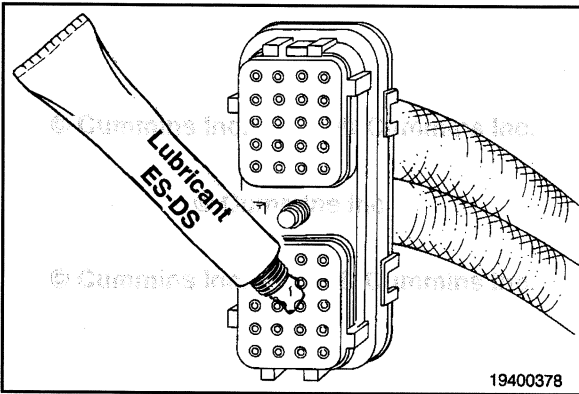




Insert the pin into the correct hole of the connector.

The pin **must** click into place and hold the wire in the connector.

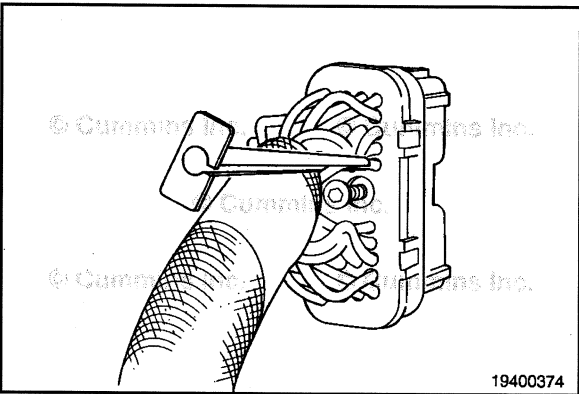
Pull the wire gently to make sure it is seated in the connector.



### ⚠ CAUTION ⚠

Use only Cummins recommended lubricant DS-ES, Part Number 3822934. Other lubricants, such as lubricating oil or grease, in the connectors can cause Electronic Control Unit damage, poor performance, or premature connector pin wear.

Apply a small amount of lubricant to the connector terminals. Do **not** fill the entire connector cavity with the lubricant.



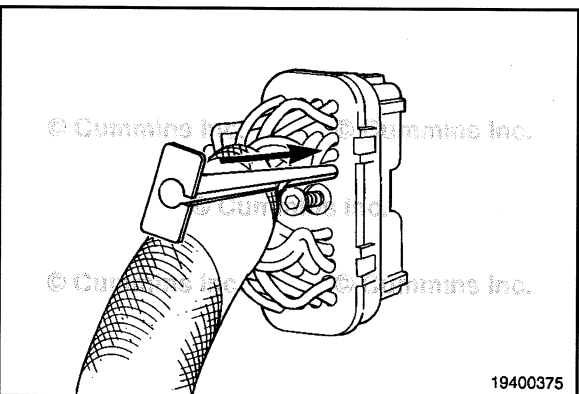
### Connector Replacement

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

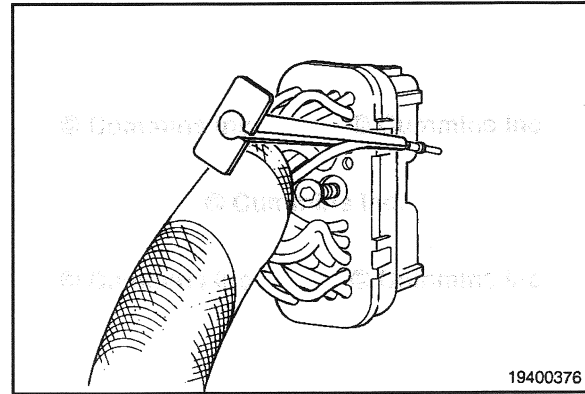
Replace one wire at a time. Attach a lettered tag to each wire removed.

Refer to the wiring diagram 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.

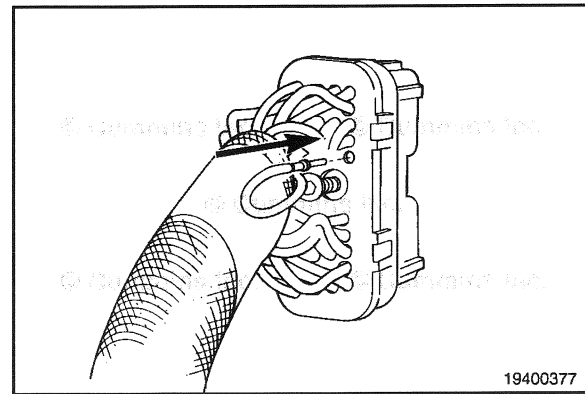
Refer to the wiring diagram for pin locations.

Insert the pins into the correct holes of the replacement connector.



Each pin **must** click into place and hold the wires in the connector.

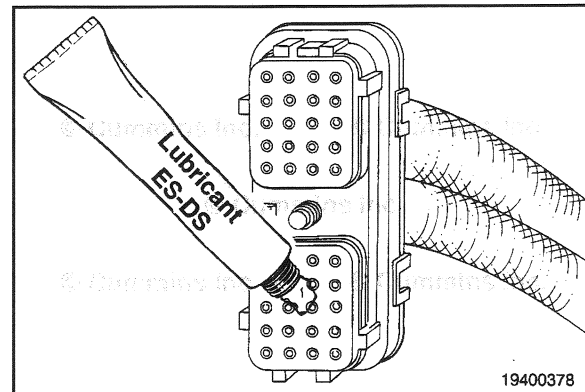
Pull each wire gently to make sure it is seated in the connector.

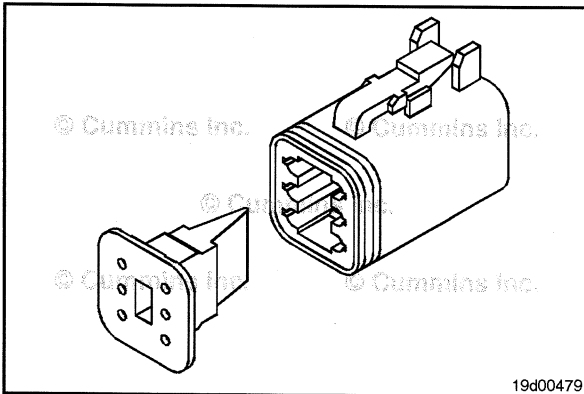


**⚠ CAUTION ⚠**

Use only Cummins lubricant DS-ES, Part Number 3822934. Other lubricants such as lubricating oil or grease, in the connectors can cause Electronic Control Unit damage, poor performance or premature connector pin wear.

Apply a small amount of lubricant to the connector terminals. Do **not** fill the entire connector cavity with lubricant.





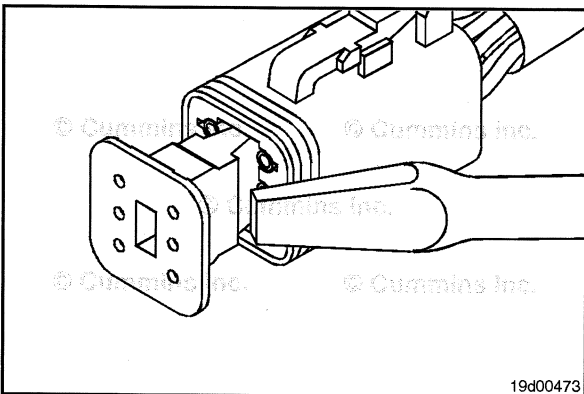
## Deutsch DT Connector Series (019-205)

### Pin Replacement

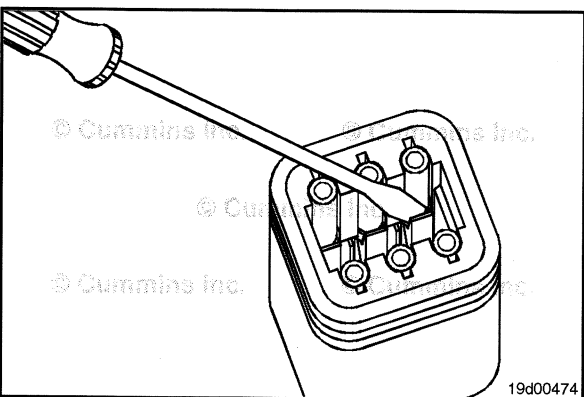
The connector can have multiple pin configurations. All type of connectors are repaired in the same manner.

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.



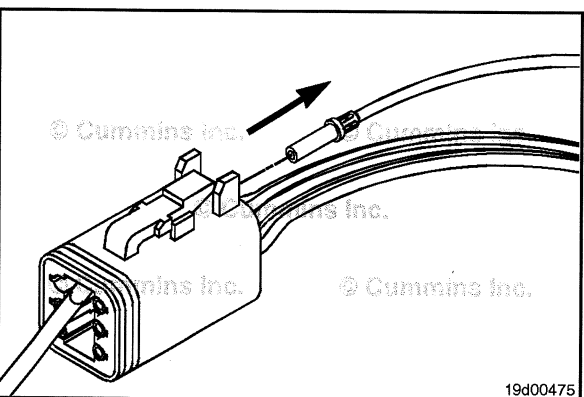
To replace the pin in the receptacle connector, remove the orange wedge using needle nose pliers or a hook-shaped wire to pull the wedge straight out.



### ⚠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 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.

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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.

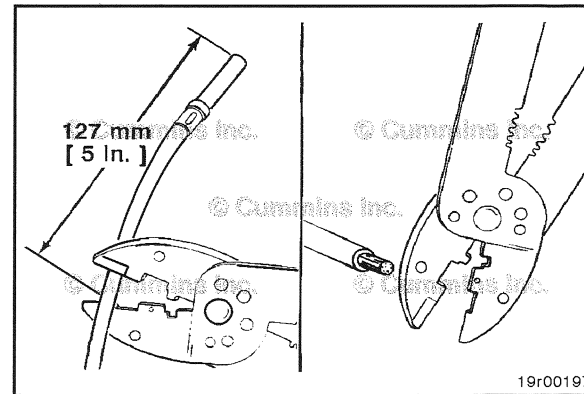


Refer to the wiring diagram in Section E for pin locations.

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.

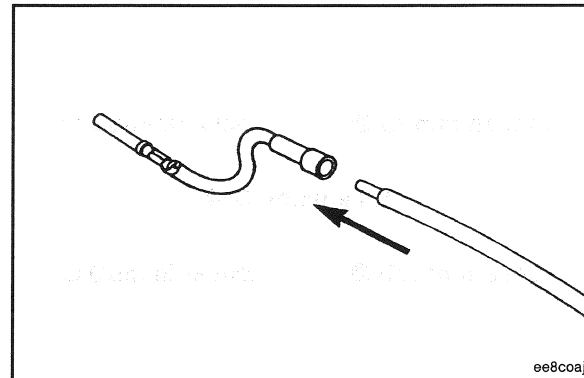
Use wire crimping tool, Part Number 3163109 or equivalent, to remove 6 mm [1/4 in.] of insulation from the wire.



19r00197

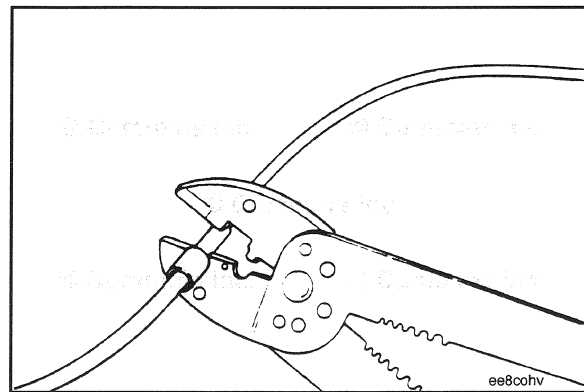
Install the correct repair wire on the bare wire.

Make sure the bare wire extends into the splice connector.



ee8coaj

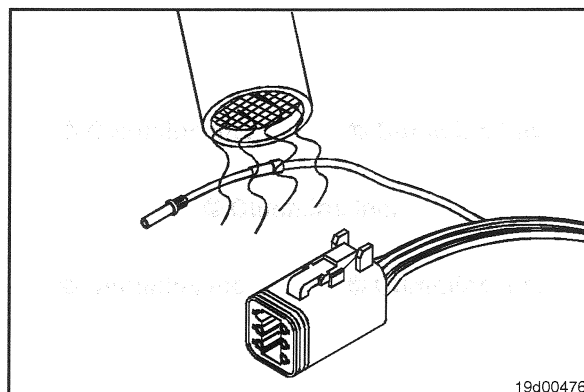
Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



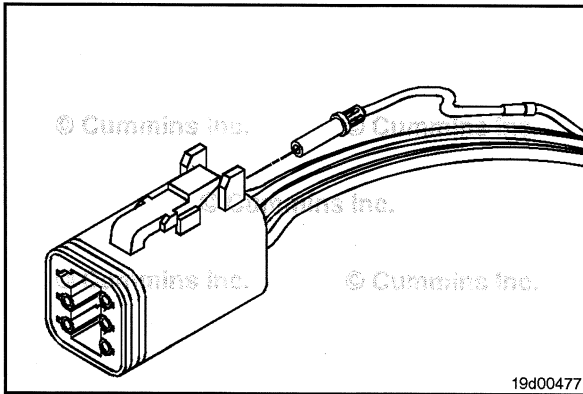
ee8cohv

Use heat gun, Part Number 3822860, to heat shrink the tubing around the wire.

The tubing will shrink and make the connection waterproof.



19d00476

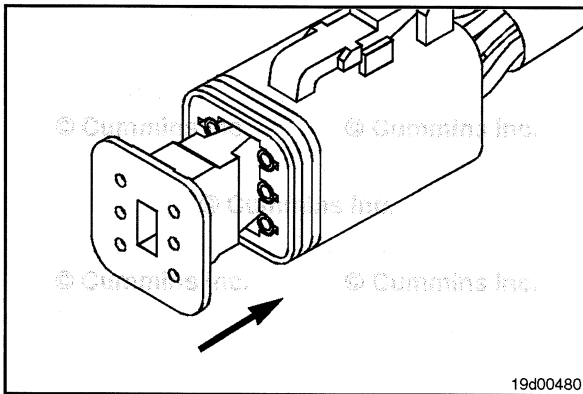


### ⚠ CAUTION ⚠

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.

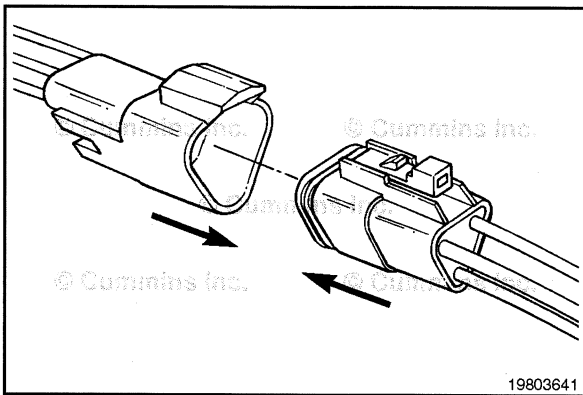


Once the wires are in place, insert the orange wedge with arrow pointing toward the exterior locking mechanism.

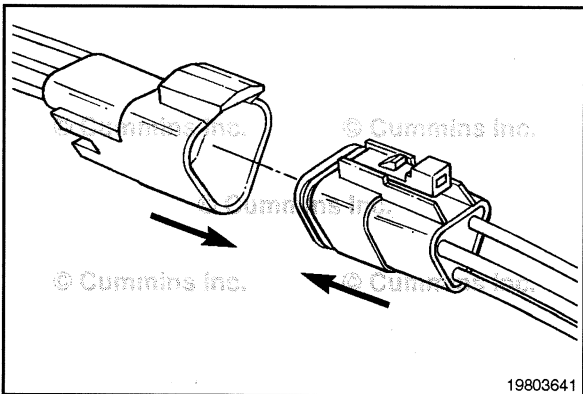
Push the orange wedge in until it snaps in place.



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

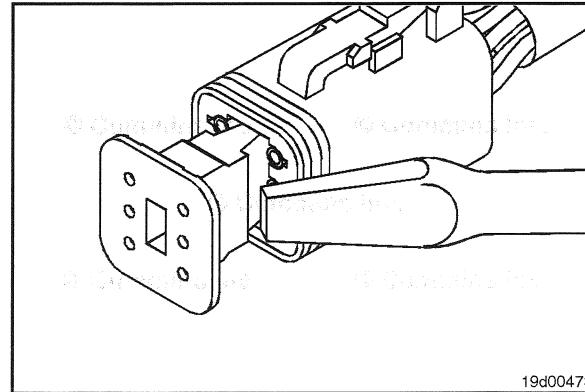
The connector can have multiple pin configurations. All types of connectors are repaired in the same manner.

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.

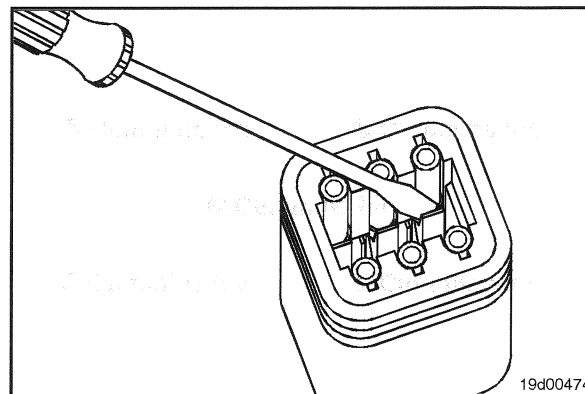


19d00473

**⚠ 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.

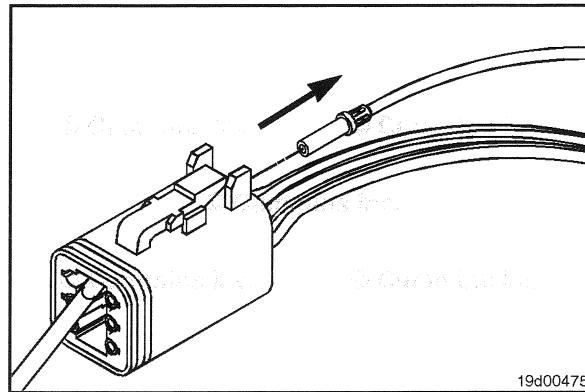


19d00474

**⚠ 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.

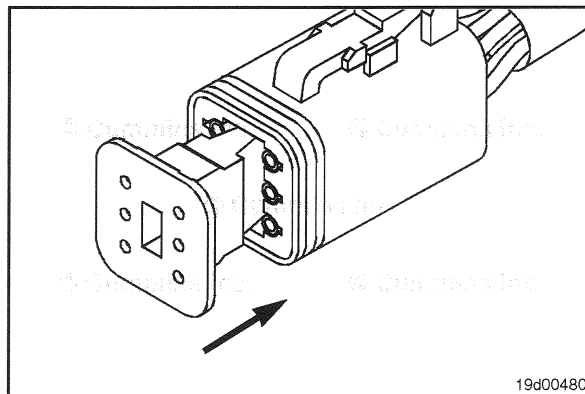
Replace the connector and install the wire and terminal into the seal at the back of the connector. Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.



19d00475

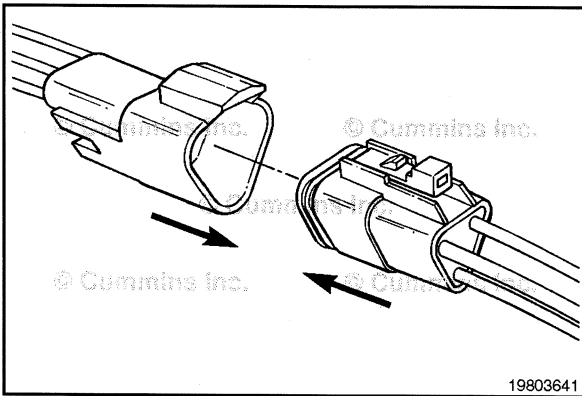
Once the wires are in place, insert the orange wedge with arrow pointing toward the exterior locking mechanism. Push the orange wedge in until it snaps in place.

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.

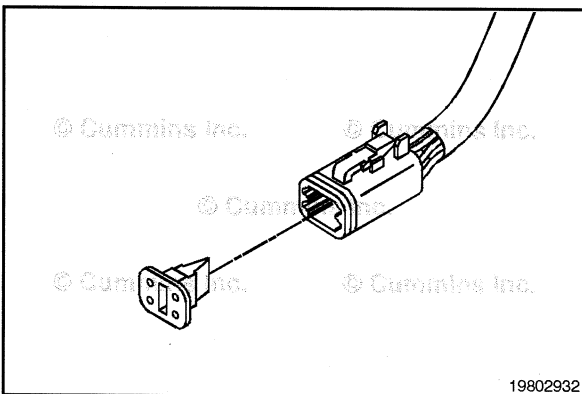


19d00480





Push the connector plug into the connector receptacle until the external locking clip snaps into place.



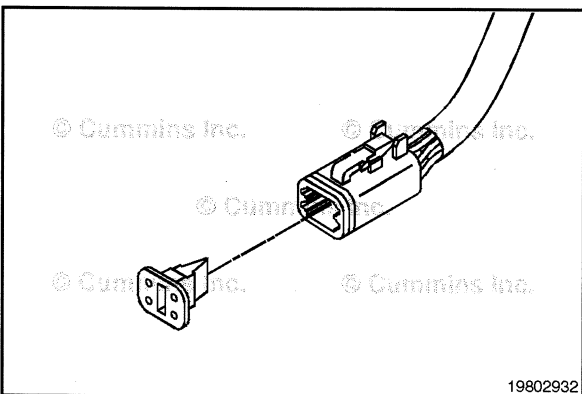
## Deutsch DTM and DTP Connector Series (019-206)

### 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.



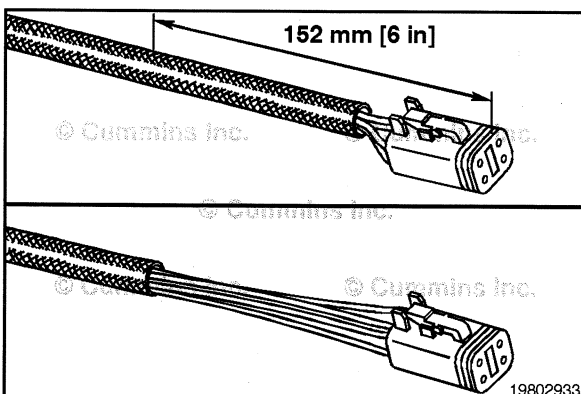
### Connector Replacement

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.

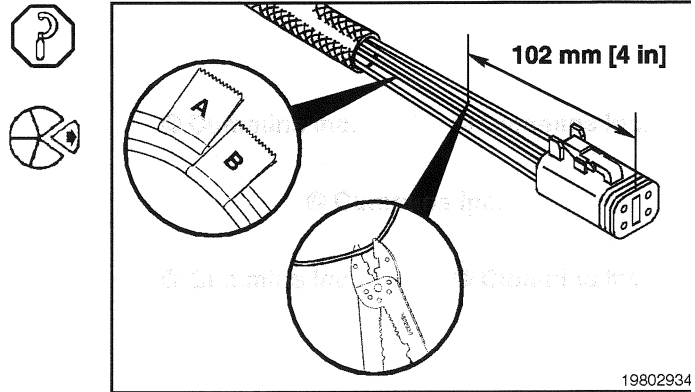


Measure 152 mm [6 in] back from the face of the connector and remove the wiring harness protective cover.

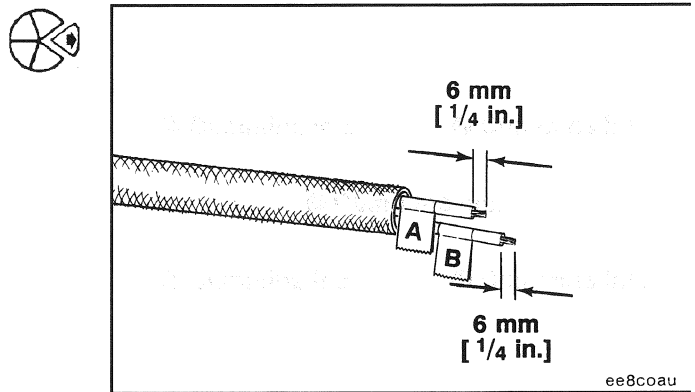


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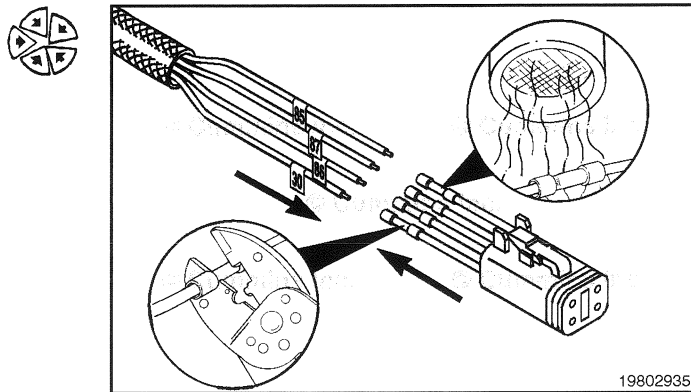
Before cutting the wires, measure and tag all wires.  
Use wire crimping tool, Part Number 3822930.  
Cut wire A 102 mm [4 in] from the face of the connector.  
Cut wire B 102 mm [4 in] from the face of the connector.



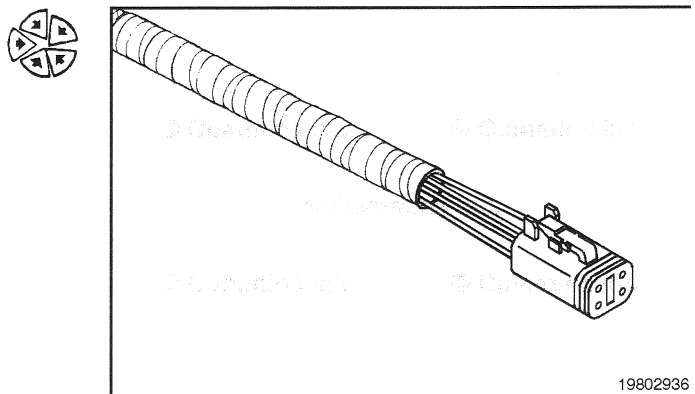
Use wire crimping tool, Part Number 3822930, to remove 6 mm [1/4 in] of insulation from both electrical wires.

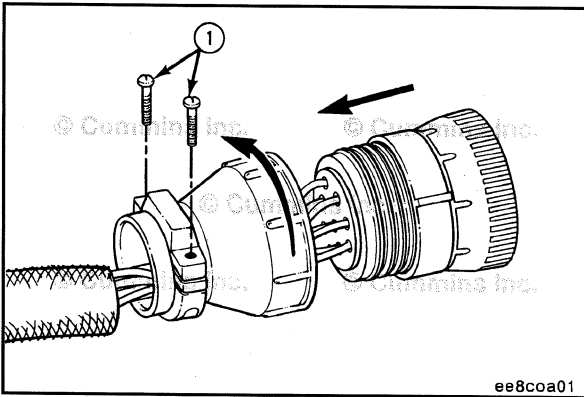


Install the connector repair wires and use wire crimping tool, Part Number 3822930, to crimp the terminals.  
Use heat gun, Part Number 3822860, to heat the shrink tubing. The tubing will shrink and make the connection waterproof.



Wrap the wires with tape, for added protection, to complete the repair.





## Deutsch HD10 Connector Series (019-207)



### Pin Replacement

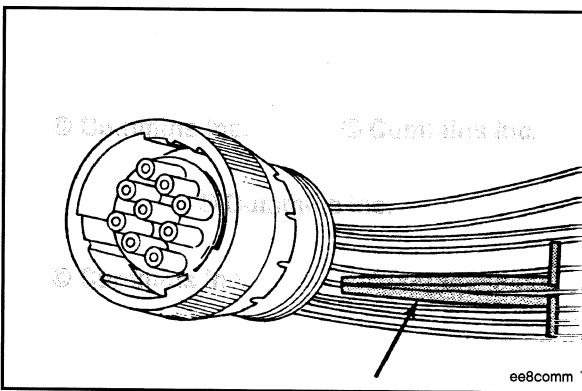
These connectors are available with multiple pin configurations.

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 cap screws (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.

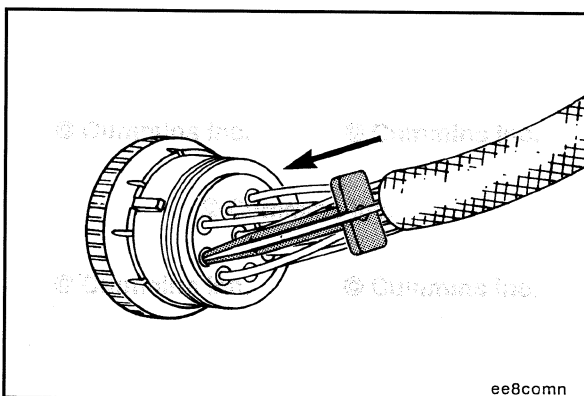


Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.

Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

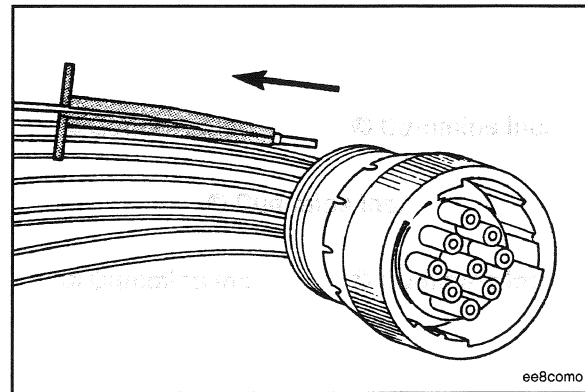
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

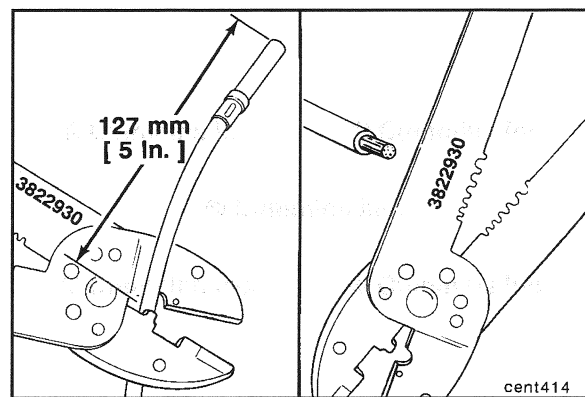


Push the tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange.

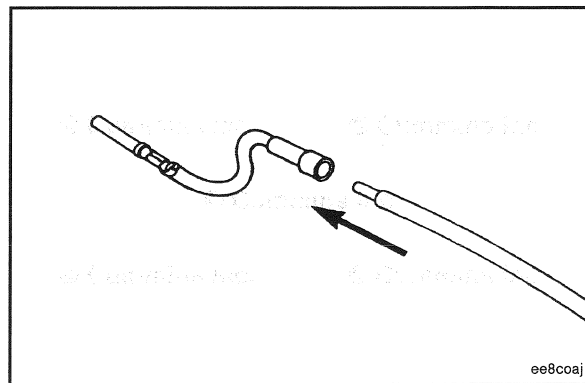
Hold the tool on the terminal flange and pull the wire and the connecting pin out of the connector. Note and record the hole from which the pin is removed.



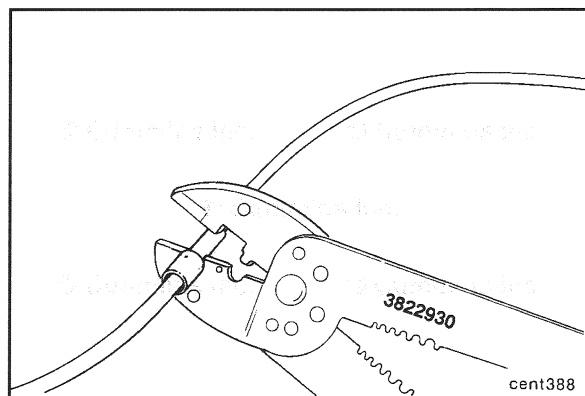
**NOTE:** The repair wire is 127 mm [5 in] long.  
 Remove about 6 mm [¼ in] of insulation from the wire.  
 Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.  
 Refer to the appropriate wiring repair kit in the service tools table in the front of Section 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.

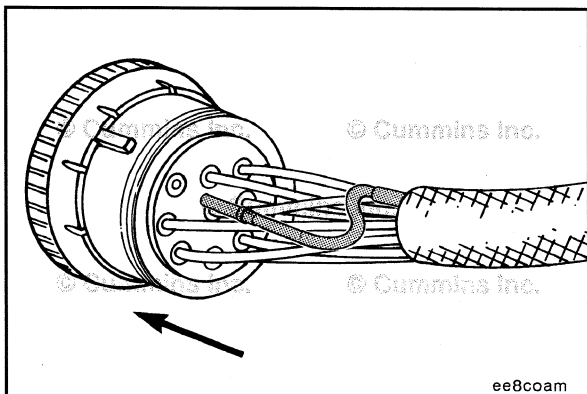


Install a repair wire on the bare wire. Make sure the bare wire extends into the splice.



Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.

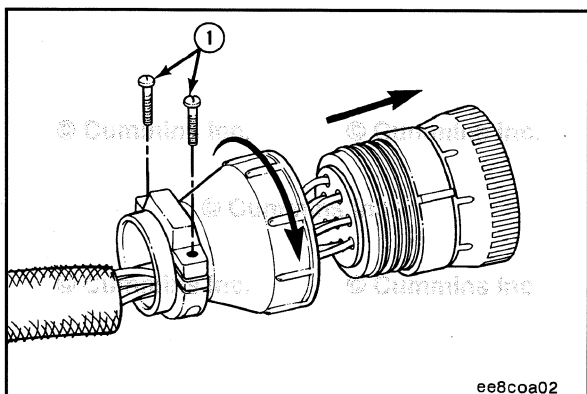




Insert the pin into the correct hole of the connector.

The pin **must** lock into place and hold the wire in the connector.

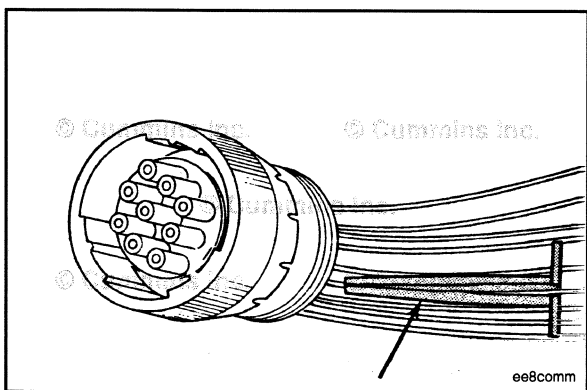
Pull the wire gently to make sure it is seated in the connector.



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.

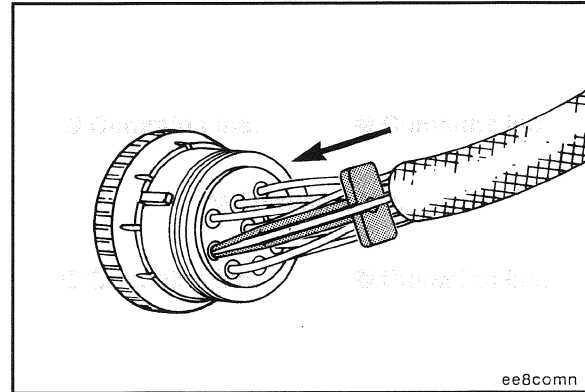
Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

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.

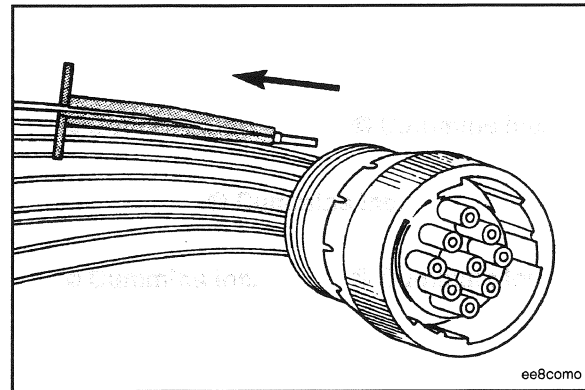
QSF3.8 CM2350 F107  
Section 19 - Electronic Controls - Group 19

Push the tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange.



ee8comn

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.



ee8como

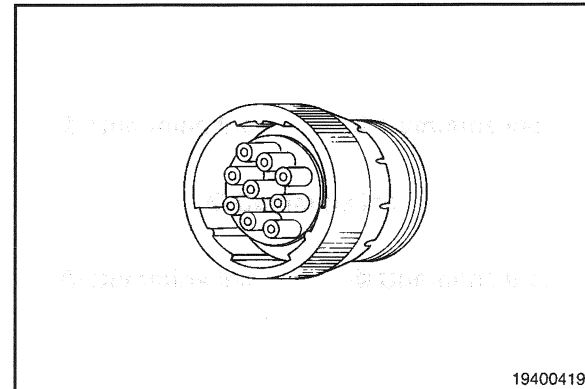
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.



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.



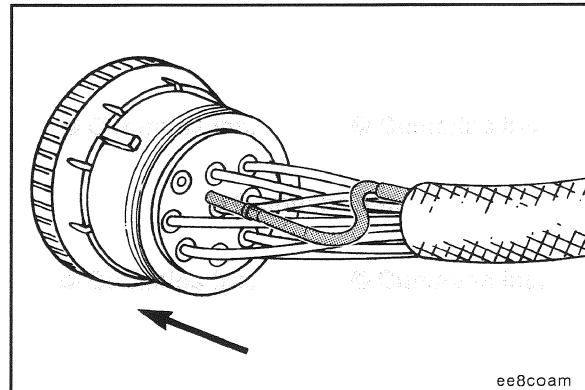
19400419

Insert the pins into the correct holes of the replacement connector.

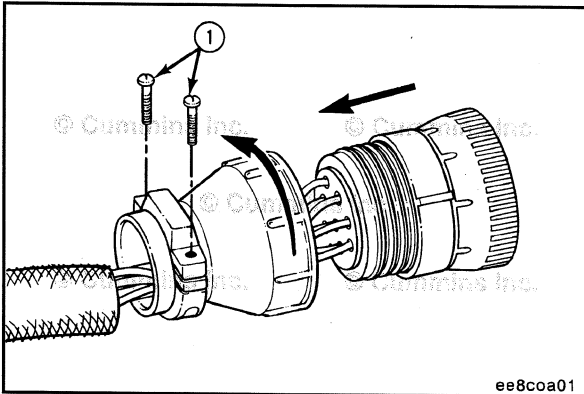


The pin **must** click into place and hold the wire in the connector.

Pull the wire gently to make sure it is seated in the connector.



ee8coam

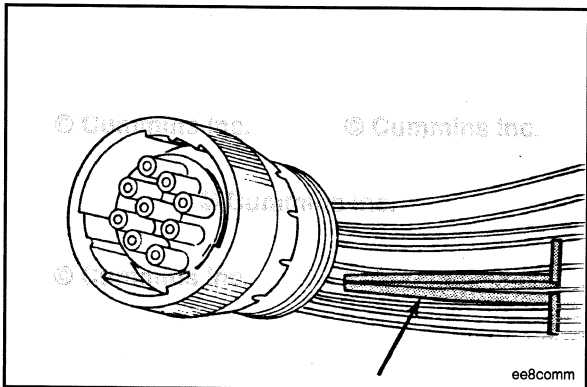


## Deutsch HDP20 and HD30 Connector Series (019-208)

### Pin Replacement

Remove the two clamp capscrews (1) from the rear of the connector.

Turn the retainer of the connector **counterclockwise** until the two pieces are separated.



Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.



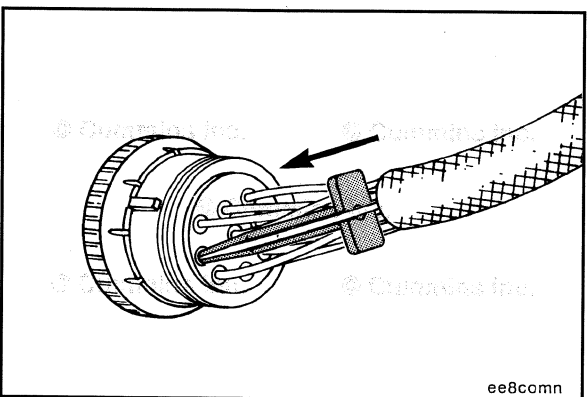
Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

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.

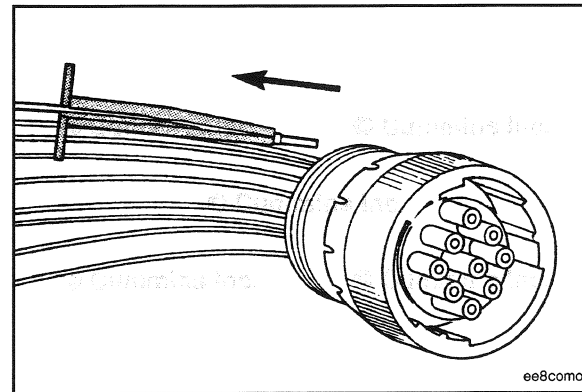
Refer to the wiring diagram in Section E for pin locations.



Push the tool into the connector about 25 mm [1 in] until it bottoms on the terminal flange.

**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

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.

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

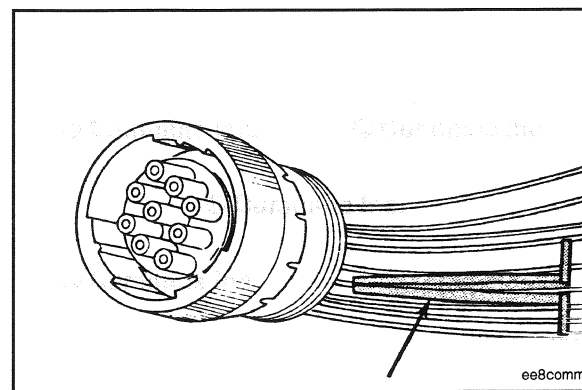
Refer to the appropriate wiring repair kit tools table in the front of Section 19 for the correct repair wire.

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.

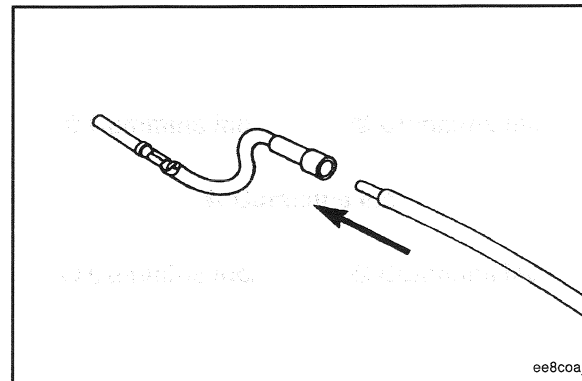
Use wire crimping tool, Part Number 3822930, to cut 127 mm [5 in] off the wire and pin.

Use the wire crimping tool to remove 6 mm [ $\frac{1}{4}$  in] of insulation from the wire.

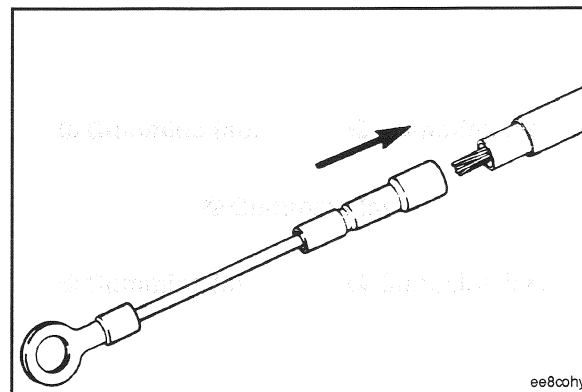


Install the correct repair wire on the bare wire.

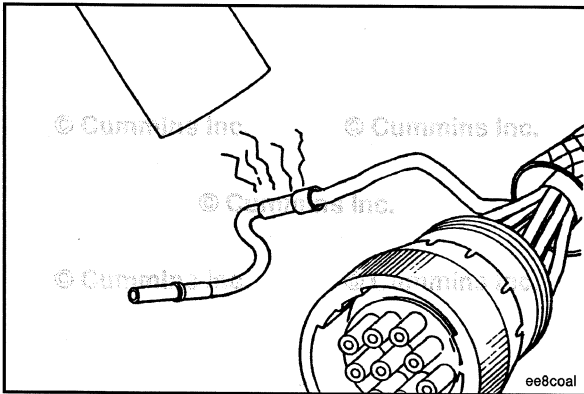
Make sure the bare wire extends into the splice connector.



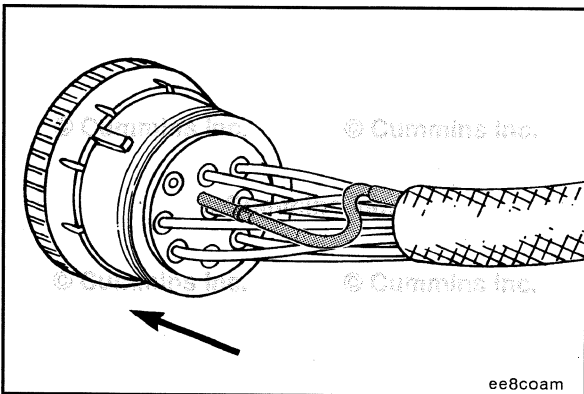
Use the wire crimping tool to crimp the repair wire onto the bare wire.



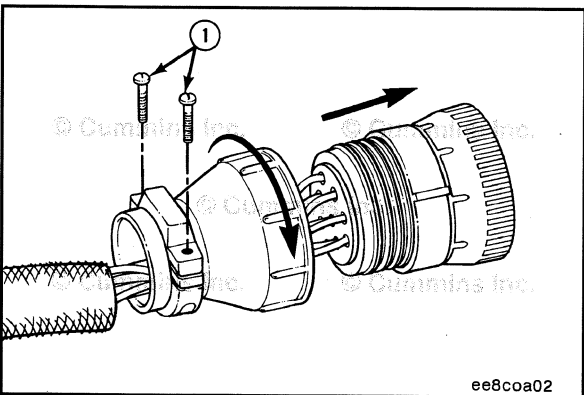




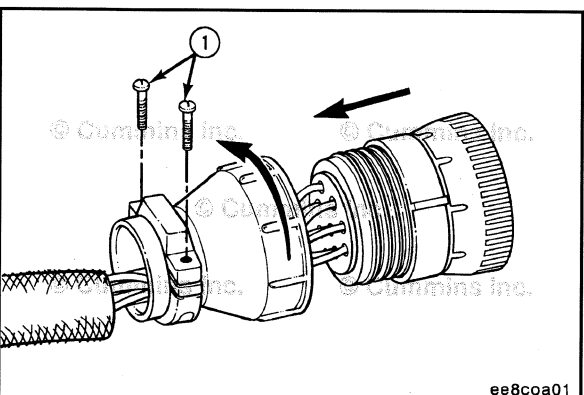
Use heat gun, Part Number 3822860, or an open flame to heat shrink the tubing around the wire. The tubing will shrink and make the connector waterproof.



Insert the pin into the correct hole of the 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.



Install the retainer. Tighten the two clamp capscrews.  
**Torque Value: 1 N•m [ 9 in-lb ]**



### Connector Replacement

Remove the two clamp capscrews (1) from the rear of the connector.  
Turn the retainer of the connector **counterclockwise** until the two pieces are separated.

**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

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

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

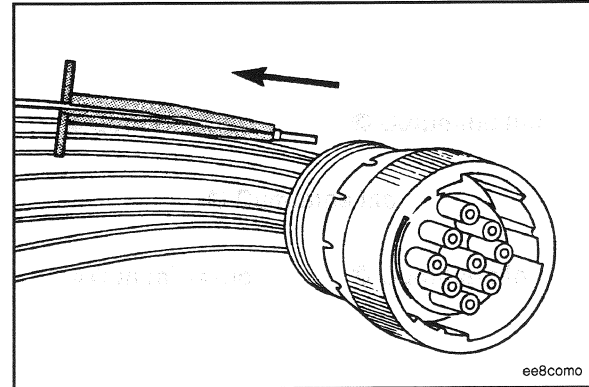
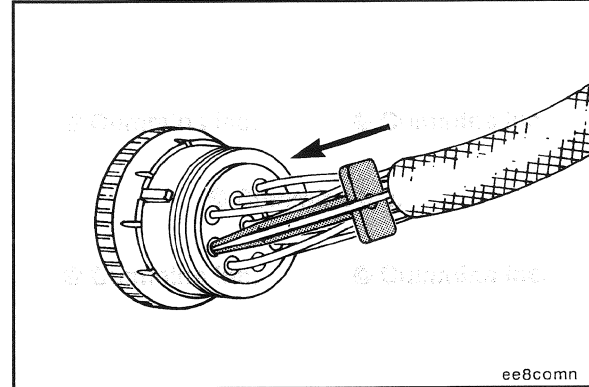
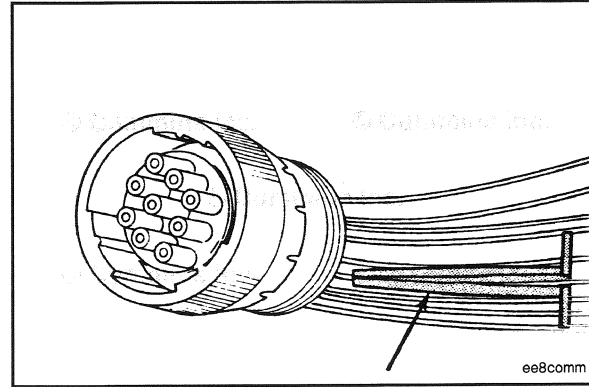
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

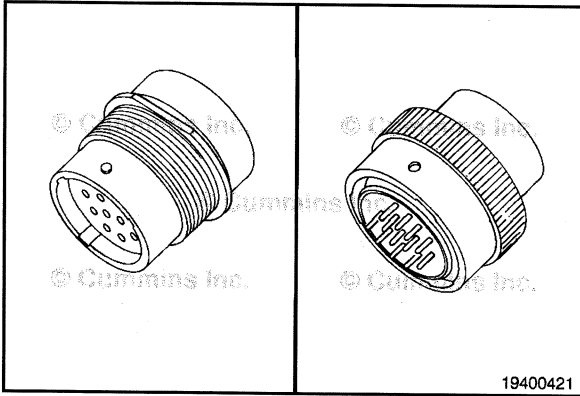
Refer to the wiring diagram in Section E for pin locations.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Push the tool into the connector about 25 mm [1 in] until it bottoms on the terminal flange.

Hold the tool on the terminal flange and pull the wire and connecting pin out of the connector. Note and record the hole from which the pin is removed.

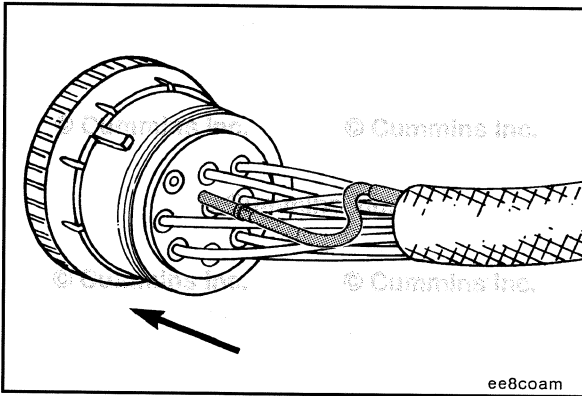




Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

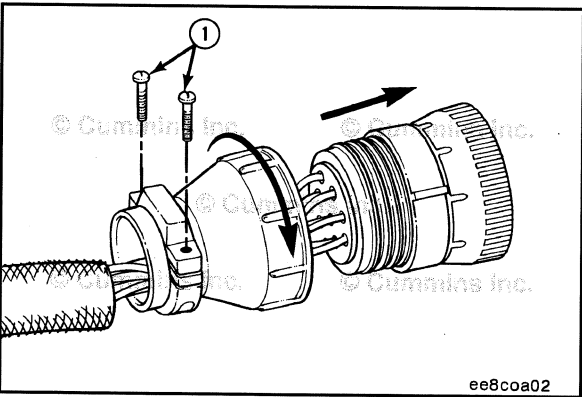
Refer to the wiring diagram in Section E for pin locations.



Insert the pins into the correct holes of the 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.



Install the retainer. Tighten the two clamp capscrews

**Torque Value:** 1 N·m [ 9 in-lb ]



## Packard Relay Connector (019-211) Pin Replacement

The connector pins can **not** be replaced. The connector **must** be replaced as a unit.

Refer to the Connector Replacement procedure for replacement instructions.

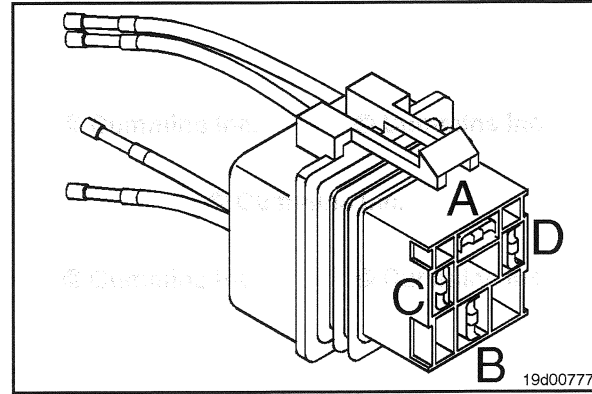
### Connector Replacement

Before installing the new connector, perform a test fit to make sure the connector is keyed properly.

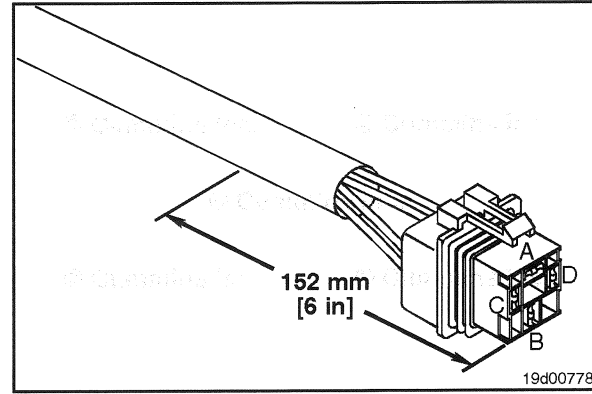
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram 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] from the face of the connector, and remove the wiring harness protective cover.



Before cutting the wires measure and tag them.

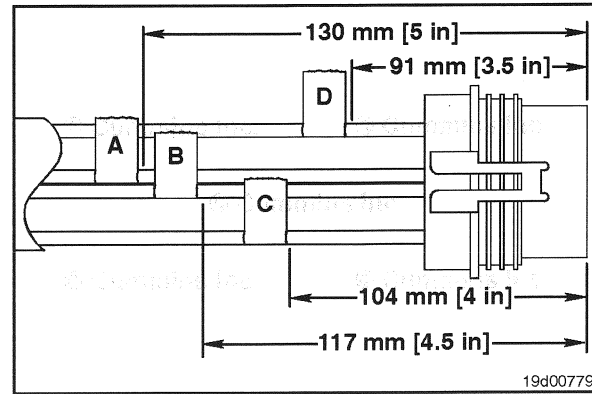
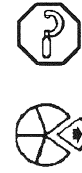
Use wire crimping tool, Part Number 3822930.

Cut wire A 130 mm [5 in] from the face of the connector.

Cut wire B 117 mm [4-½ in] from the face of the connector.

Cut wire C 104 mm [4 in] from the face of the connector.

Cut wire D 91 mm [3-½ in] from the face of the connector.



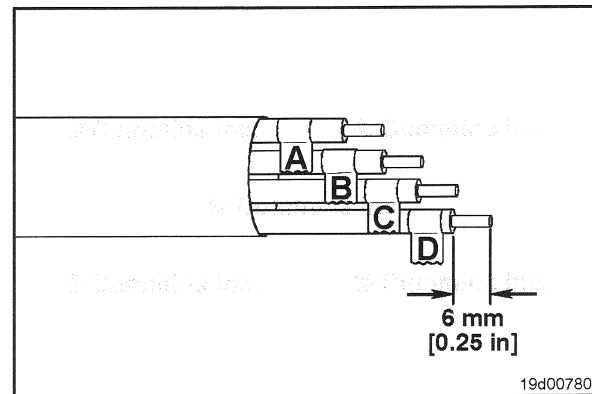
Use crimping tool, Part Number 3822930, to remove 6 mm [¼ inch] of insulation from the electrical wires.

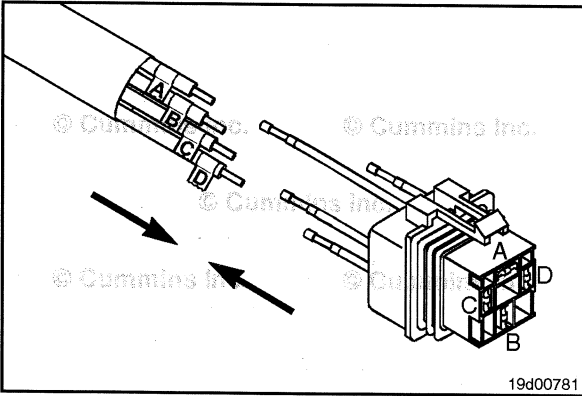
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

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 the wiring diagram for pin locations.

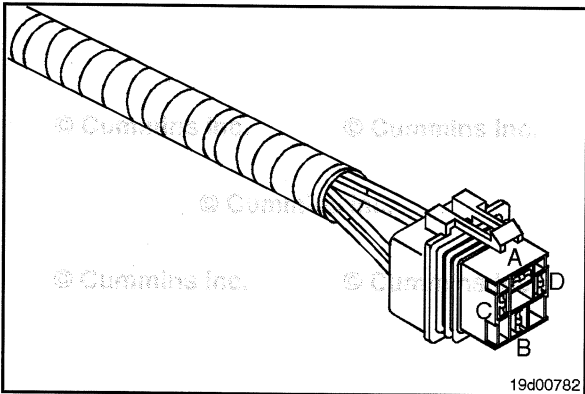
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.



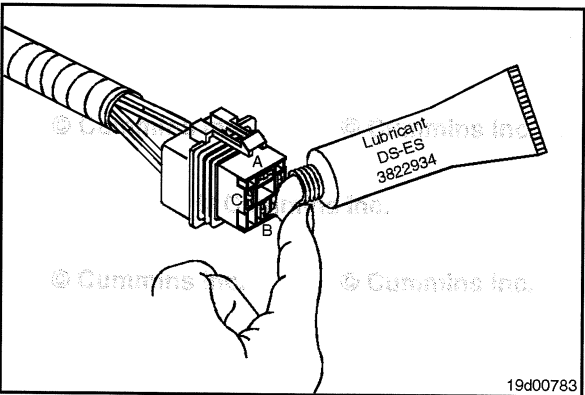


Install the terminal repair wires on the bare wires. Use wire crimping tool, Part Number 3822930, to crimp the terminals.

Use heat gun, Part Number 3822860, or an open flame to heat the shrink tubing. The tubing will shrink and make the connection waterproof.



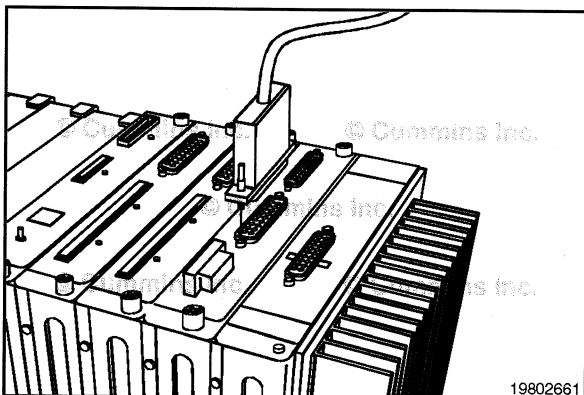
Wrap the wires with tape, for added protection, to complete the repair.



### ⚠ CAUTION ⚠

Use only Cummins-recommended lubricant DS-ES, Part Number 3822934, other lubricants, such as lubricating oil or grease, in the connectors can cause electronic control unit damage, poor performance, or premature connector pin wear.

Apply a small amount of lubricant to the connector terminals. Before installing, fill the entire connector cavity with lubricant.



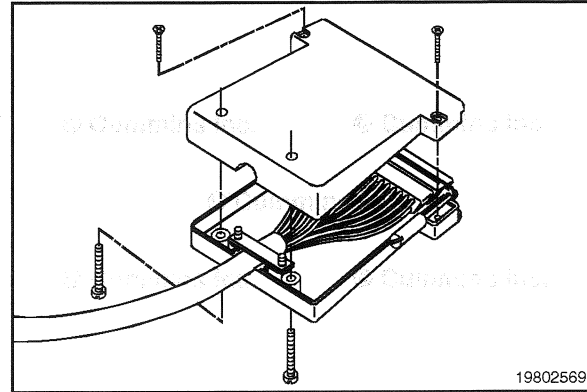
## D-Sub Miniature Connector Series (019-213)

### Pin Replacement

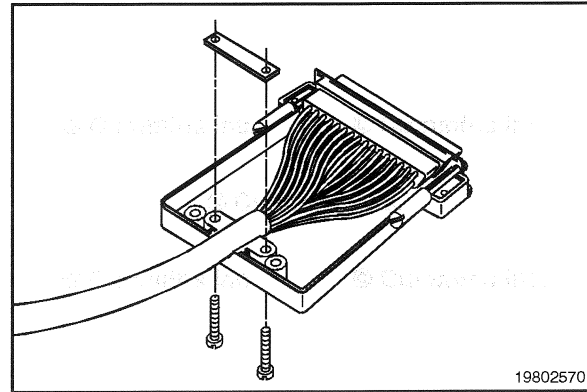
The D-sub miniature connector is used to attach the appropriate harnesses to the ECM.

Remove the connector.

Remove the backshell from the connector.  
Locate the damaged pin or wire.



Remove the strain relief to be able to work with the damaged pin.



Use the D-sub miniature extraction tool, Part Number 3163971, place over the wire to remove a pin from the connector.



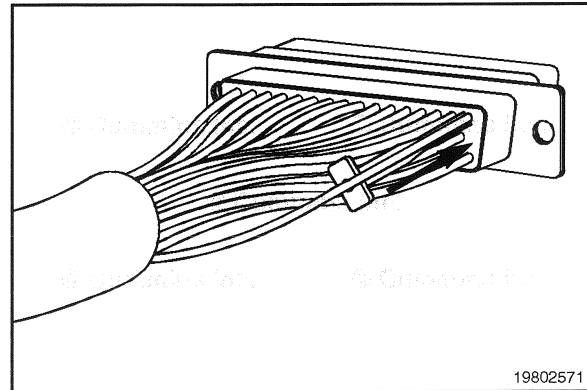
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.



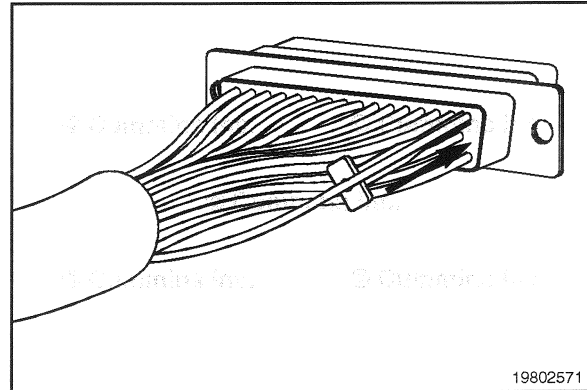
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

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.



With a twisting motion, push the pin extraction tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange. A click will be heard when the extraction tool is in place.

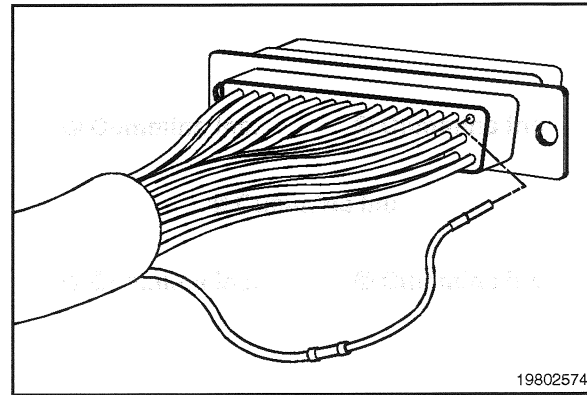




Insert the pin into the correct hole of the connector.

The pin **must** click into place and hold the wire in the connector.

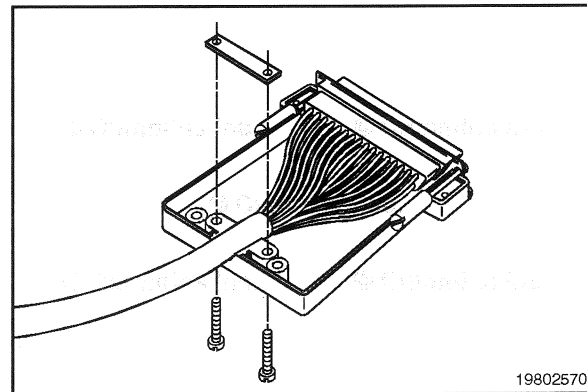
Pull the wire gently to make sure it is seated in the connector.



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Tighten the strain relief.

Complete the assembly of the backshell by placing the two halves together and tightening the screws.

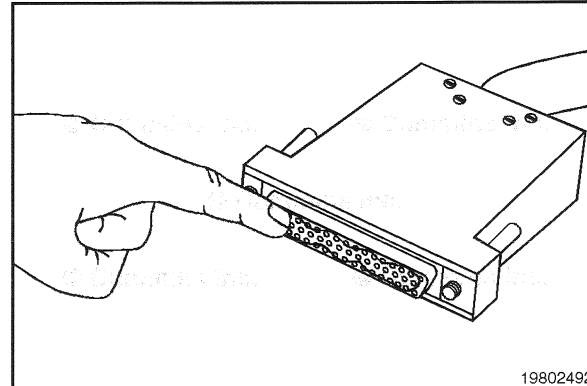


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### ⚠ CAUTION ⚠

Use only Cummins-recommended lubricant DS-ES, Part Number 3822934. Other lubricants, such as lubricating oil or grease, in the connectors can cause ECM damage, poor engine performance, or premature connector pin wear.

Apply a small amount of lubricant to the connector terminals. Do **not** fill the entire connector cavity with lubricant.



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### Connector Replacement

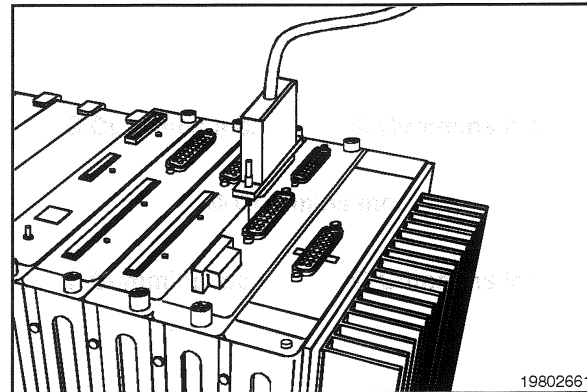
The 50-pin D-sub miniature connector is used to attach the appropriate harnesses to the ECM.

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.

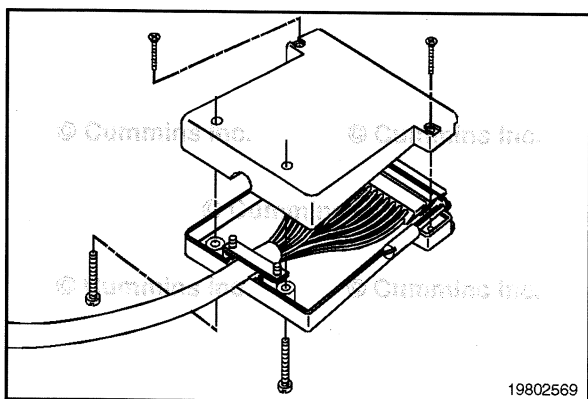
Refer to the wiring diagram in Section E for pin locations.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

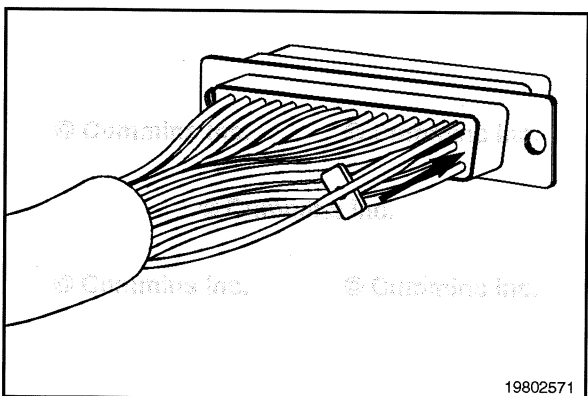


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Remove the backshell from the connector. Remove the stain relief.



To replace the connector use the D-sub miniature extraction tool, Part Number 3163971, place over each wire to remove all pins from the connector.



Before installing the new connector, perform a fit test to make sure the connector is keyed correctly.

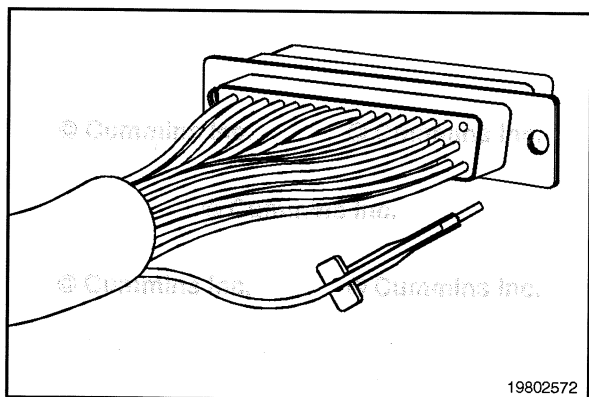


Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

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.

With a twisting motion, push the pin extraction tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange. A click will be heard when the extraction tool is in place.

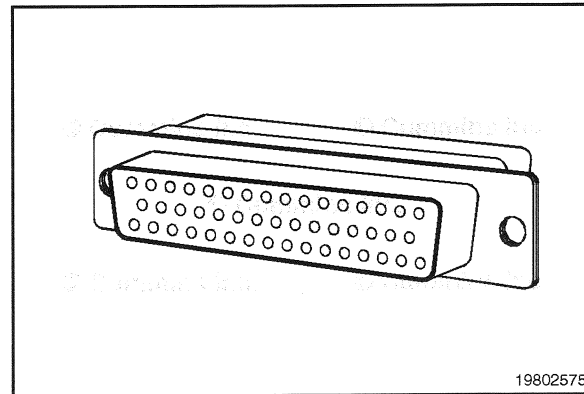


Hold the tool on the terminal flange and pull the wire and connecting pin out of the connector. Note and record the hole from which the pin was removed.

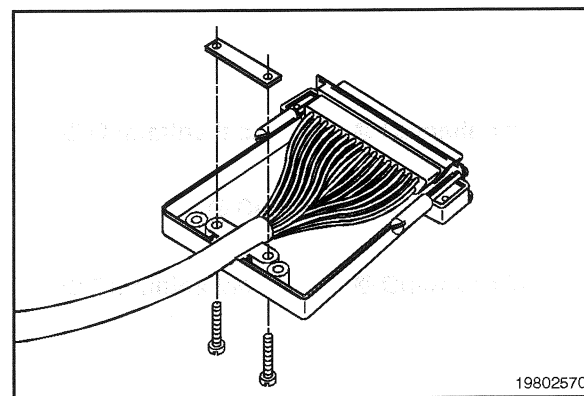
Insert the pins into the correct holes of the replacement connector.

Each pin **must** click into place and hold the wires in the connector.

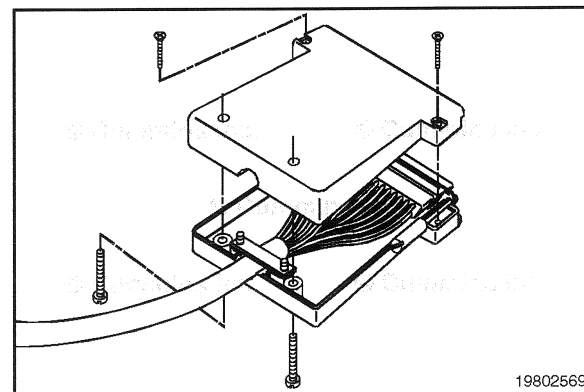
Pull each wire gently to make sure it is seated in the connector.



Place the connector pin block onto the lower half of the backshell. Place all wires within the strain relief and tighten the strain relief.



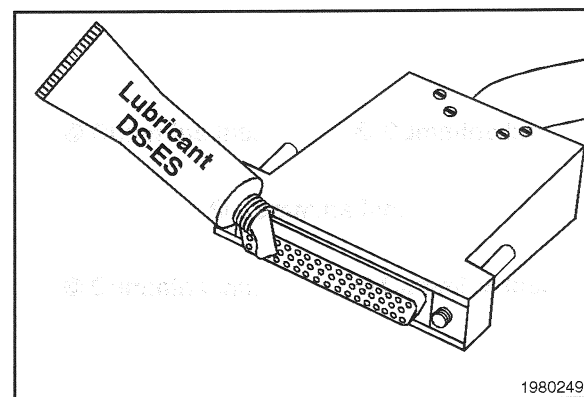
Complete the assembly of the connector by placing the upper half of the backshell onto the lower half and tightening the screws.



**⚠ CAUTION ⚠**

Use only Cummins-recommended lubricant DS-ES, Part Number 3822934. Other lubricants, such as lubricating oil or grease, in the connectors can cause ECM damage, poor engine performance, or premature connector pin wear.

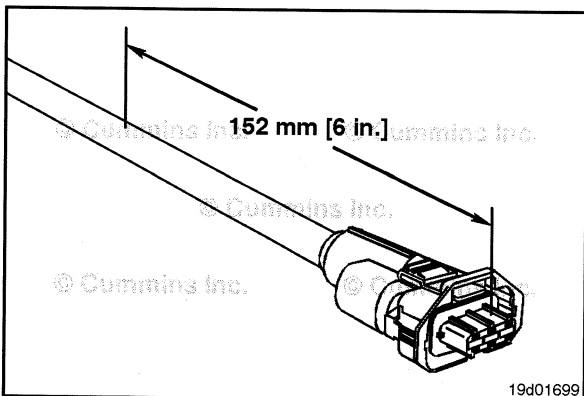
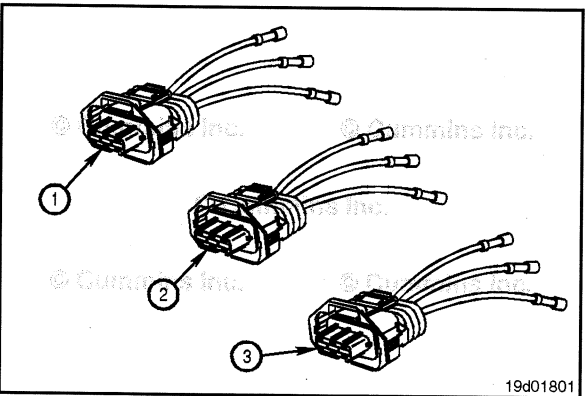
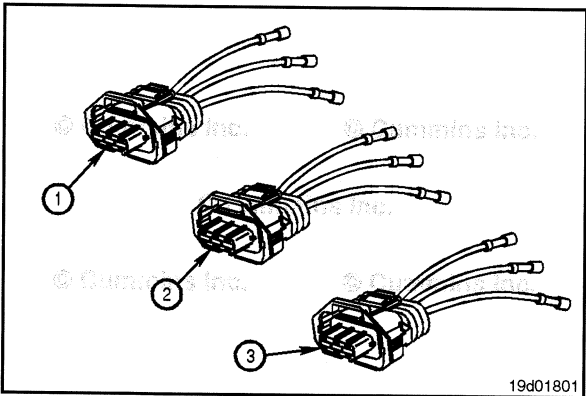
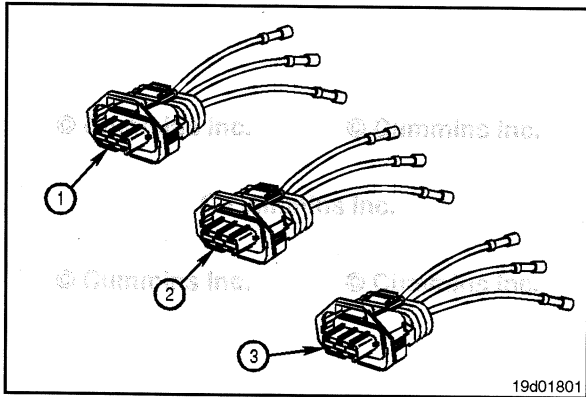
Apply a small amount of lubricant to the connector terminals. Do **not** fill the entire connector cavity with lubricant.



## 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.



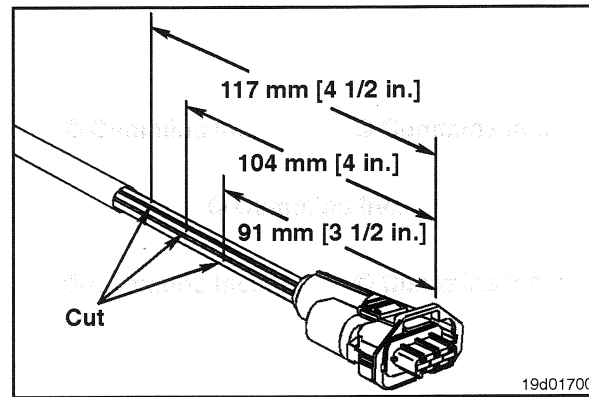
**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

Before cutting the wires, measure and tag the three wires.

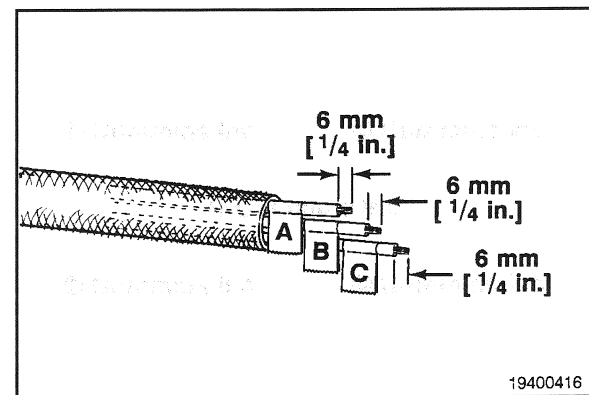
Use wire cutters to cut wire 1 117 mm [4-½ in] from the face of the connector.

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.

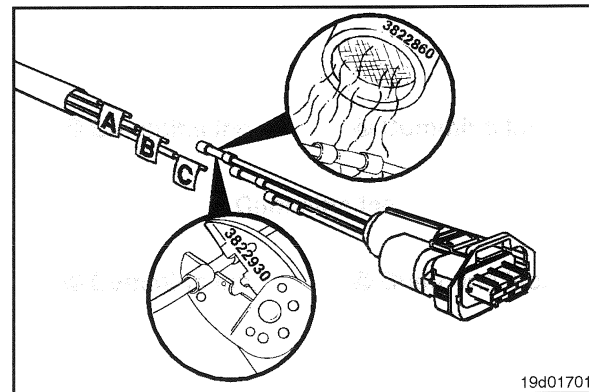


Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from all electrical wires.

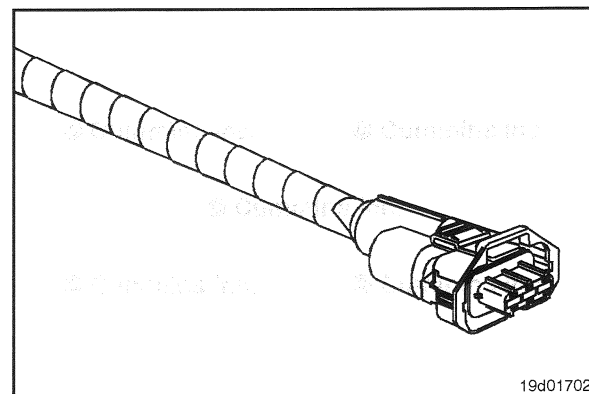


Install the pin repair wires and connector onto the bare wires of the harness and use the wire crimping tool to crimp each repair wire onto the harness.

Use heat gun, Part Number 3822860, to shrink the tubing. The tubing will shrink and make the connection waterproof.



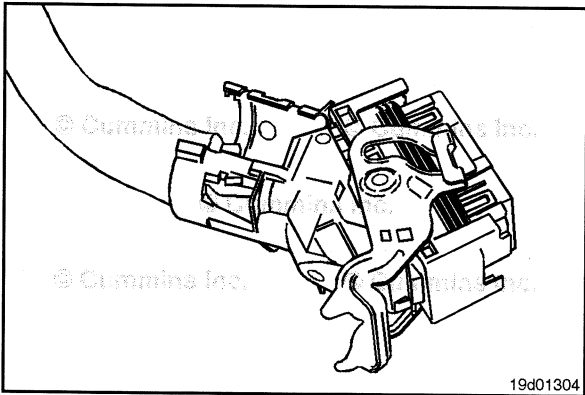
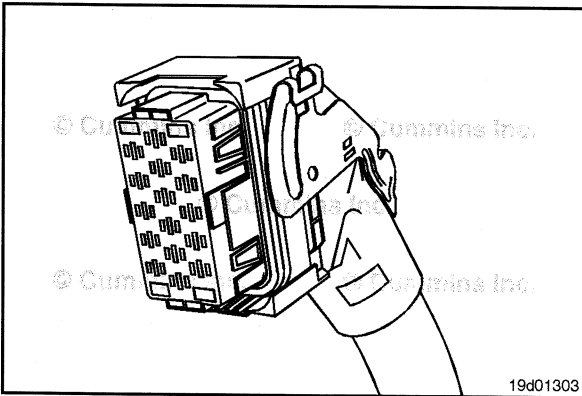
Wrap the wires with tape, for added protection, to complete the repair.



## Bosch™ ECM Injector Driver Connector Series (019-215)

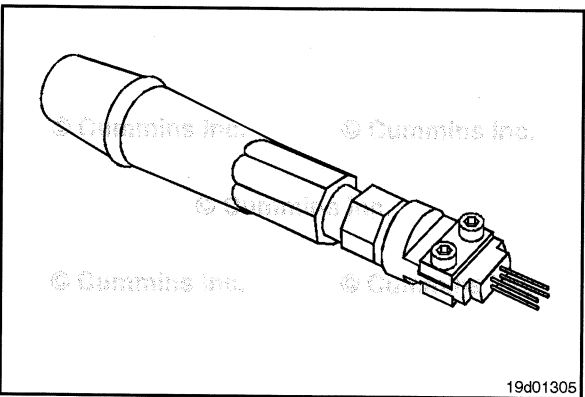
### Pin Replacement

This connector is used to attach the appropriate harness to the ECM.



Remove the connector shell by slightly bending the connector shell (black) away from the two tangs that hold the shell to the ECM connector (red).

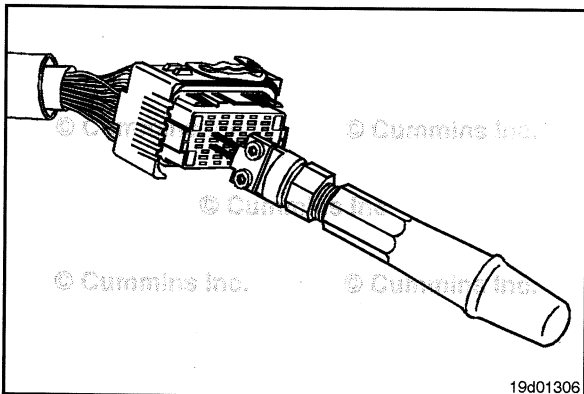
Before pins can be removed, they **must** be unlocked. Slide the purple tabs on the edges of the connector sideways at the same time. When unlocked, the purple tab will align with a slot, making the entire length of the purple tab visible.



Use Bosch® extraction tool, Part Number 3164091, place over the wire to remove a pin from the connector.

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.

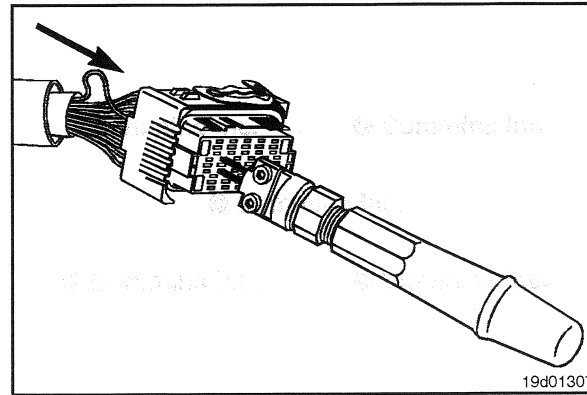


Insert the pin extraction tool into the unlocking holes in the connector.

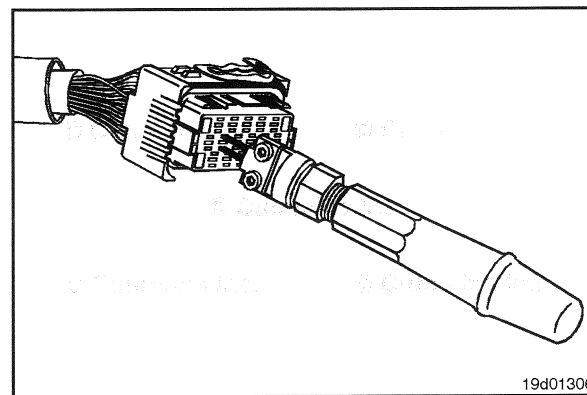
Do **not** push the tool all the way into the connector.

QSF3.8 CM2350 F107  
Section 19 - Electronic Controls - Group 19

Push the corresponding wire toward the pin extraction tool.



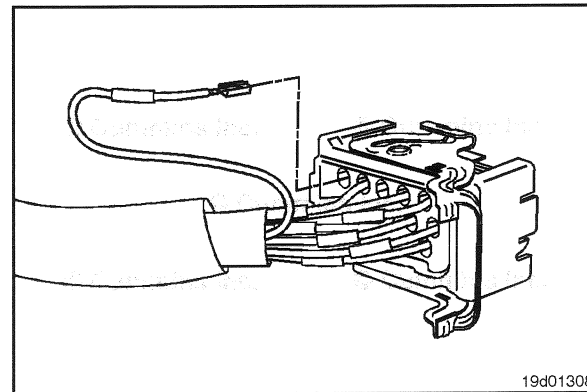
Press the pin extraction tool all the way into the connector.



**⚠ CAUTION ⚠**

If the wire is difficult to remove, do not pull hard on wire; the locking tang of the wire terminal will stick or the terminal will pull off the wire and remain in the connector.

Carefully pull the wire out of the connector. If it is difficult to remove, repeat the entire procedure.

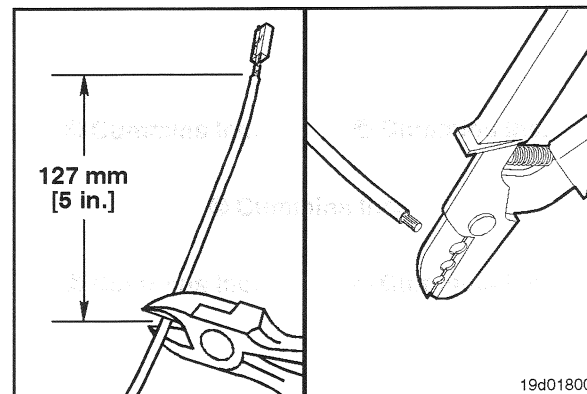


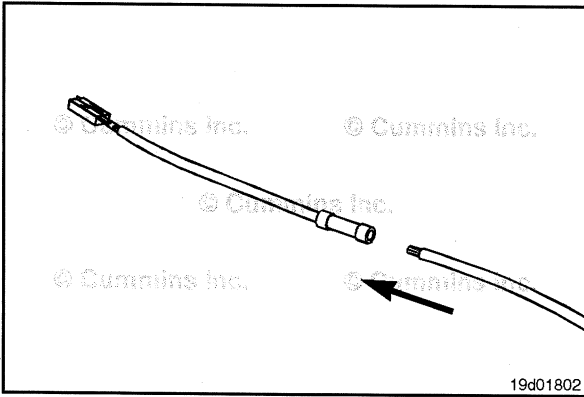
**NOTE:** The repair wire is 127 mm [5 in] long.

Use wire cutters to cut 127 mm [5 in] off the wire and pin.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

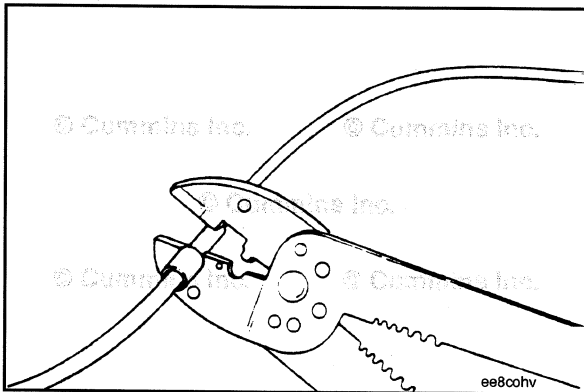
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.



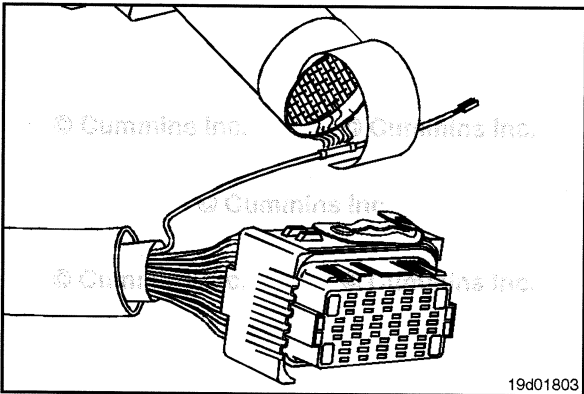


Install the repair wire on the bare wire.

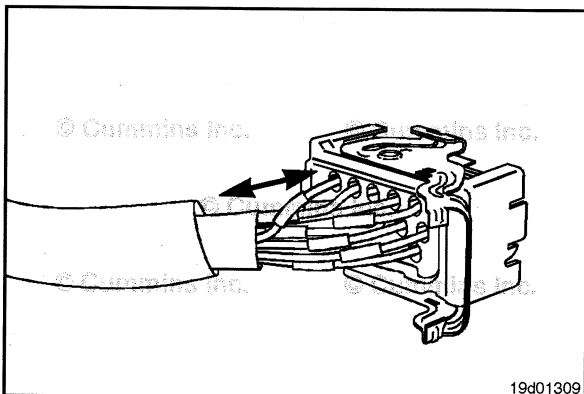
Make sure the bare wire extends into the splice connector.



Use the wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



Use heat gun, Part Number, 3822860, to heat the shrink tubing around the wire. The tubing will shrink and make the connection waterproof.



The wire terminal has locating pins that **only** allow it to be inserted in a certain orientation.

Insert the wire from the backside of the connector.

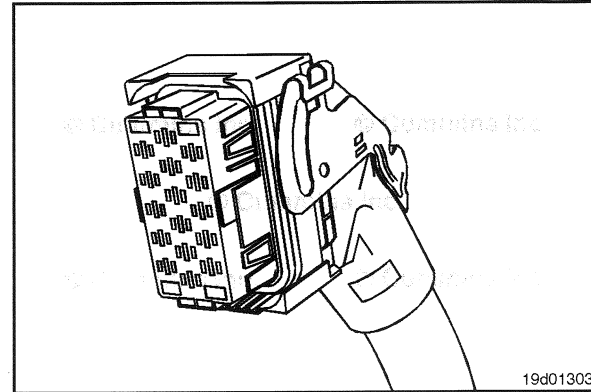
Pull the wire into the connector.

Pull the wire gently to make sure it is locked into the connector.

**NOTE:** If the wire's locking tang did **not** latch, then remove the wire and pry the tang away from the terminal and repeat this step.

## Connector Replacement

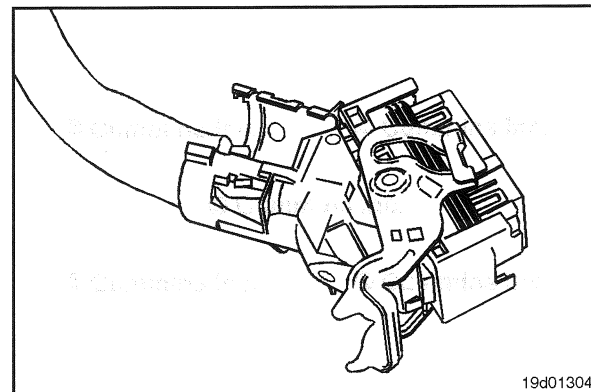
This connector is used to attach the harness to the ECM.



Remove the connector shell by slightly bending the connector shell (black) away from the two tangs that hold the shell to the ECM connector (red).



Before pins can be removed, they **must** be unlocked. Slide the purple tabs on the edges of the connector sideways at the same time. When unlocked, the purple tab will align with a slot, making the entire length of the purple tab visible.



Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

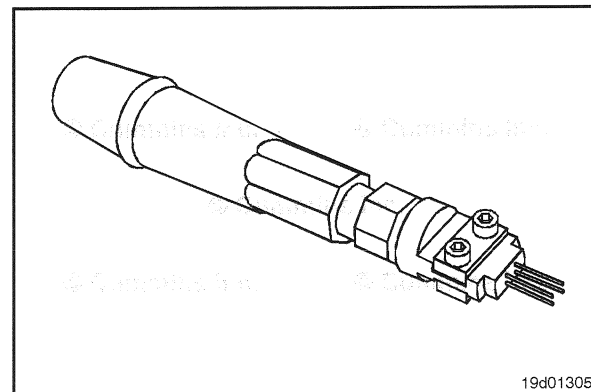


Refer to the wiring diagram in Section E for pin locations.



Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

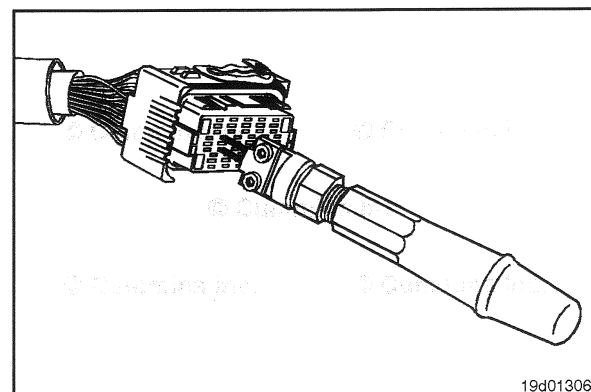
To replace the connector, use Bosch® extraction tool, Part Number 3164091, over each wire to remove all pins from the connector.



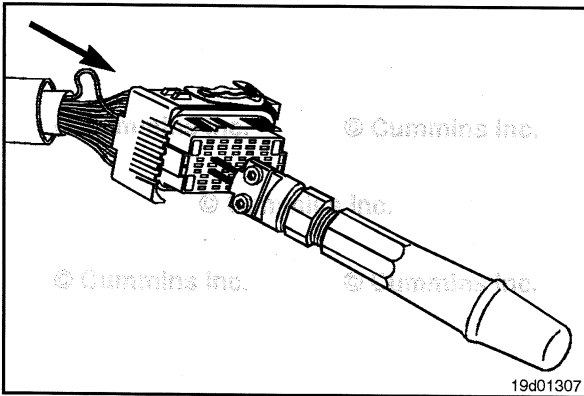
Insert the pin extraction tool into the unlocking holes in the connector.



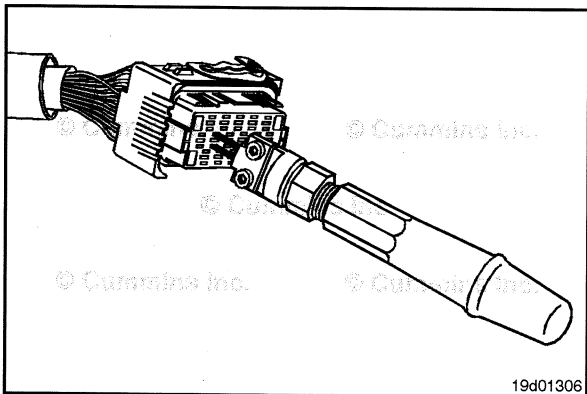
Do **not** push the tool all the way into the connector.



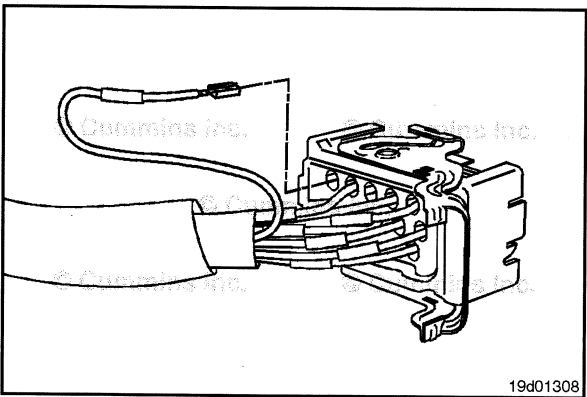




Push the corresponding wire toward the pin extraction tool.



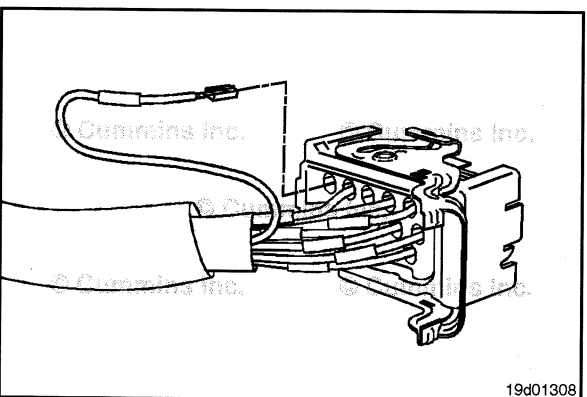
Press the pin extraction tool all the way into the connector.



**CAUTION**

If the wire is difficult to remove, do not pull hard on the wire; otherwise, the locking tang of the wire terminal will stick or the terminal will pull off the wire and remain in the connector.

Carefully pull the wire out of the connector and record the hole from which the pin is removed. If it is difficult to remove, repeat the procedure.



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 wire terminal has locating pins that allow it to be inserted in **only** a certain orientation.

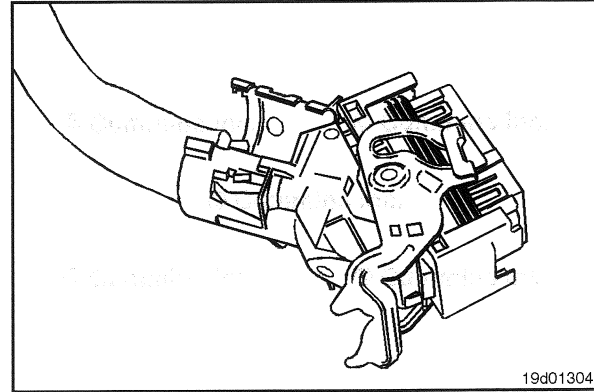
Insert the pins into the correct holes of the replacement connector.

Each pin **must** click into place and hold the wires in the connector.

Pull each wire gently to make sure it is seated in the connector.

Replace the connector shell by inserting the hinge of the connector shell (black) into the hinge of the connector (red).

Close the connector shell onto the connector and wiring harness by pressing it onto the tang of the connector until a click is heard.



19d01304

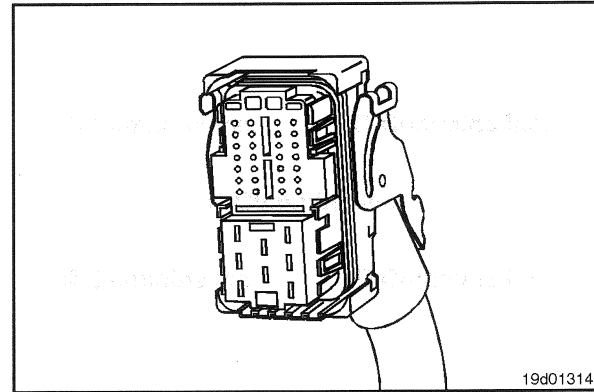
## Bosch™ ECM Actuator and Sensor Connector Series (019-216)

### Pin Replacement

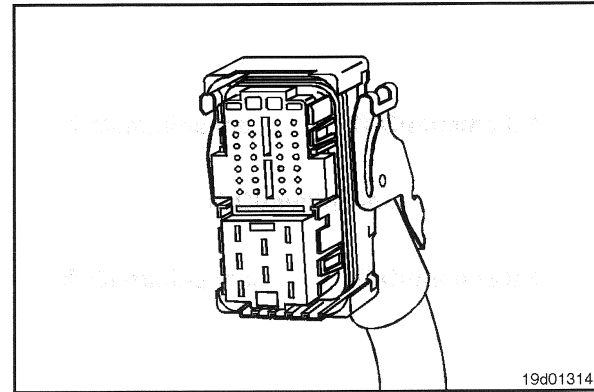
The connector is used to attach the appropriate harness to the ECM.

Remove the connector shell by slightly bending the connector shell (black) away from the two tangs that hold the shell to the ECM connector (red).

Before pins can be removed, they **must** be unlocked. Slide the purple tabs on the edges of the connector sideways at the same time. When unlocked, the purple tab will align with a slot, making the entire length of the purple tab visible.



19d01314



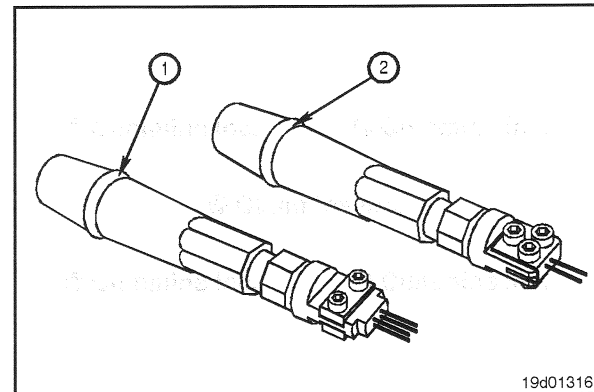
19d01314

Use Bosch® extraction tool (2), Part Number 3164093, (small terminals), or use Bosch® extraction tool (1), Part Number 3164091 (large terminals), over the wire to remove a pin from the connector.

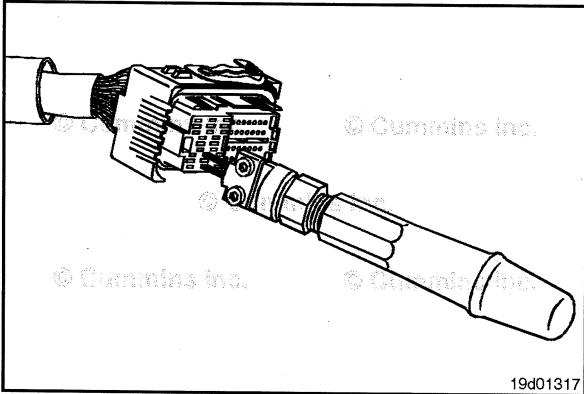
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

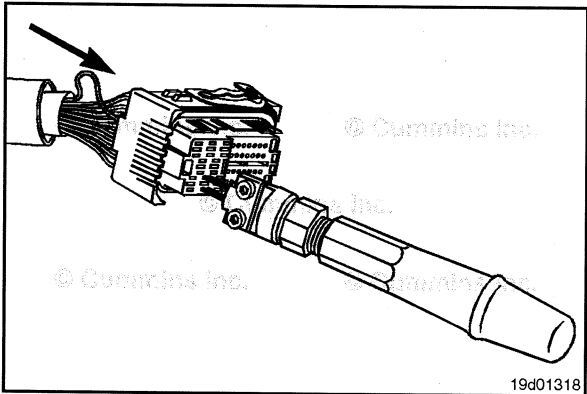


19d01316

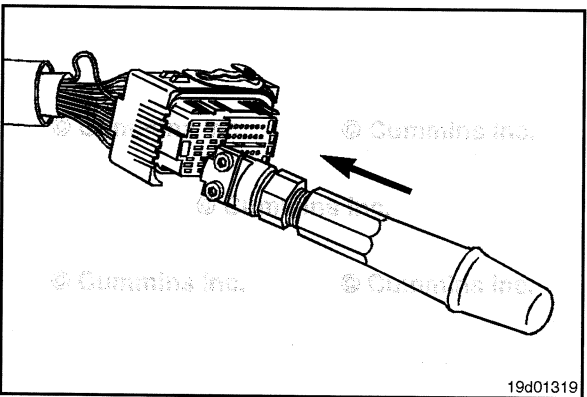


Insert the pin extractor tool into the unlocking holes in the connector.

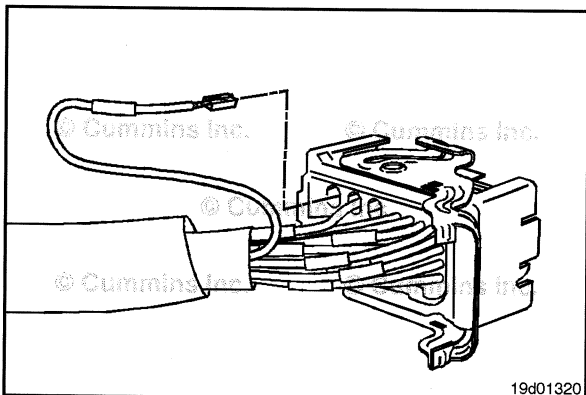
Do **not** push the tool all the way into the connector.



Push the corresponding wire toward the pin extraction tool.



Press the pin extraction tool all the way into the connector.



**⚠CAUTION⚠**

If the wire is difficult to remove, do not pull hard on the wire; otherwise, the locking tang of the wire terminal will stick or the terminal will pull off the wire and remain in the connector.

Carefully pull the wire out of the connector. If it is difficult to remove, repeat the entire procedure.

**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

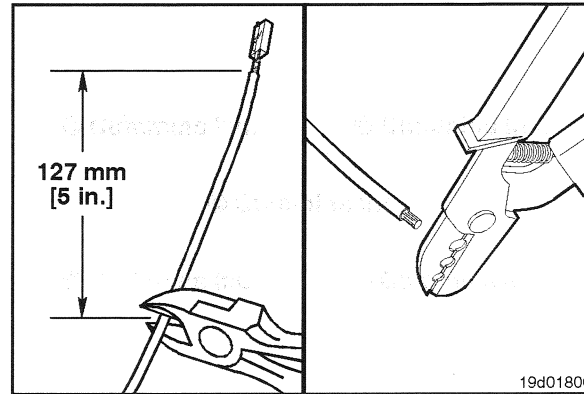
**NOTE:** The repair wire is 127 mm [5 in.] long.

Use wire cutters to cut 127 mm [5 in.] of the wire and pin.

Use wire crimping tool, Part Number 3822930, to remove 6 mm [ $\frac{1}{4}$  in.] of insulation from the wire.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

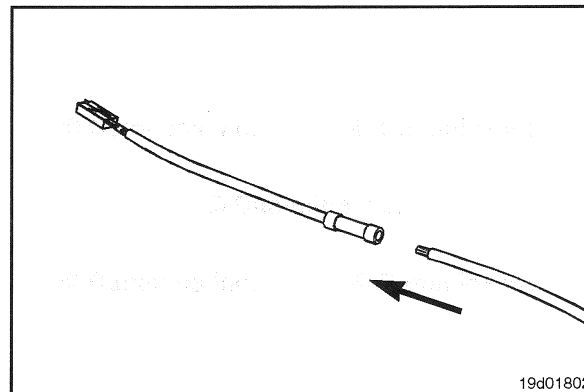
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.



19d0180t

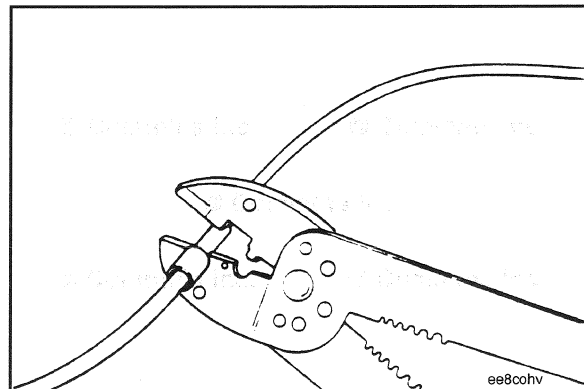
Install the repair wire on the bare wire.

Make sure the bare wire extends into the splice connector.



19d0180z

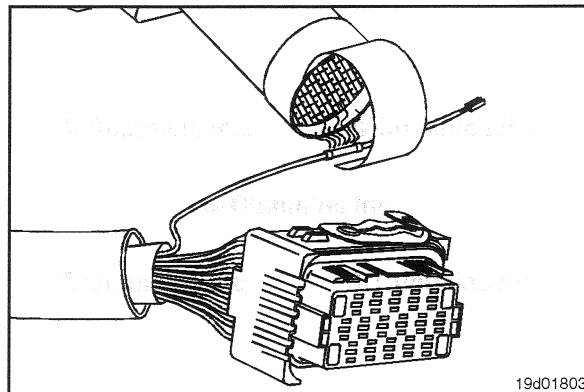
Use wiring crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



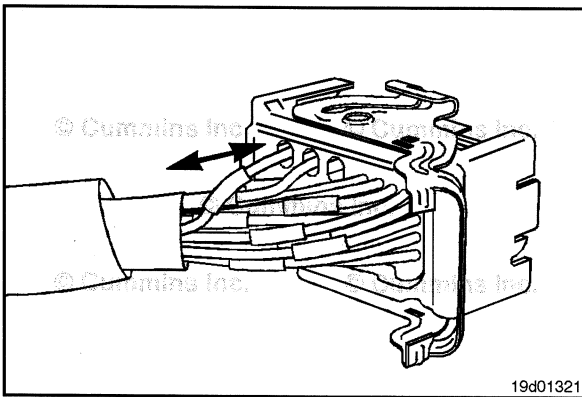
ee8cohv

Use heat gun, Part Number 3822860, to heat the shrink tubing around the wire.

The tubing will shrink and make the connection waterproof.



19d01803



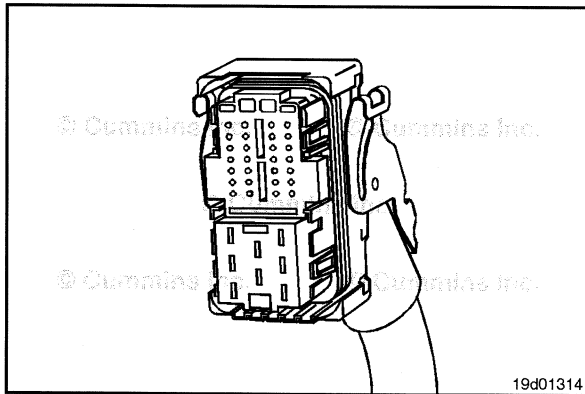
The wire terminal has locating pins that **only** allow it to be installed in a certain orientation.

Insert the wire from the backside of the connector.

Push the wire into the connector.

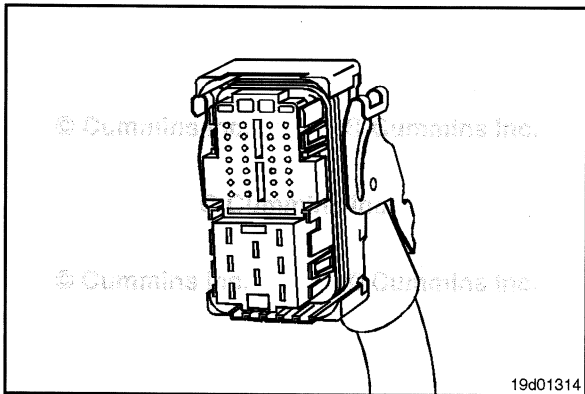
Pull the wire gently to make sure it is locked into the connector.

**NOTE:** If the wire's locking tang has **not** latched, then remove the wire, pry the tang away from the terminal, and repeat this step.



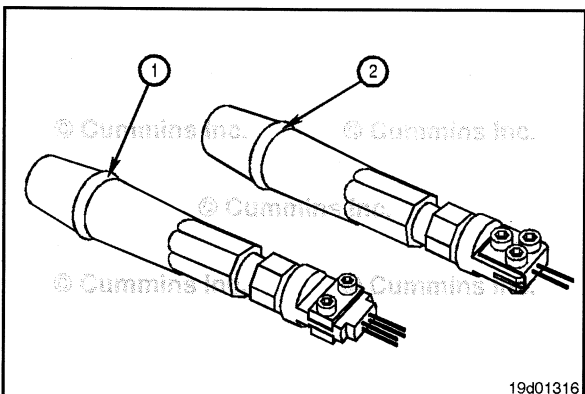
### Connector Replacement

This connector is used to attach the engine harness to the ECM.



Remove the connector shell by slightly bending the connector shell (black) away from the two tangs that hold the shell to the ECM connector (red).

Before pins can be removed, they **must** be unlocked. Slide the purple tabs on the edges of the connector sideways at the same time. When unlocked, the purple tab will align with a slot, making the entire length of the purple tab visible.



Use Bosch® extraction tool (2), Part Number 3164093, (small terminals), or use Bosch® extraction tool (1), Part Number 3164091 (large terminals), over the wire to remove a pin from the connector.



Remove 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.

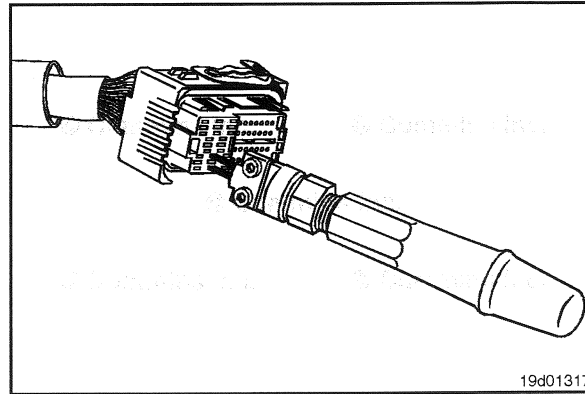
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

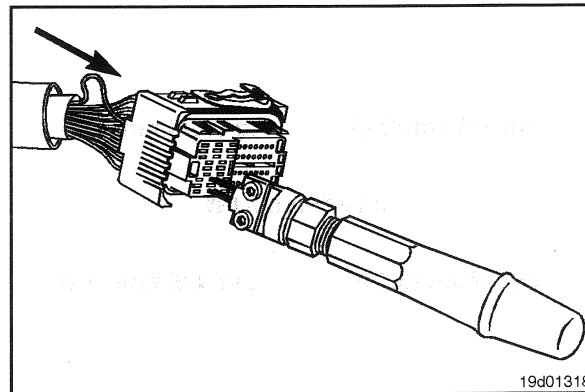
Insert the pin extraction tool into the unlocking holes in the connector.



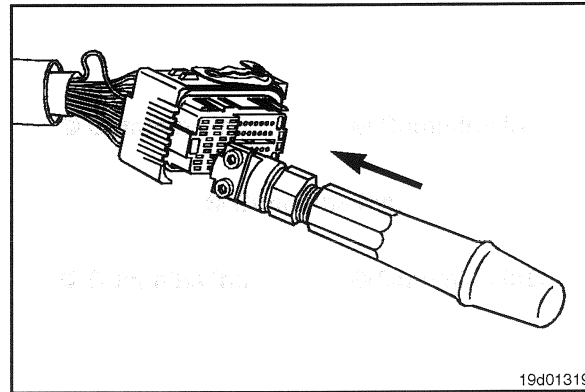
Do **not** push the tool all the way into the connector.



Push the corresponding wire toward the pin extraction tool.



Press the pin extraction tool all the way into the connector.

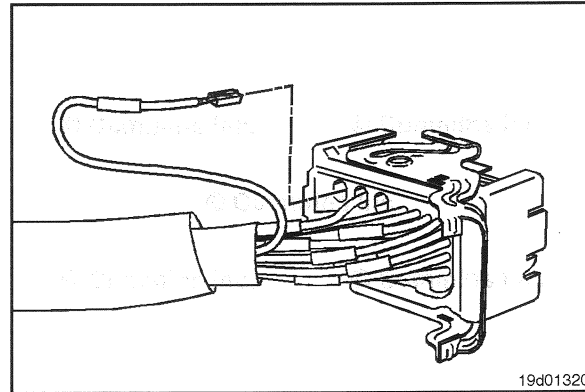


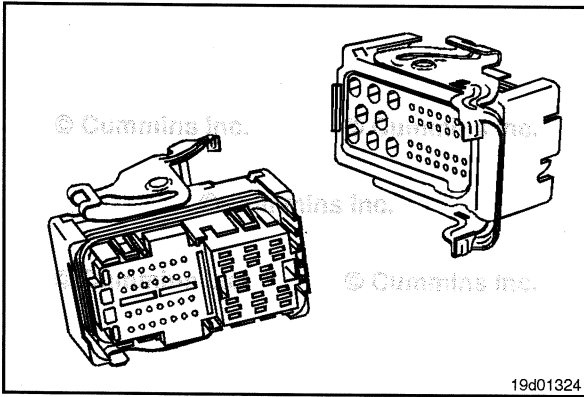
**⚠ CAUTION ⚠**

If the wire is difficult to remove, do not pull hard on the wire; otherwise, the locking tang of the wire terminal will stick or the terminal will pull off the wire and remain in the connector.



Carefully pull the wire out of the connector and record the hole from which the pin is removed. If it is difficult to remove, repeat the entire procedure.

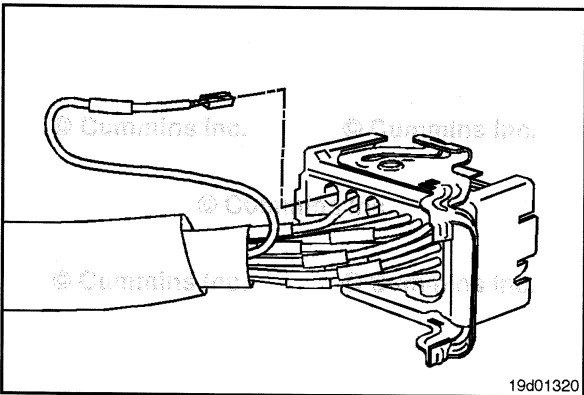




Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

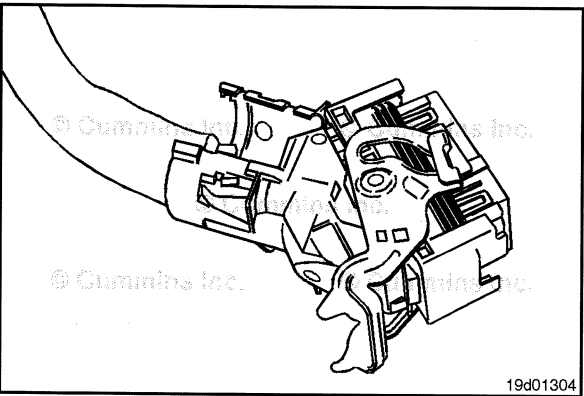
Refer to the wiring diagram in Section E for pin locations.



Insert the pins into the correct hole of the replacement connector.

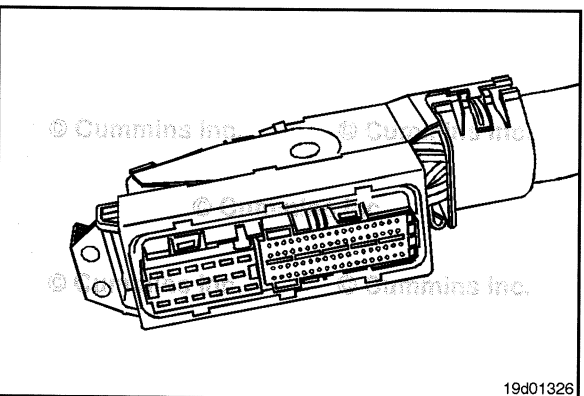
Each pin **must** click into place and hold the wires in the connector.

Pull each wire gently to make sure it is seated in the connector.



Replace the connector shell by inserting the hinge of the connector shell (black) into the hinge of the connector (red).

Close the connector shell onto the connector and wiring harness by pressing it on the tang of the connector until a click is heard.



## Bosch™ ECM OEM Connector Series (019-217)

### Pin Replacement

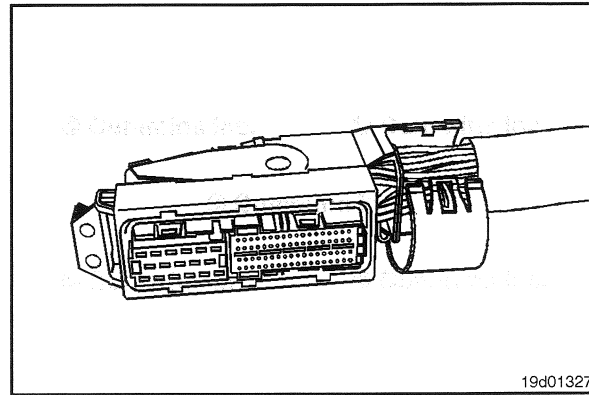
This connector is used to attach the appropriate harness to the ECM.

**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

Remove the connector shell by slightly bending the connector shell (black) away from the two tangs that hold the shell to the ECM connector (red).



Before pins can be removed, they **must** be unlocked. Slide the purple tabs on the edges of the connector sideways at the same time. When unlocked, the purple tab will align with a slot, making the entire length of the purple tab visible.



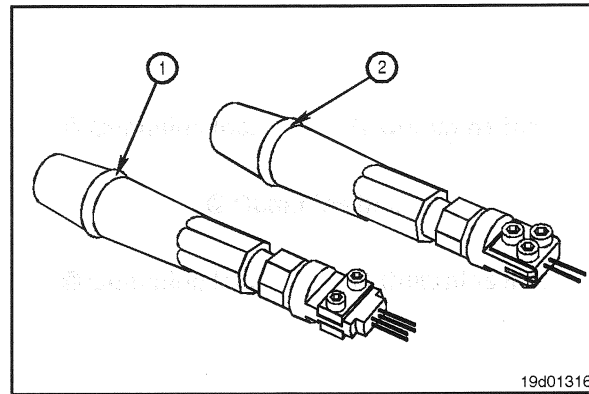
Use Bosch® extraction tool (2), Part Number 3164093, (small terminals), or use Bosch® extraction tool (1), Part Number 3164091 (large terminals), over the wire to remove a pin from the connector.



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.

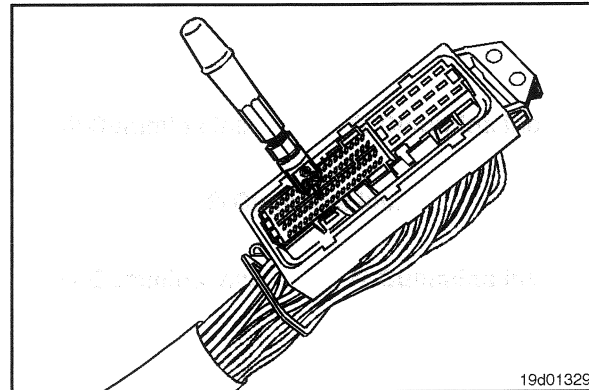
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.



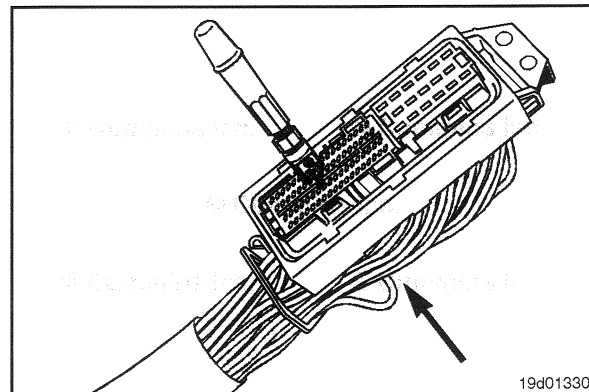
Insert the pin extraction tool into the unlocking holes in the connector.



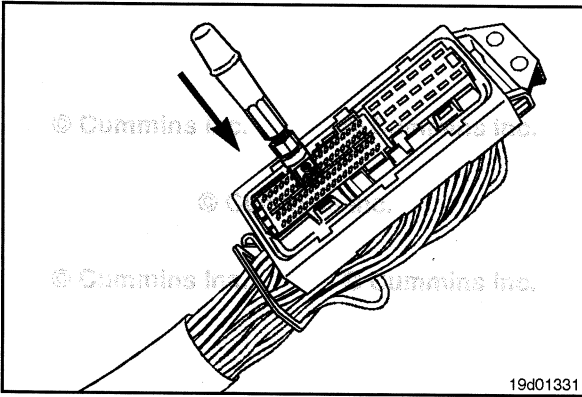
Do **not** push the tool all the way into the connector.



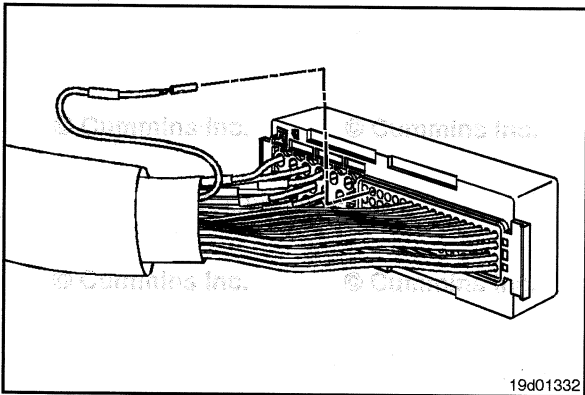
Push the corresponding wire toward the pin extraction tool.







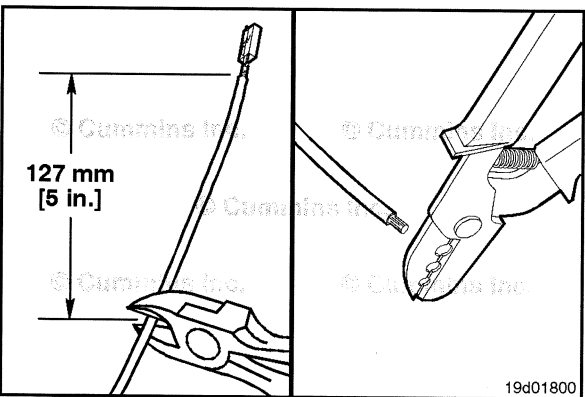
Press the pin extraction tool all the way into the connector.



**CAUTION**

If the wire is difficult to remove, do not pull hard on the wire; otherwise, the locking tang of the wire terminal will stick or the terminal will pull off the wire and remain in the connector.

Carefully pull the wire out of the connector. If it is difficult to remove, repeat the entire procedure.



**NOTE:** The repair wire is 127 mm [5 in.] long.

Use wire cutters to cut 127 mm [5 in.] of the wire and pin.

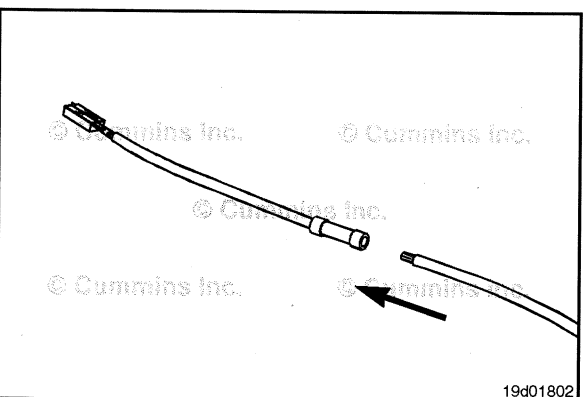


Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in.] of insulation from the wire.



Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.



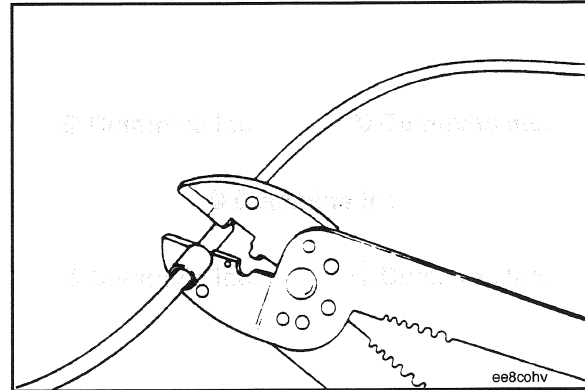
Install the repair wire on the bare wire.



Make sure the bare wire extends into the splice connector.

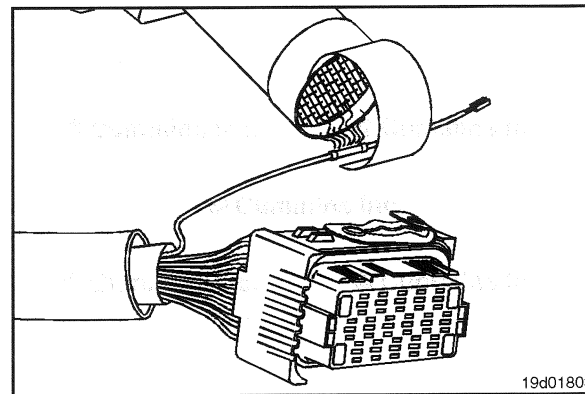
**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



Use heat gun, Part Number 3822860, to heat the shrink tubing around the wire.

The tubing will shrink and make the connection waterproof.



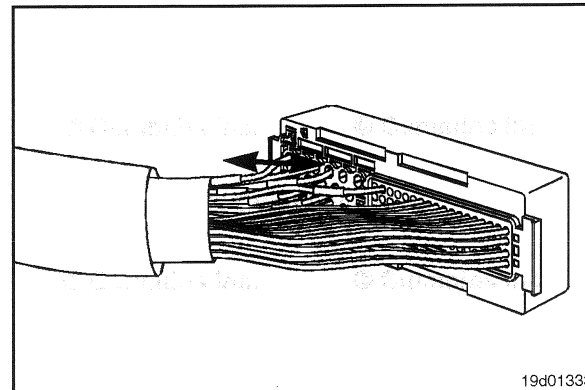
The wire terminal has locating pins that **only** allow it to be installed in a certain orientation.

Insert the wire from the backside of the connector.

Push the wire into the connector.

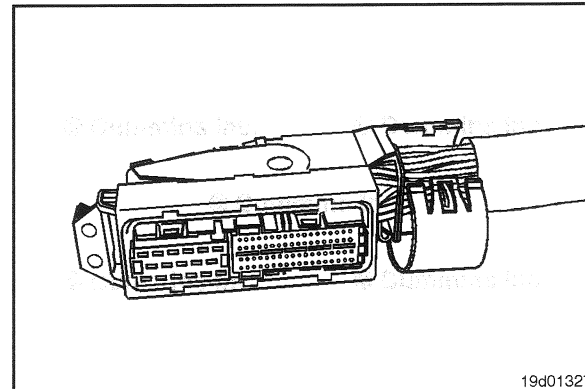
Pull the wire gently to make sure it is locked into the connector.

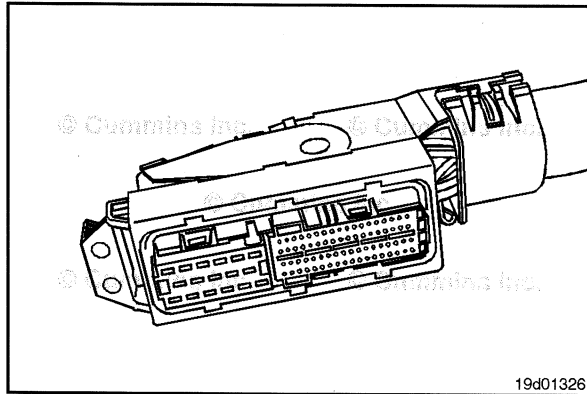
**NOTE:** If the wire's locking tang has **not** latched, then remove the wire, pry the tang away from the terminal, and repeat this step.



Replace the connector shell by inserting the hinge of the connector shell (black) into the hinge of the connector (red).

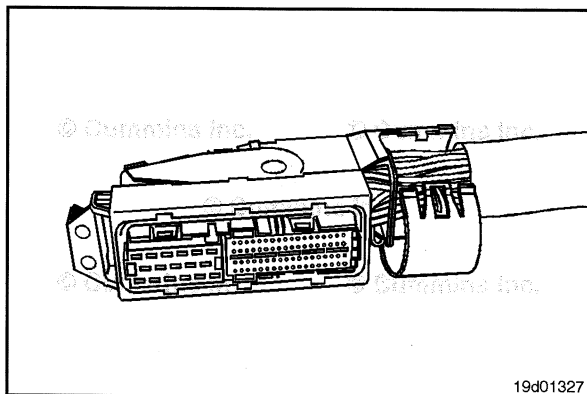
Close the connector shell onto the connector and wiring harness by pressing it onto the tang of the connector until you hear it click.





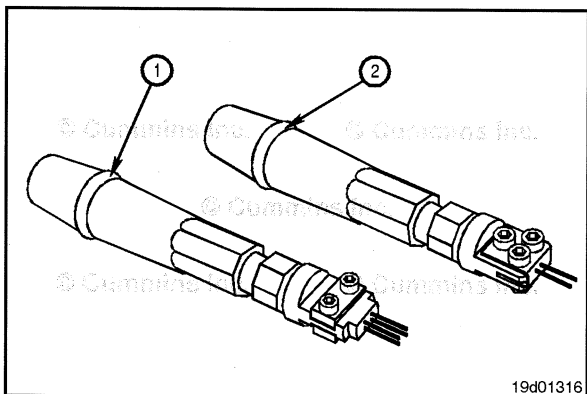
## Connector Replacement

This connector is used to attach the appropriate harness to the ECM.



Remove the connector shell by slightly bending the connector shell (black) away from the two tangs that hold the shell to the ECM connector (red).

Before pins can be removed, they **must** be unlocked. Slide the purple tabs on the edges of the connector sideways at the same time. When unlocked, the purple tab will align with a slot, making the entire length of the purple tab visible.



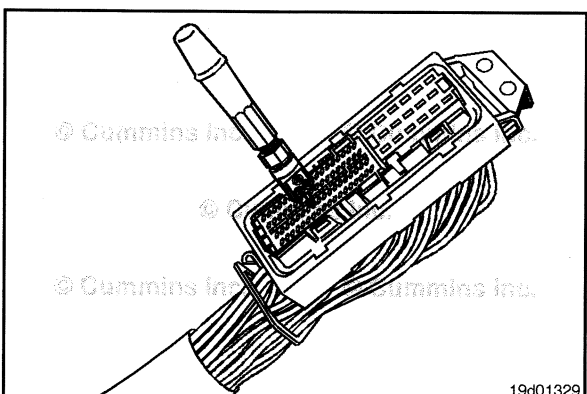
Use Bosch® extraction tool (2), Part Number 3164093, (small terminals), or use Bosch® extraction tool (1), Part Number 3164091 (large terminals), over the wire to remove a pin from the connector.



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.

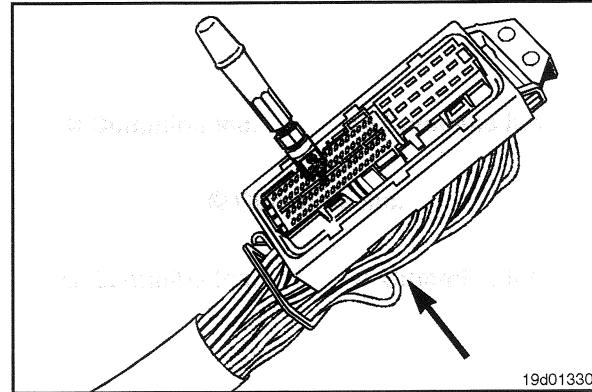
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.



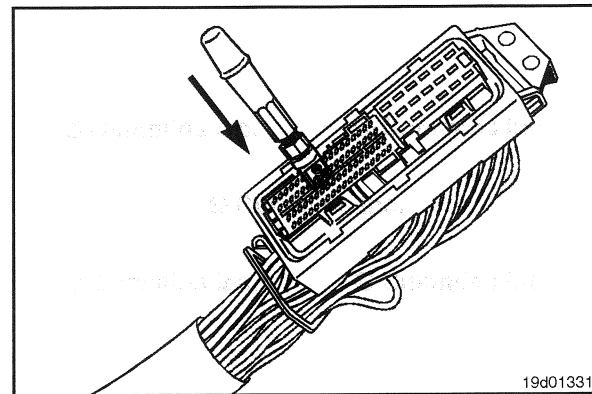
Insert the pin extraction tool into the unlocking holes in the connector.

Do **not** push the tool all the way into the connector.

Push the corresponding wire toward the pin extraction tool.



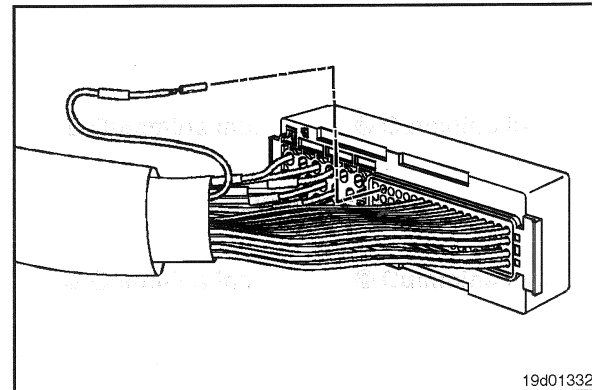
Press the pin extraction tool all the way into the connector.



**⚠ CAUTION ⚠**

If the wire is difficult to remove, do not pull hard on the wire; otherwise, the locking tang of the wire terminal will stick or the terminal will pull off the wire and remain in the connector.

Carefully pull the wire out of the connector. If it is difficult to remove, repeat the entire procedure.

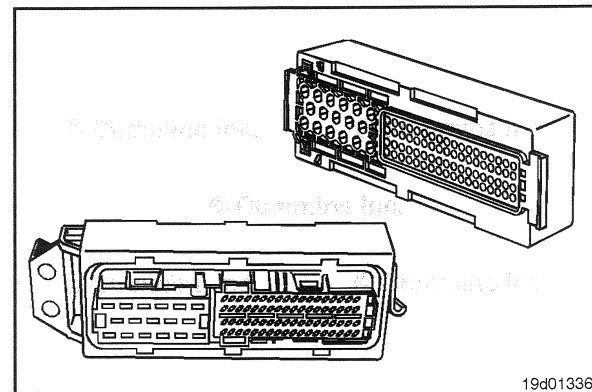


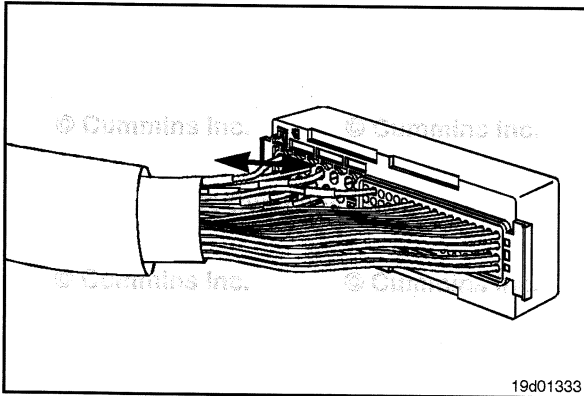
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.



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.

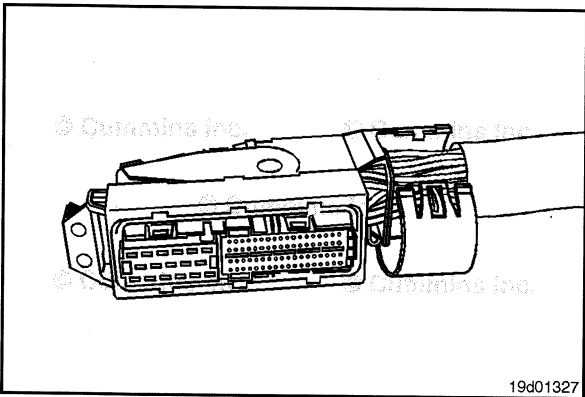




Insert the pins into the correct hole of the replacement connector.

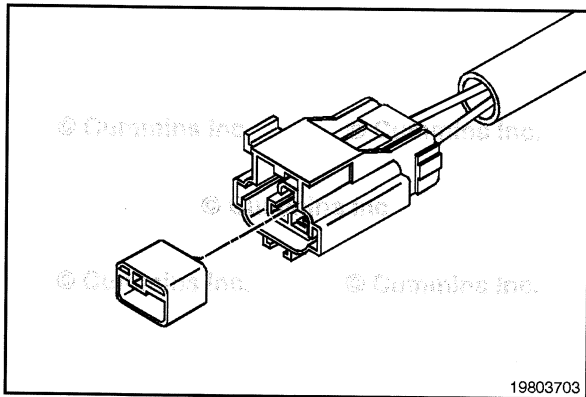
Each pin **must** click into place and hold the wires in the connector.

Pull each wire gently to make sure it is seated in the connector.



Replace the connector shell by inserting the hinge of the connector shell (black) into the hinge of the connector (red).

Close the connector shell onto the connector and wiring harness by pressing it onto the tang of the connector until you hear it click.



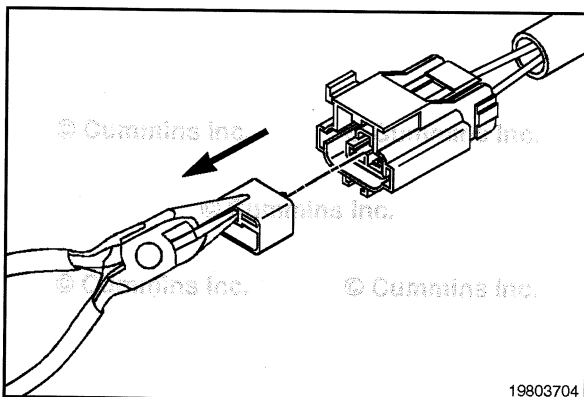
## Framatome Connector Series (019-218)

### 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.

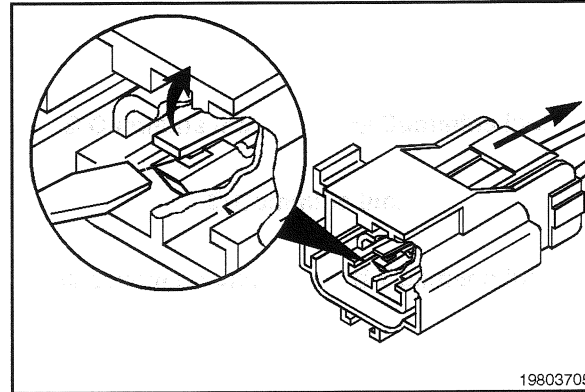


To replace the pin in the receptacle connector, remove the blue inter connector lock using needle nose pliers.

**⚠ 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.

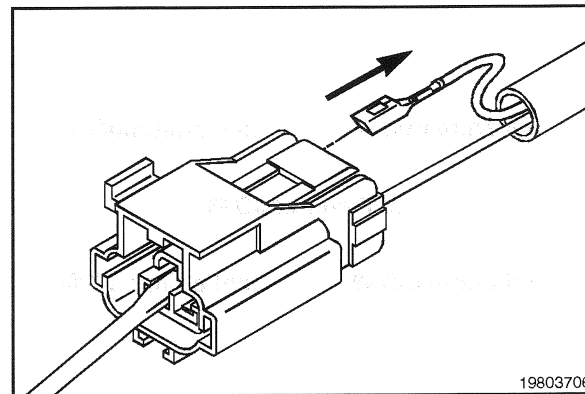


1980370E

**⚠ 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.



1980370E

Refer to the appropriate wiring repair kit in the service tools table in the front of this section for the correct repair wire.

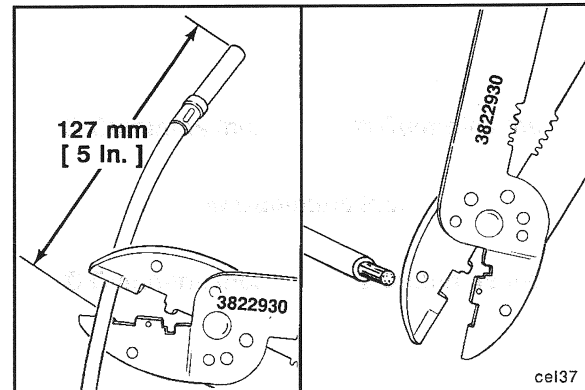
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

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.

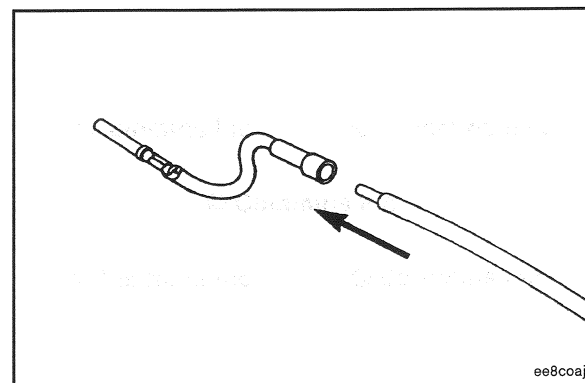
Use wire crimping tool, Part Number 3822930, to remove 6 mm [1/4 in.] of insulation from the wire.



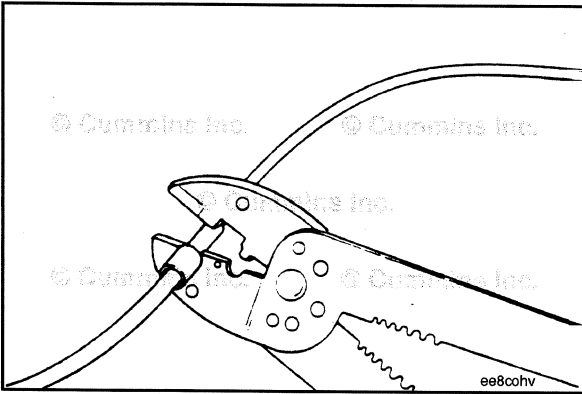
ce137

Install the correct repair wire on the bare wire.

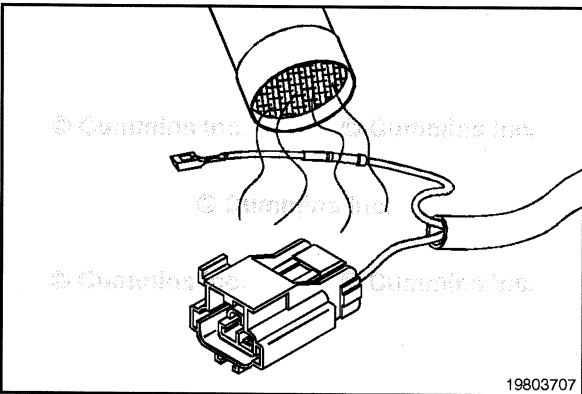
Make sure the bare wire extends into the splice connector.



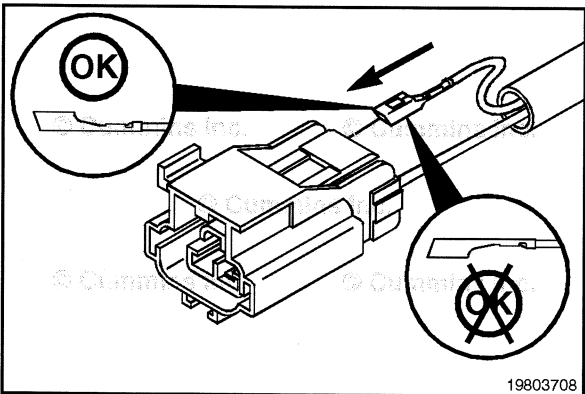
ee8coa



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.



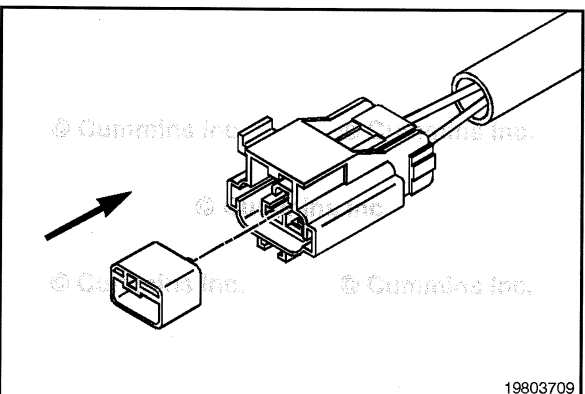
**⚠CAUTION⚠**

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.

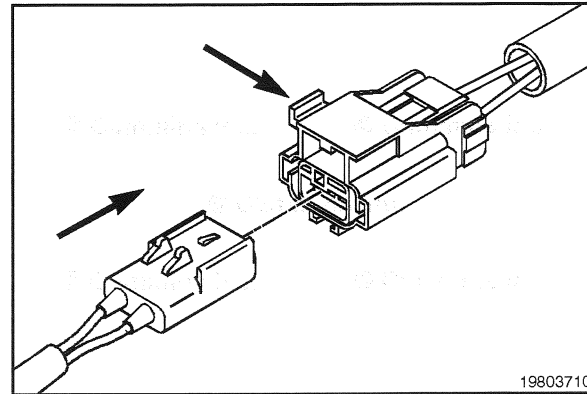


Once the wires are in place, insert the blue inter connector lock with the locking tab positioned towards the connector locking tab.

Push the blue inter connector lock in until it snaps in place.

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

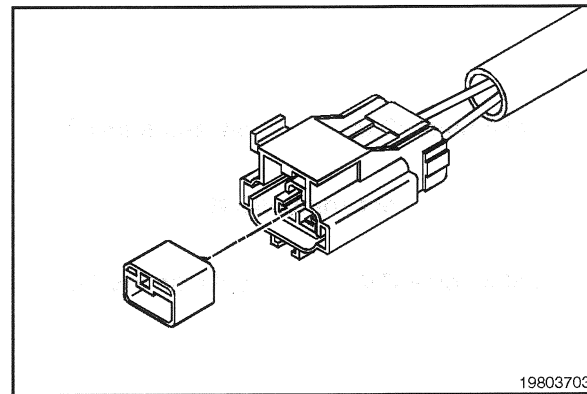
### Connector Replacement

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.

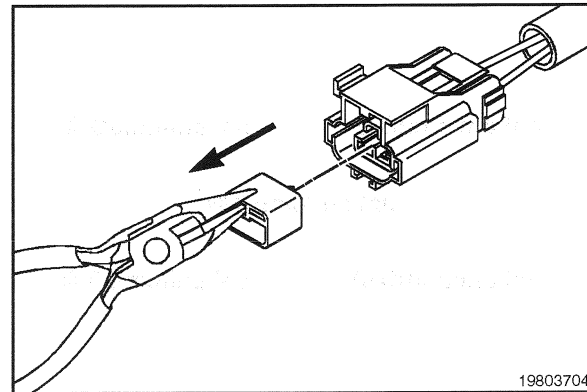


19803703

### ⚠ 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.

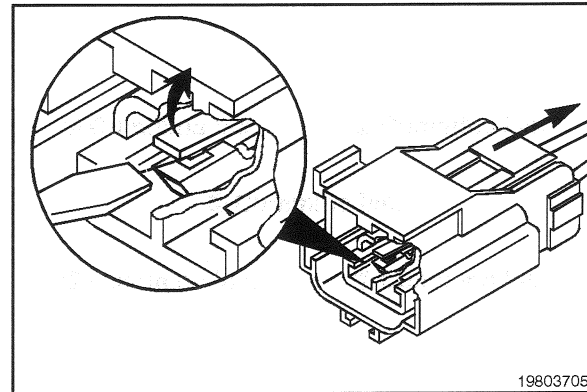


19803704

### ⚠ CAUTION ⚠

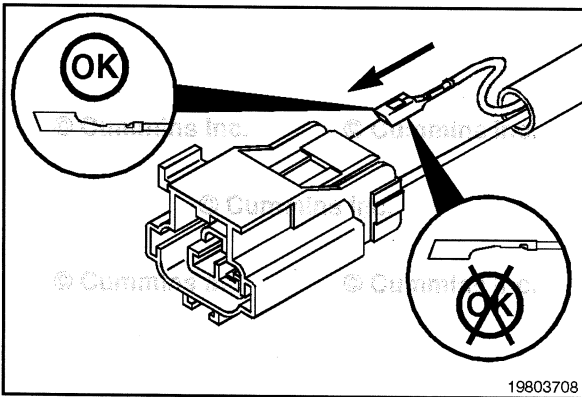
The locking finger can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

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.

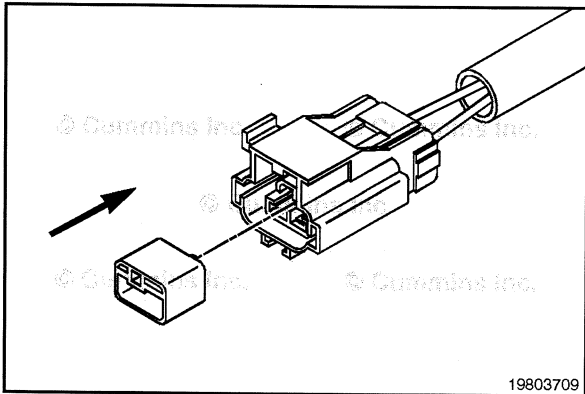


19803705



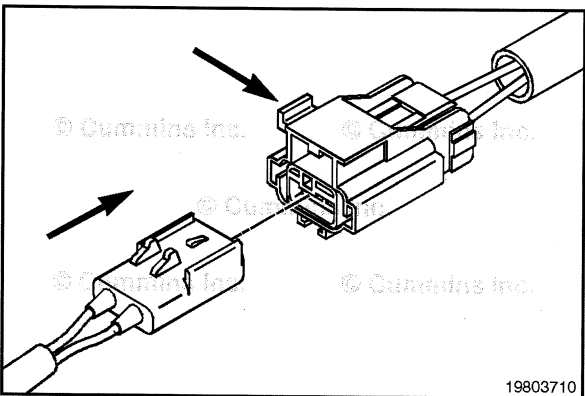


Replace the connector and install the wires and terminals into the seal at the back of the connector. Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.



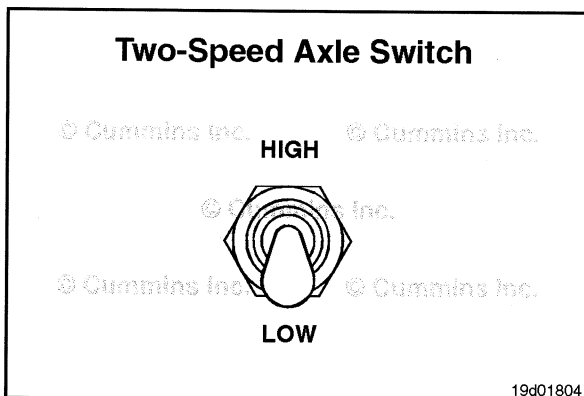
Once the wires are in place, insert the blue inter connector lock with the locking tab positioned towards the connector locking tab.

Push the blue inter connector lock in until it snaps in place.



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.



## Two-Speed Axle Switch (019-255) General Information

The 2-speed axle switch allows the operator the capability of switching from one axle to another. The ECM can then calculate the vehicle speed correctly.

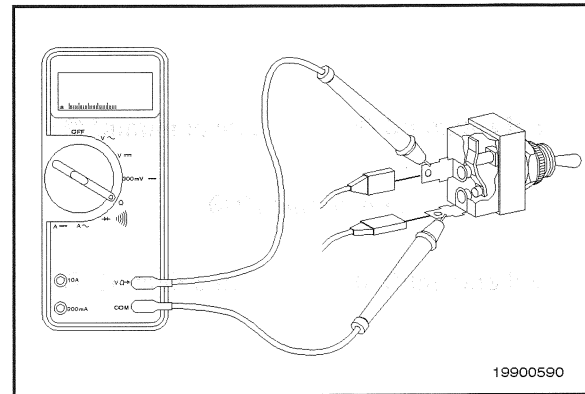
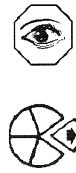
### Resistance Check

If INSITE™ electronic service tool is available, monitor the 2-speed axle switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate the 2-speed axle switch.

Remove and tag the two connectors from the terminals on the switch.

Touch the multimeter probes to the terminals on the switch.

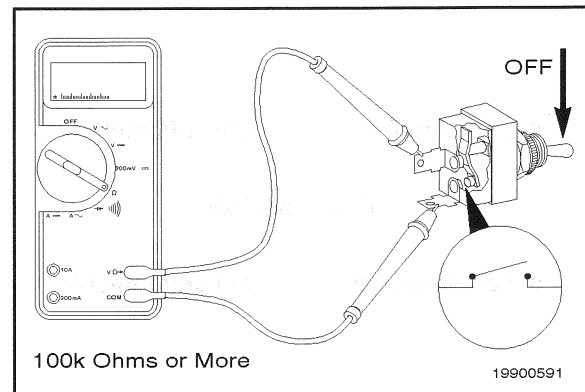


Move the switch to the OFF position, and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch is damaged and **must** be replaced.

Refer to the OEM troubleshooting and repair manual for the replacement instructions.



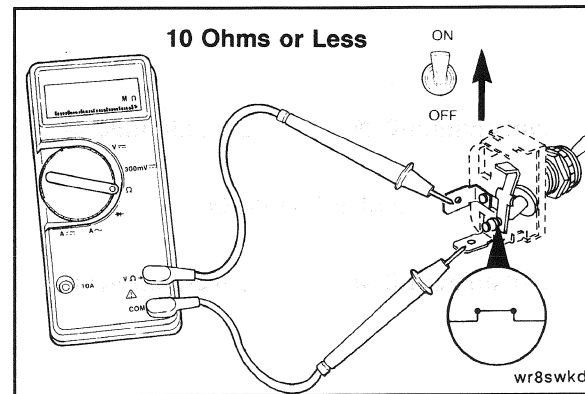
Move the switch to the ON position, and measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch is damaged and **must** be replaced.

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

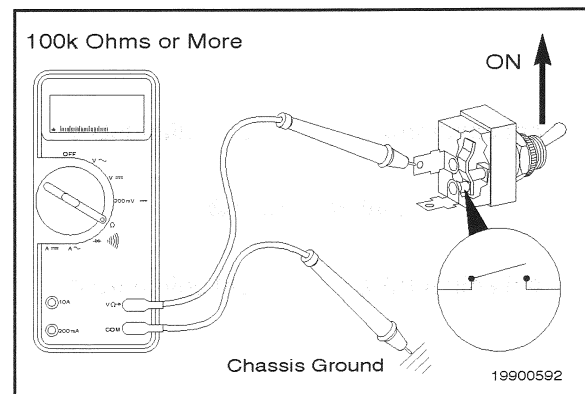
Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground.

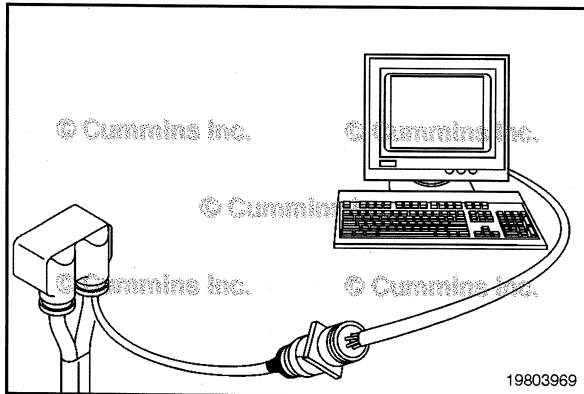
Move the switch to the ON position, and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch is damaged and **must** be replaced.

Refer to the OEM repair manual for replacement procedures.





## Two-Speed Axle Switch Circuit (019-256)

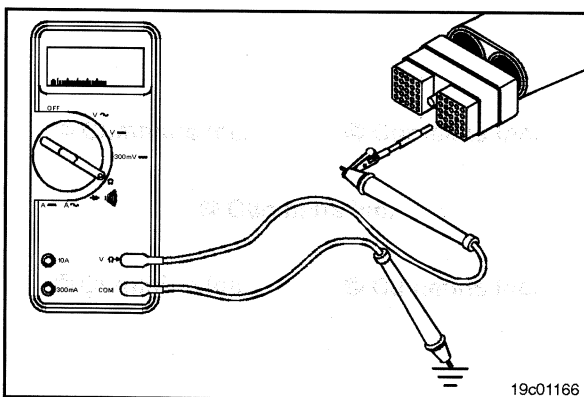
### Resistance Check

#### ⚠ 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 INSITE™ electronic service tool is available, monitor the 2-speed axle switch circuit for proper operation.

If **not**, follow the troubleshooting procedures in this section.

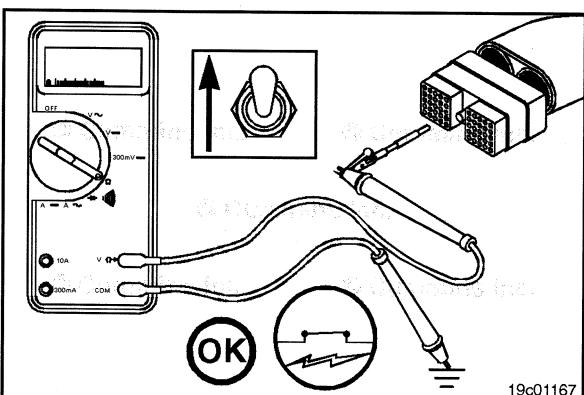


Disconnect the OEM harness from the ECM connector.

Insert a test lead into the 2-speed axle switch signal pin of the OEM harness connector, and attach it to a multimeter probe.



Touch the other multimeter probe to the engine block ground.



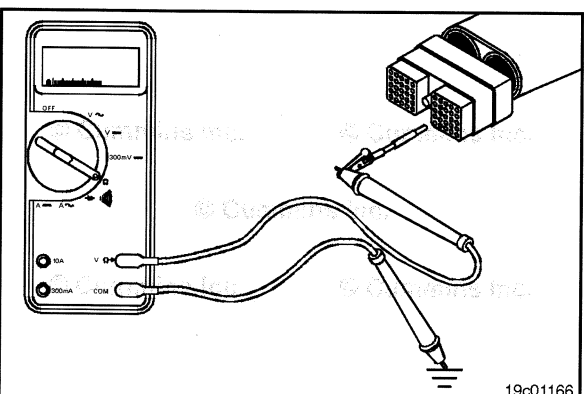
Move the 2-speed axle switch to the ON position.

The multimeter **must** show a closed circuit (10 ohms or less).



If the circuit is **not** closed, inspect the 2-speed-axle-switch signal wire for an open circuit. Refer to the OEM troubleshooting and repair manual.

If the resistance is within specification, the 2-speed axle switch signal pin **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 2-speed axle switch circuit.



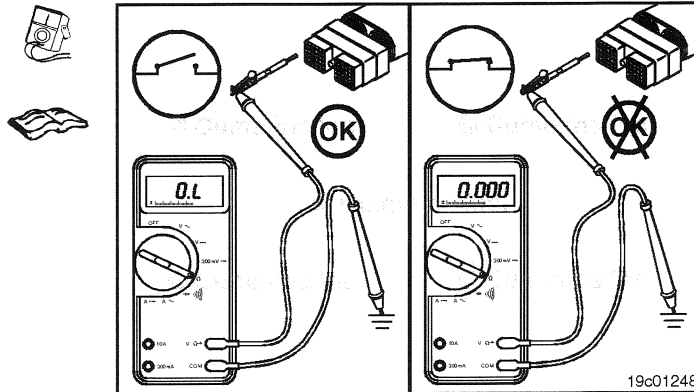
Insert the test lead attached to the multimeter probe into the 2-speed axle switch signal pin of the OEM harness connector.

Touch the other multimeter probe to the engine block, and 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 2-speed axle switch circuit, provided that the switch has been previously checked.

Repair or replace the wire connected to the 2-speed axle switch signal pin according to the vehicle manufacturer's instructions.



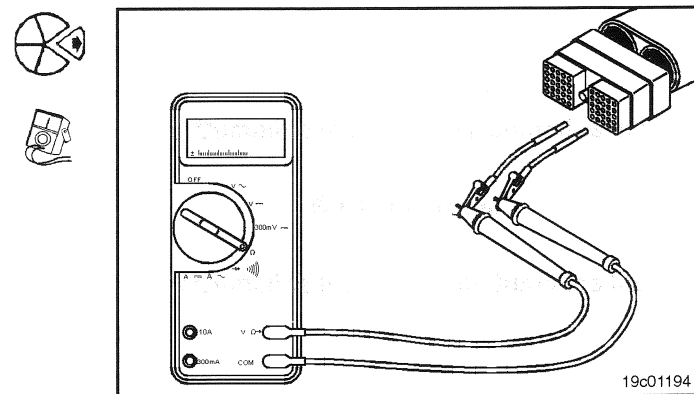
### Check for Short Circuit from Pin to Pin

Isolate the 2-speed axle switch circuit.

Insert the appropriate test lead into the 2-speed axle switch signal pin of the OEM harness connector.

Insert the other appropriate test lead into one of the other pins 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).

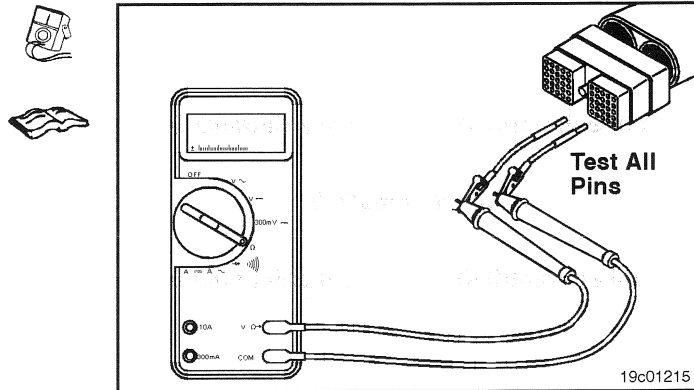


Remove the lead and check all other pins.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit from the wire connected to the 2-speed axle switch signal pin to any pin that measured less than 100k ohms.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's instructions.



### Check for Short Circuit to External Voltage Source

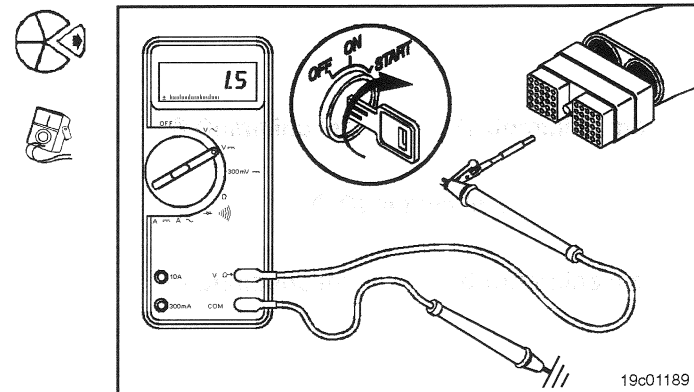
Isolate the 2-speed axle switch circuit. Turn the keyswitch to the ON position. Set the multimeter to measure VDC.

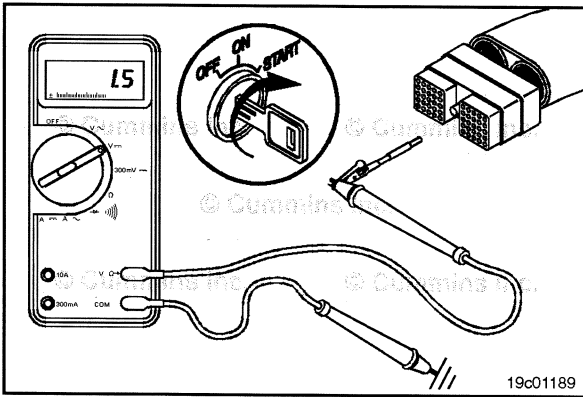
Insert the test lead connected to the positive (+) multimeter probe into the 2-speed axle switch signal pin of the OEM harness connector.

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.





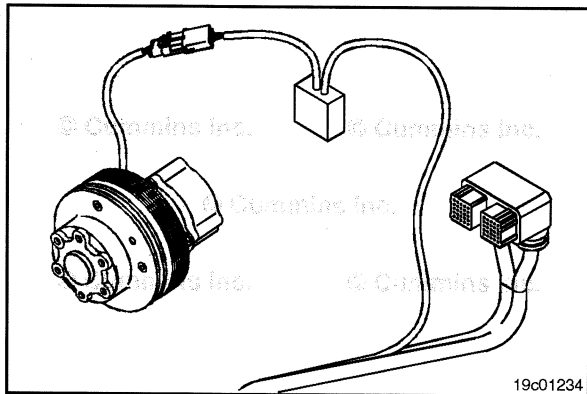
If the voltage value is more than 1.5-VDC, there is a short circuit between the wire connected to the 2-speed axle switch signal pin and a wire that is carrying power in the OEM harness.



Repair or replace the OEM harness. Refer to Procedure 019-071.



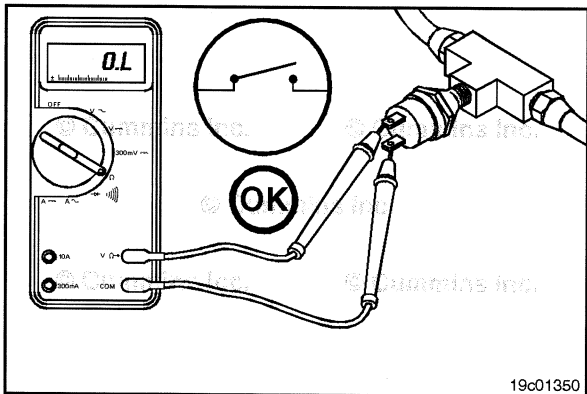
Connect all components after completing the repairs.



## Air Conditioning Pressure Switch (019-261)

### General Information

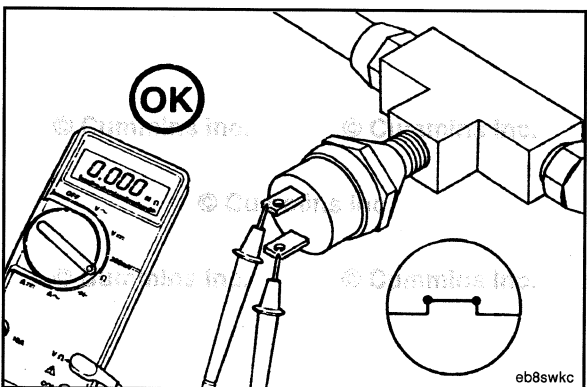
The air conditioning pressure switch circuit signals the system that the air conditioner head pressure is high and the engine fan **must** be engaged. The air conditioning pressure circuit consists of the air conditioning pressure switch signal pin and switch return pin. This circuit is considered "fail 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.

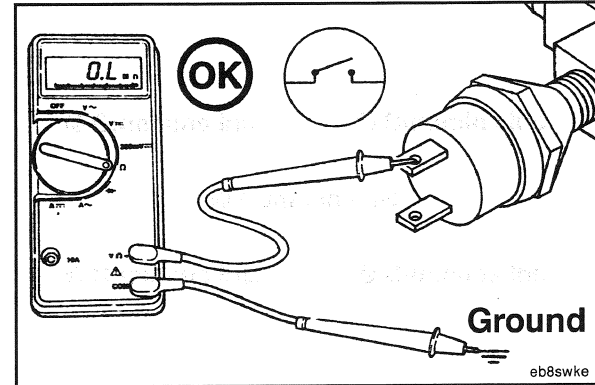
When the system head pressure is high, the multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual for replacement procedures.



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)

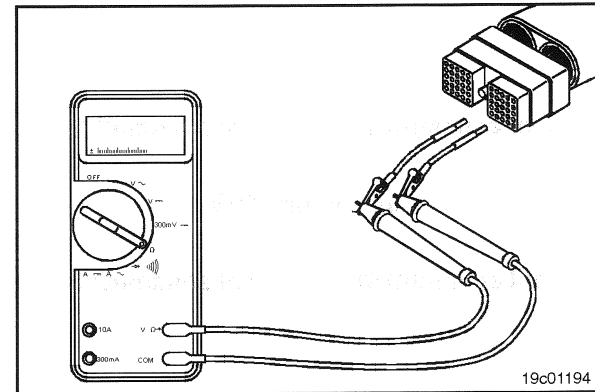
#### Resistance Check

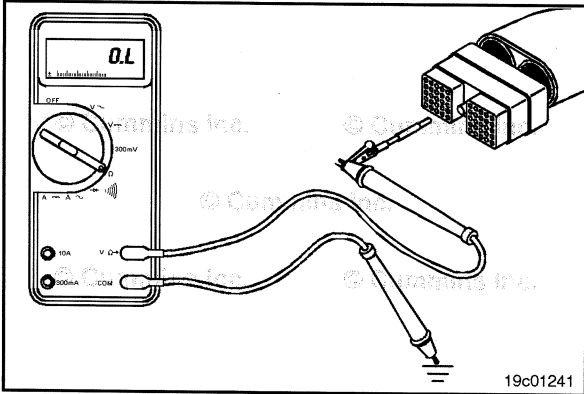
#### ⚠ CAUTION ⚠

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 connector from the electronic control module (ECM). 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.

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

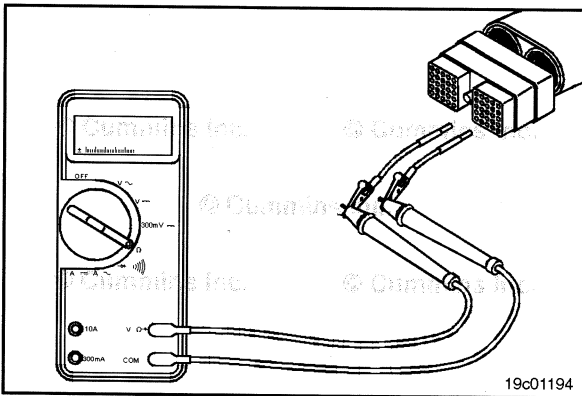
To isolate the air conditioning switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM.



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.

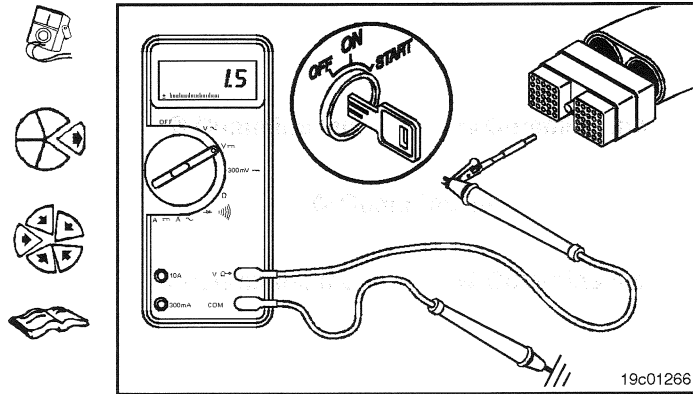
### Check for Short Circuit to External Voltage Source

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.

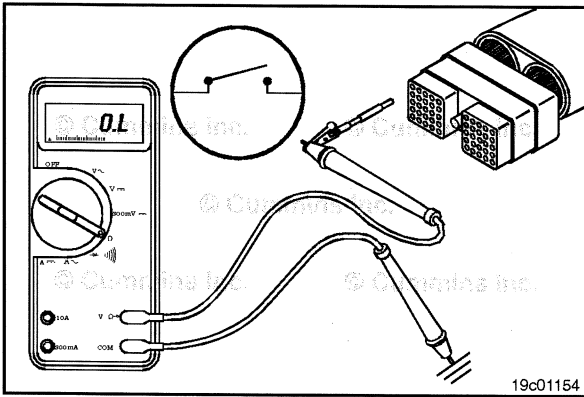
**NOTE:** If the air conditioning pressure switch circuit was approved in all of the previous tests, it is functioning properly.

### 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

#### ⚠ CAUTION ⚠

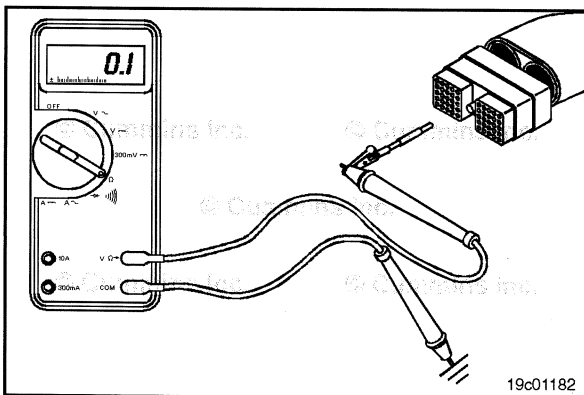
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

The accelerator interlock switch is programmable. Check the setting with INSITE™ electronic service tool before continuing with the troubleshooting steps.

If INSITE™ 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.

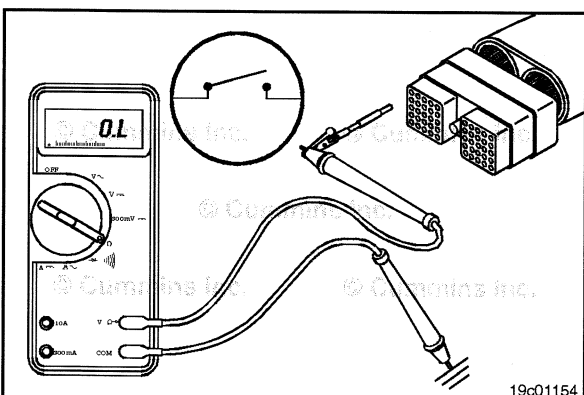
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). Insert a test lead into the accelerator interlock switch signal pin. Touch the other multimeter probe to engine block ground. With the switch in the inhibit position, the multimeter **must** read an open circuit (100k ohms or more).



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



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.

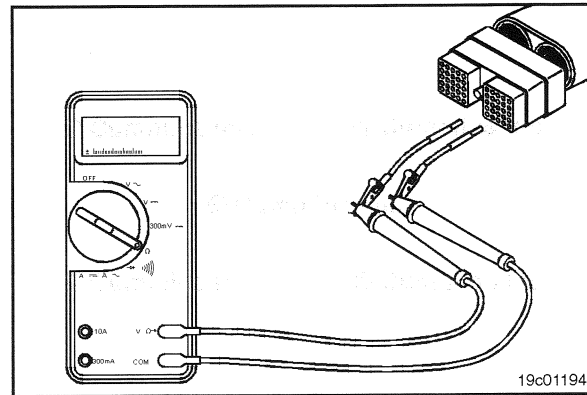
Repair or replace the OEM harness. Refer to Procedure 019-071.

### 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.

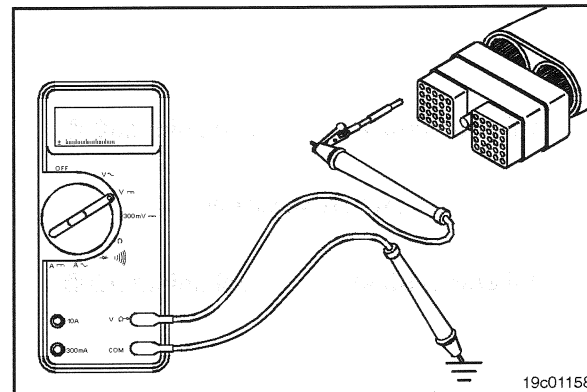


### Check for Short Circuit to External Voltage Source

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.

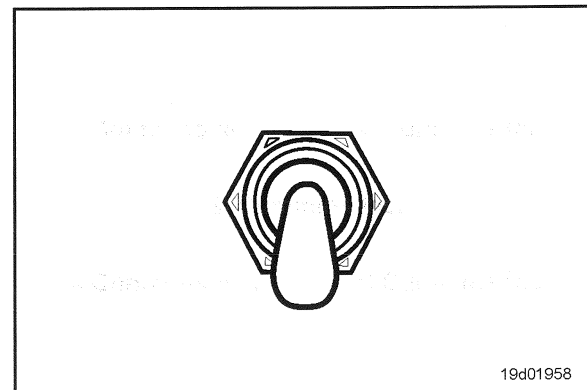


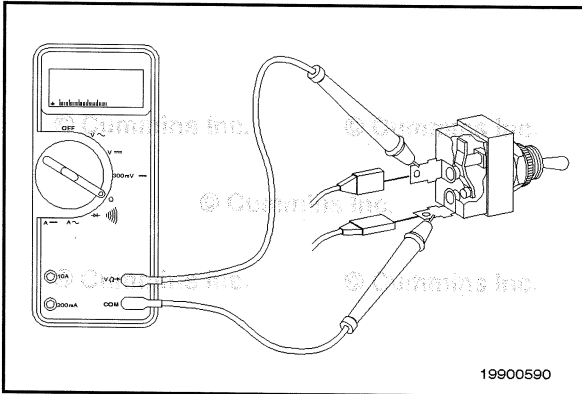
## Cab Switchable Governor Switch (019-266)

### General Information

The cab switchable governor switch selects between variable speed (VS) and automotive accelerator governors. Governor selection often occurs while changing operation modes: for example, between cab accelerator and remote accelerator. When the OEM enables the switchable accelerator type of feature, the automotive or VS governing feature uses the accelerator governor switch.

The accelerator governor switch has two positions: ALTERNATE and PROGRAMMABLE. The PROGRAMMABLE position allows the accelerator-type parameter, VS or automotive, to choose the governor. The ALTERNATE position chooses the opposite governor from that selected by the accelerator-type parameter.





### Resistance Check



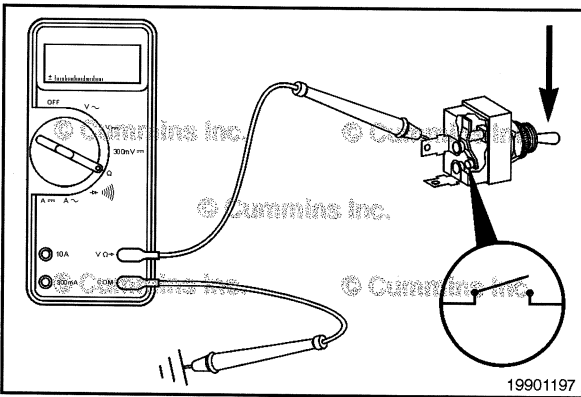
If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the following procedure.



Locate the switch. Disconnect the connectors and label the wires. Touch a multimeter probe to each switch terminal and measure the resistance with the switch set to both positions.

The multimeter **must** show a value of 100k ohms or more (open circuit) while the switch is in one position and a value of 10 ohms or less (closed circuit) in the other position.

If the switch does **not** transition from an open to a closed circuit when flipped from one position to the other, the switch is defective. Replace the switch. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual.



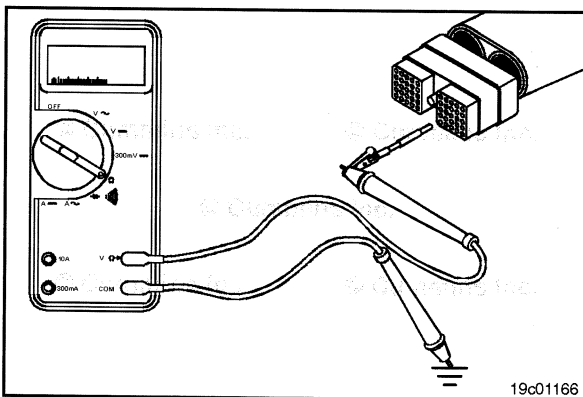
### Check for Short Circuit to Ground



Locate the switch. Disconnect the connectors and label the wires. Touch one of the multimeter probes to one of the switch terminals and touch the other multimeter to engine block ground. Move the switch from one position to the other.



The multimeter **must** show a value of 100k ohms or more (open circuit) with the switch in both positions. If the switch does not show an open circuit, the switch is defective. Replace the switch. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual.



### Cab Switchable Governor Switch Circuit (019-267)



#### 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.

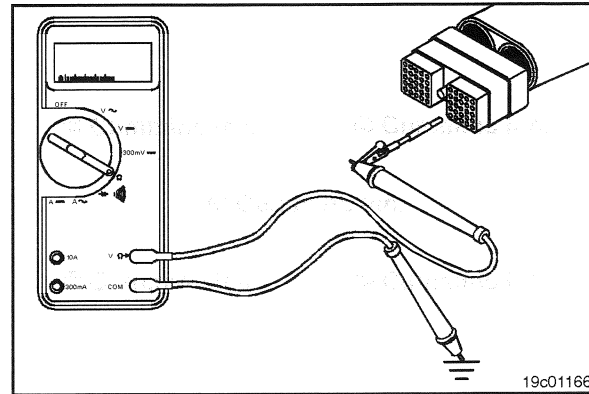
If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the following procedure.

Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). Set the multimeter to measure resistance. Insert a test lead into the accelerator governor switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe. Touch the other multimeter probe to engine block ground.

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Transition the switch from one position to the other and measure the resistance at both positions. The multimeter **must** show a value of 100k ohms or more (open circuit) while the switch is in one position, and a value of 10 ohms or less (closed circuit) in the other position.

If the switch does **not** transition from an open to a closed circuit when flipped from one position to the other, there is an open circuit in the input wire. If the specification is 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.



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**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 OEM harness connector from the ECM. Set the multimeter to measure resistance.

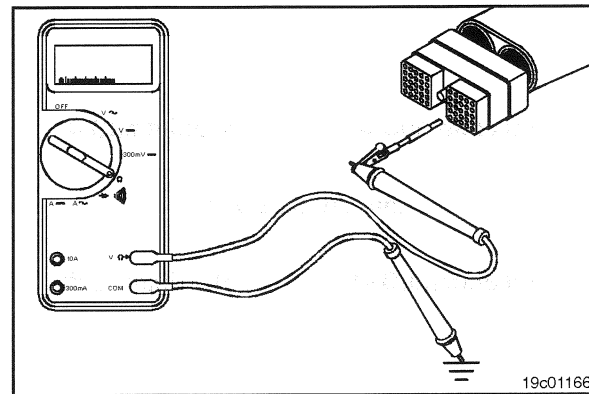
Insert a test lead into the accelerator governor switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

Touch the other multimeter probe to engine block ground. Move the switch from its present position to the other position, and measure the resistance.

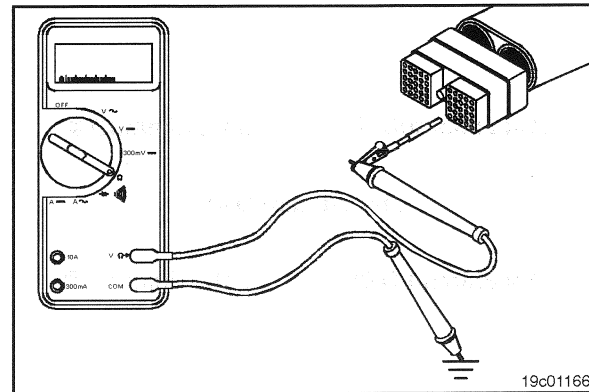
The multimeter **must** show a value of 100k ohms or more (open circuit).

If the multimeter does **not** show an open circuit, there is a short circuit to ground in the circuit.

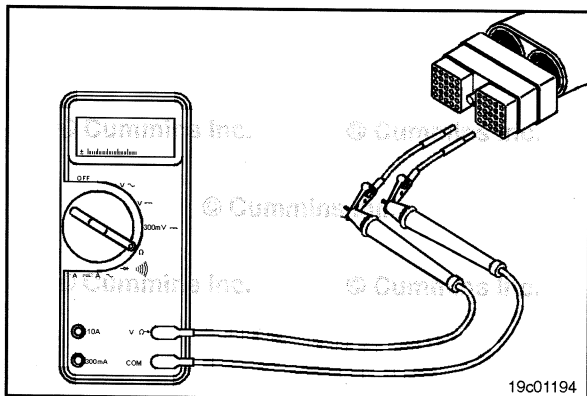
Repair or replace the OEM harness. Refer to Procedure 019-071.



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### Check for Short Circuit from Pin to Pin



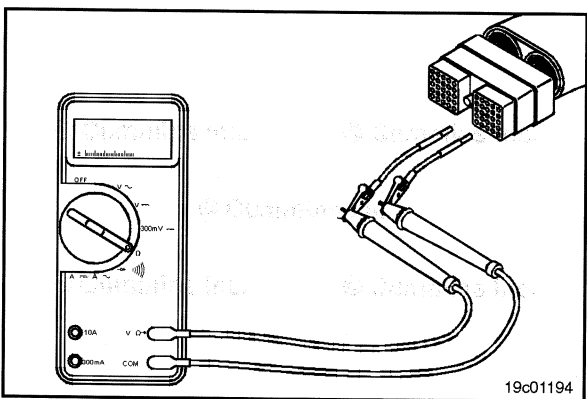
#### ⚠CAUTION⚠

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 OEM harness connector from the ECM. Set the multimeter to measure resistance.

Insert a test lead into the accelerator governor switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

Touch the other multimeter probe with attached test lead to all other pins in the connector. Measure the resistance.

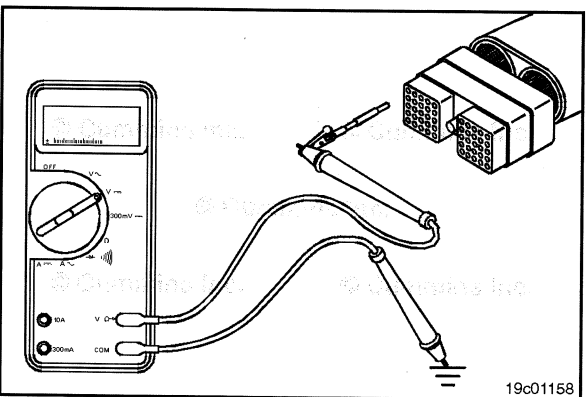


The multimeter **must** show a value of 100k ohms or more (open circuit) at all pins.



If any circuit is **not** open, there is a short circuit between the input pin and the applicable pin.

Repair or replace the OEM harness. Refer to Procedure 019-071.



### Check for Short Circuit to External Voltage Source



#### ⚠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.

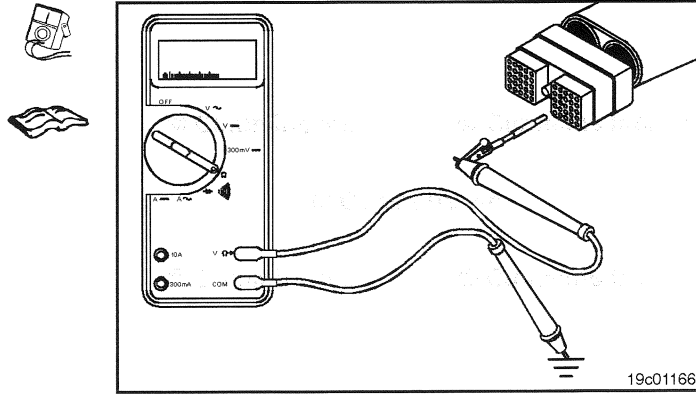
Disconnect the OEM harness connector from the ECM. Set the multimeter to measure VDC. Turn the keyswitch to the ON position.

Insert a test lead into the accelerator governor switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

Touch the other multimeter probe to engine block ground and measure the voltage.

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The multimeter **must** show a value of 1.5 VDC or less.  
 If the voltage is more than 1.5 VDC, there is a short circuit to an external voltage source.  
 Remove the external voltage source.



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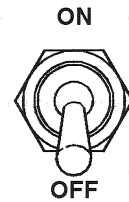
**Switched Maximum Operating Speed Switch (019-268)**

**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.

**Switched Maximum Operating**



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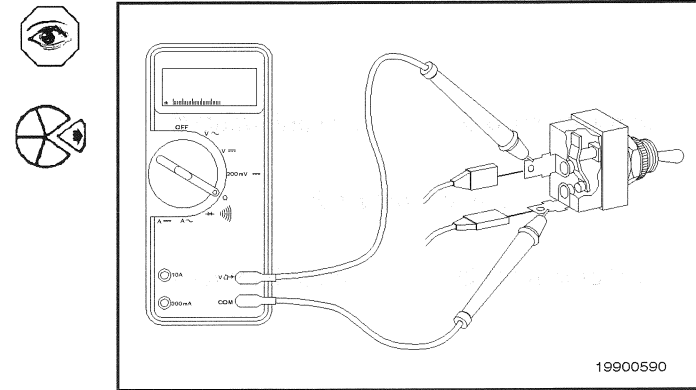
**Resistance Check**

If INSITE™ 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.

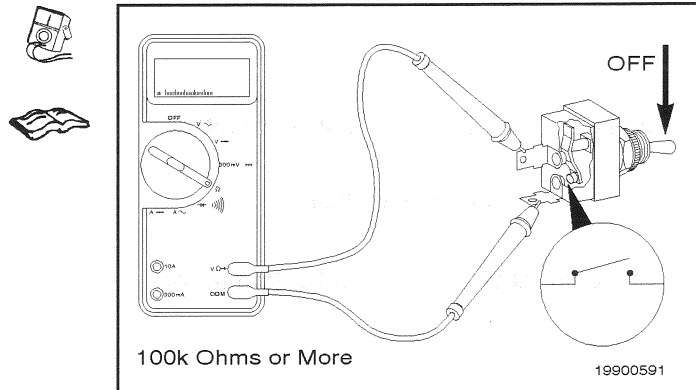
Set the multimeter to measure resistance. Touch the other multimeter probe to the other terminal of the switch.



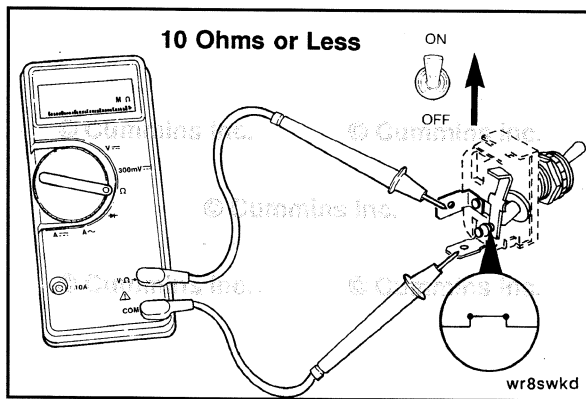
19900590

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.

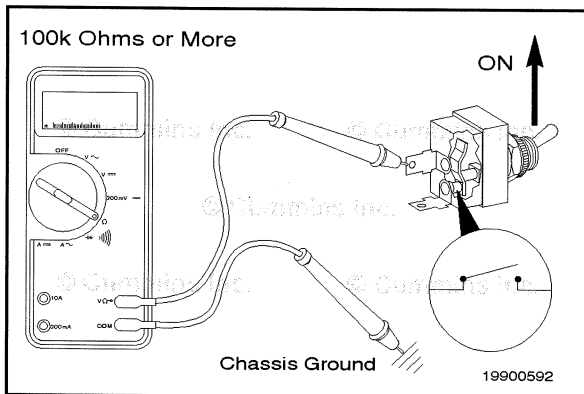


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Place the switch in the ON and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch is defective. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

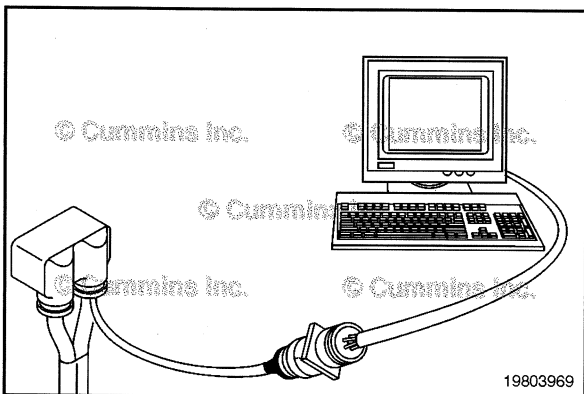


### Check for Short Circuit to Ground

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.



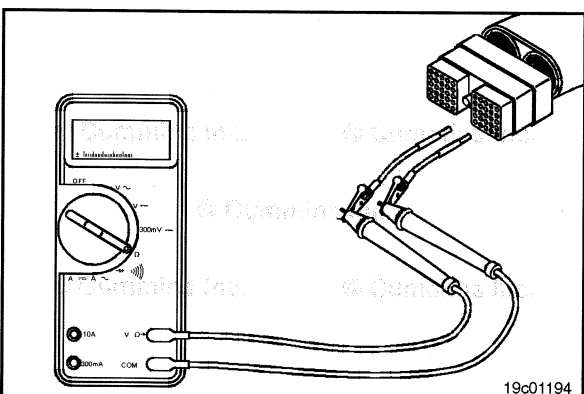
### Switched Maximum Operating Speed Switch Circuit (019-269)

#### Resistance Check

#### ⚠CAUTION⚠

The leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

If INSITE™ 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 from the electronic control module (ECM). Set the multimeter to measure resistance.



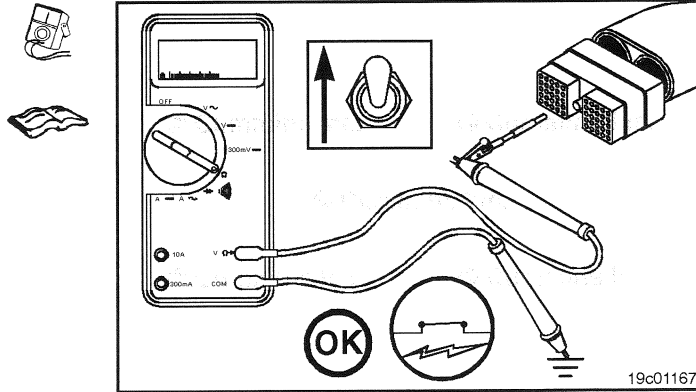
Insert a test lead into the switched maximum operating speed switch return (-) pin of the OEM harness connector, and connect the alligator clip to the multimeter probe. Touch the other lead to the switched maximum operating speed switch input pin of the connector, and connect the alligator clip to the other multimeter probe.

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**Switched Maximum Operating Speed Switch Circuit**  
**Page 19-16;**

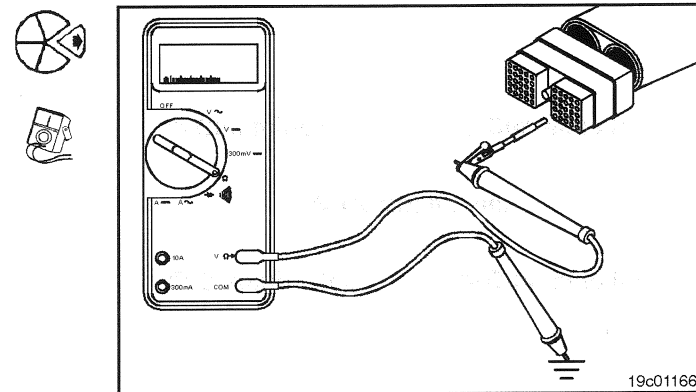
Move the switched maximum operating speed switch to the ON position. The multimeter **must** show 10 ohms or less (closed circuit). If the circuit is **not** closed, inspect both the return (-) wire and the input wire for an open circuit, provided that the switch has been previously checked.

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**

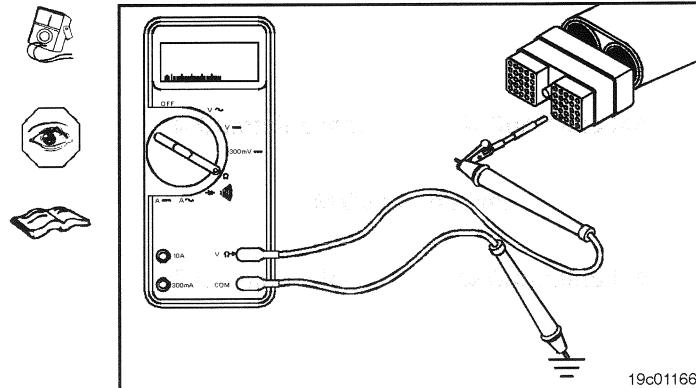
Isolate the switched maximum operating speed switch circuit.



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.

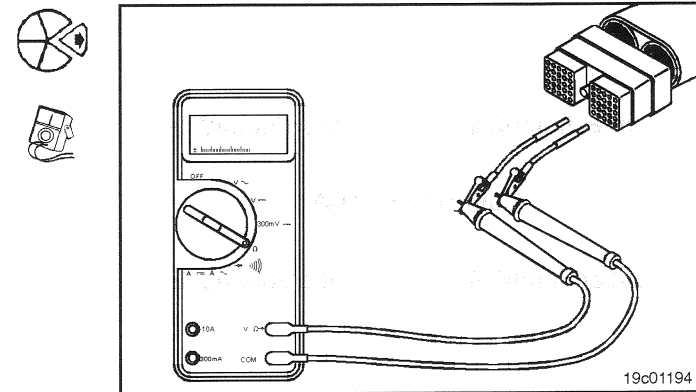
The multimeter **must** show 100k ohms or more (open circuit). If the circuit is **not** open, there is a short circuit to ground in the switched maximum operating speed switch circuit, provided that the switch has been previously checked.

Repair or replace the wire connected to the return (-) pin according to the vehicle manufacturer's instructions.

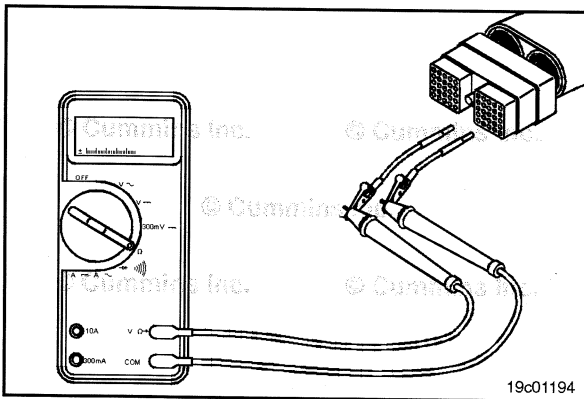


**Check for Short Circuit from Pin to Pin**

Isolate the switched maximum operating speed switch circuit. Disconnect the OEM harness connector from the ECM. Set the multimeter to measure resistance.



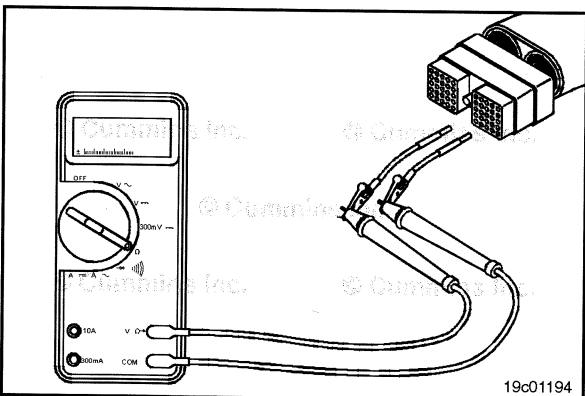




Insert a test lead into the maximum operating speed switch input pin of the OEM harness connector. Insert the other test lead into the switch return pin of the connector. Connect the alligator clips to the multimeter probes.

Measure the resistance.

The multimeter **must** show 100k ohms or more (open circuit).

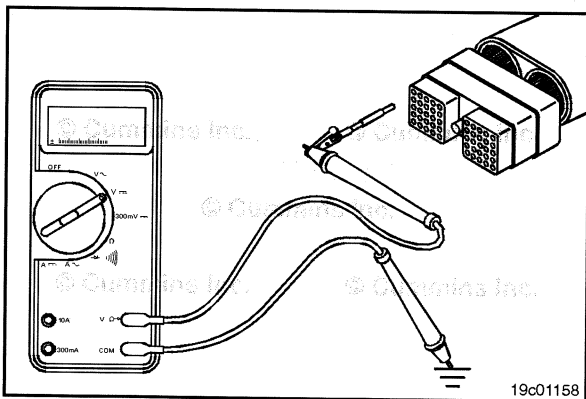


Remove the lead from the maximum operating speed switch return pin, and check all other pins.



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.



### Check for Short Circuit to External Voltage Source

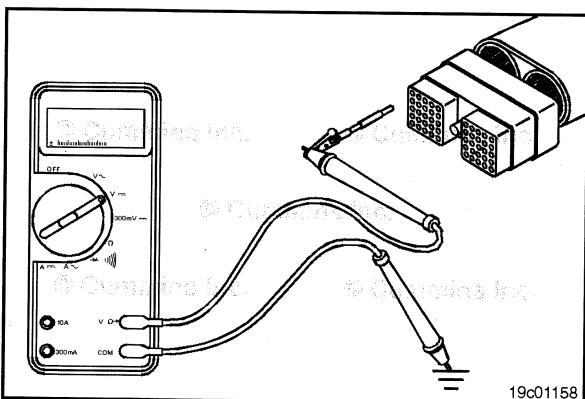


**NOTE:** An external voltage source is any wire in the OEM harness wiring that carries the voltage.

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.



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.

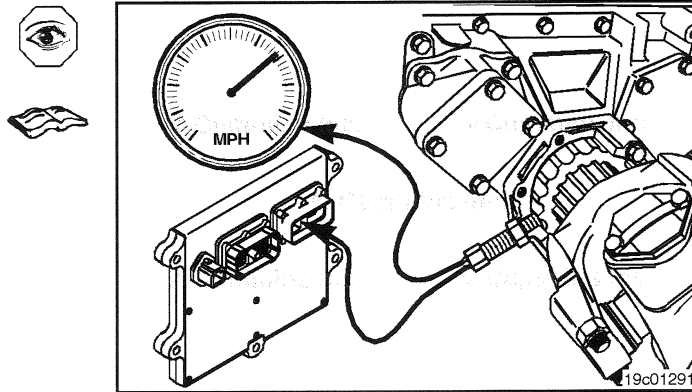


## Tachograph Circuit (019-325)

### General Information

The engine control module (ECM) can supply an output signal to operate the vehicle tachograph. The circuit consists of the tachograph signal wire and the common switch RETURN (-) wire.

See equipment manufacturer service information for troubleshooting instructions.



### Resistance Check

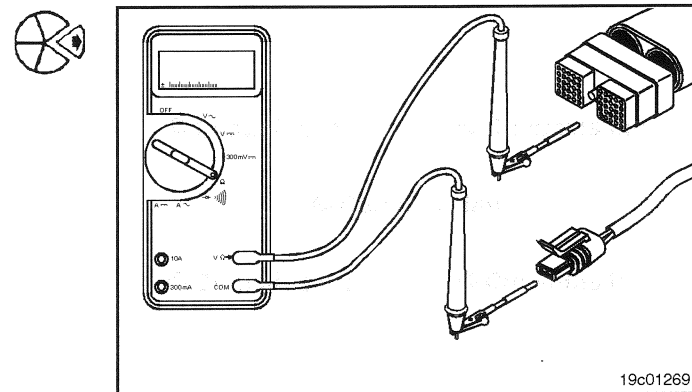
#### ⚠ CAUTION ⚠

To reduce the possibility of pin and connector damage, use test lead, Cummins™ Part Number 3822758, when taking a measurement.

Disconnect the 96-pin original equipment manufacturer (OEM) harness connector from the engine control module (ECM) connector.

Disconnect the tachograph from the OEM harness.

Set the multimeter to measure resistance.

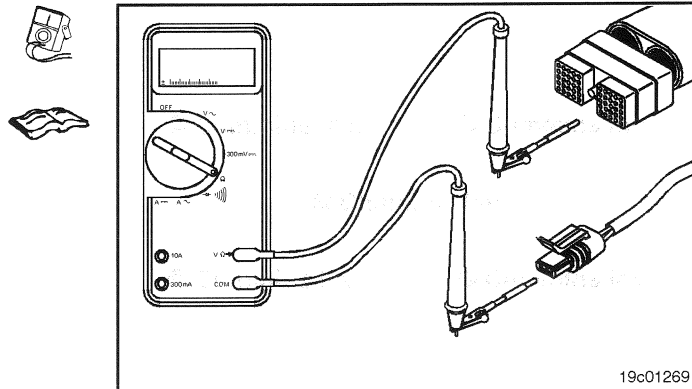


Insert one of the test leads into the tachograph signal pin of the 96-pin OEM harness connector. Connect the alligator clip to the multimeter probe.

Insert the other test lead into the tachograph signal pin of the sensor harness connector, and connect the alligator clip to the other multimeter probe. Measure the resistance.

The multimeter **must** show 10 ohms or less (closed circuit).

If the circuit is **not** closed, there is an open circuit or the wires in the tachograph connector are reversed. Repair or replace the wire connected to the signal pin in the 96-pin OEM harness connector. See equipment manufacturer service information.

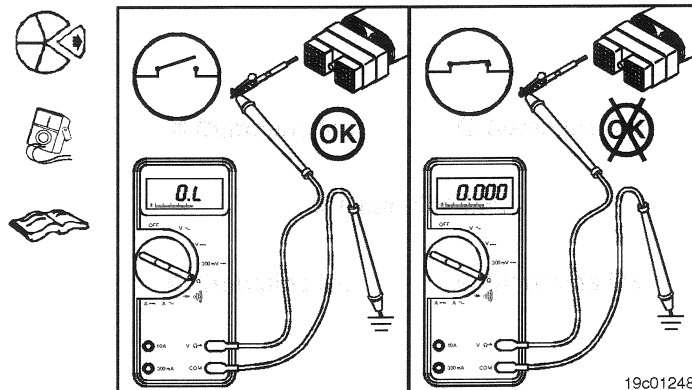


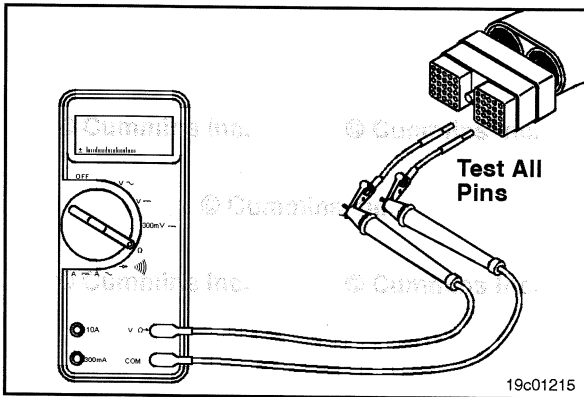
### Check for Short Circuit to Ground

Disconnect the 96-pin OEM harness connector from the ECM connector. Disconnect the tachograph from the OEM harness. Set the multimeter to measure resistance.

Touch the test lead to the tachograph SIGNAL pin of the 96-pin OEM harness connector. Touch the other multimeter lead to the engine block. Measure the resistance.

The multimeter **must** show 100k ohms or greater (open circuit).



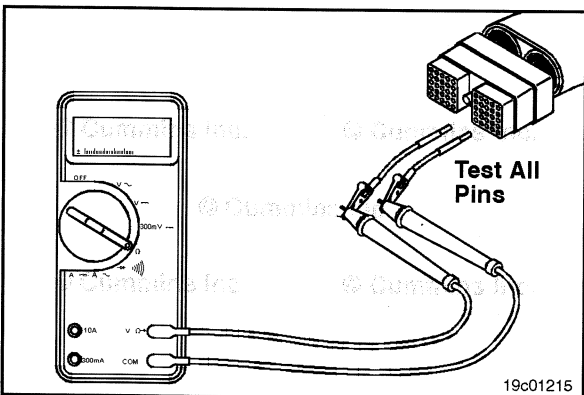


### Check for Short Circuit from Pin to Pin

Disconnect the 96-pin OEM harness connector from the ECM connector. Set the multimeter to measure resistance. Insert a test lead into the tachograph SIGNAL pin of the 96-pin OEM harness connector.

Insert the other test lead into the first pin of the 96-pin OEM harness connector, and measure the resistance.

The multimeter **must** show 100k ohms or greater (open circuit).



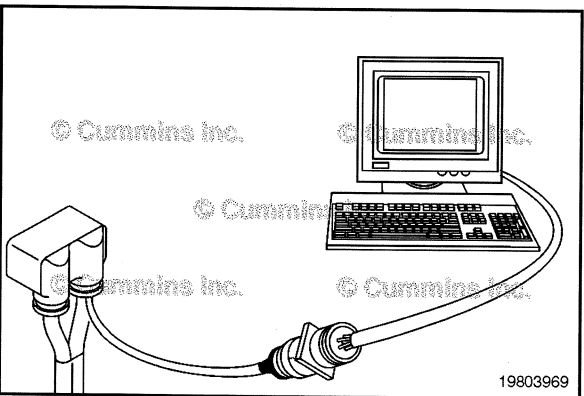
Remove the lead from the first pin and check all other pins, one at a time.



The multimeter **must** show 100k ohms or greater (open circuit) at all pins.

If the multimeter does **not** show an open circuit at any pin, a short circuit exists between the SIGNAL pin and any pin that measures less than 100k ohms.

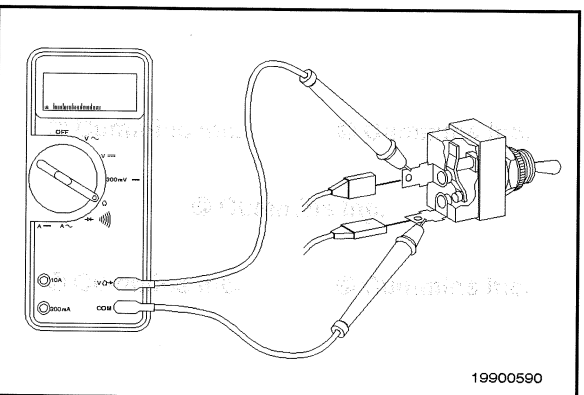
Repair or replace the OEM harness. See equipment manufacturer service information.



### Engine Protection Override Switch (019-327)

#### General Information

The engine protection override switch is an original equipment manufacturer (OEM) installed switch that allows a driver to abort a pending engine protection shutdown. The switch is **only** active when it is properly wired by the OEM and the engine protection shutdown override feature is enabled in the calibration. If the switch is **not** preventing a shutdown from occurring, check the feature with the electronic service tool to see if it is enabled in the calibration.

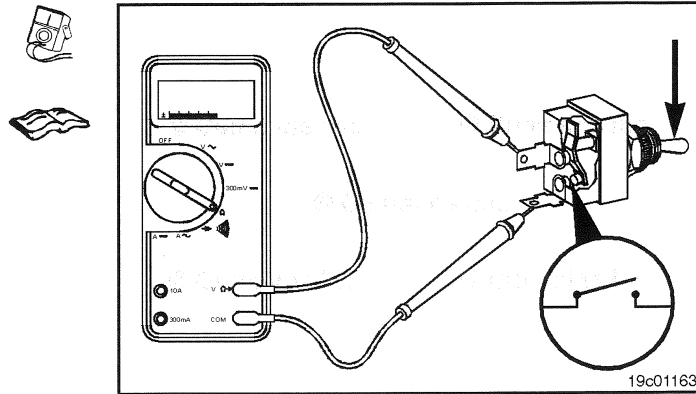


#### Resistance Check

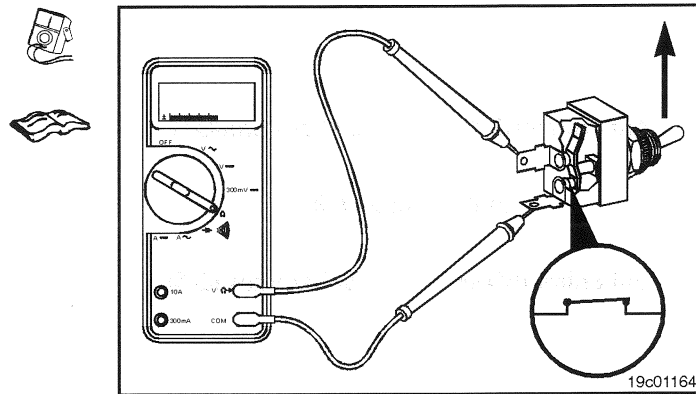
If INSITE™ electronic service tool is available, monitor the engine protection override switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate the engine protection override switch. Label the wires with the location on 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.

Place the switch in the non-override (released) 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 original equipment manufacturer (OEM) troubleshooting and repair manual for replacement procedures.



Place the switch in the override (pressed) position 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 replacement procedures. If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

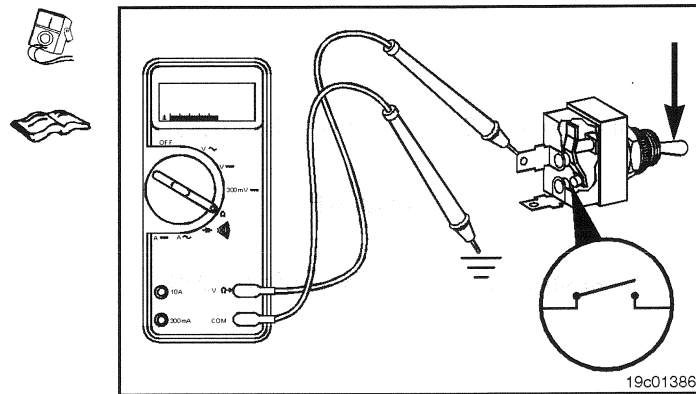


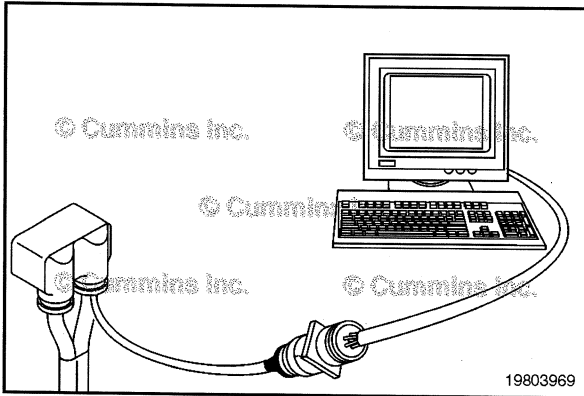
### Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the non-override (released) 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.





## Engine Protection Override Switch Circuit (019-328)

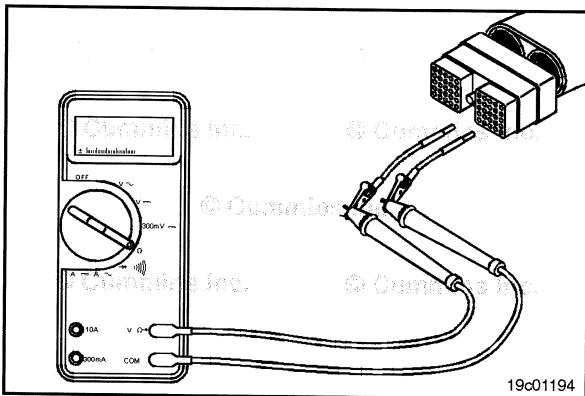
### Resistance Check

#### ⚠ 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 INSITE™ electronic service tool is available, monitor the engine protection override switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.

Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). Insert one of the test leads into the switch return negative (-) pin of the OEM harness connector and connect the alligator clip to the multimeter probe. Insert the other lead into the engine protection override switch signal pin of the OEM harness connector and connect the alligator clip to the other multimeter probe.



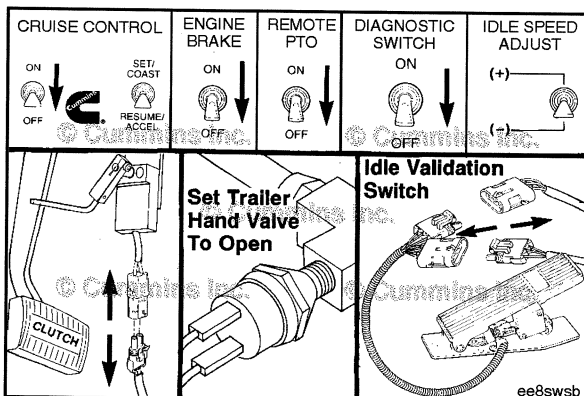
Move the engine protection override switch to the override (pressed) position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the switch return negative (-) wire and the engine protection override switch wire for an open circuit, provided that 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 cab switch return negative (-) wire and the engine protection override 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 engine protection override switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM connector and the OEM harness from the engine protection override switch. Disconnect the idle validation switch. Set all cab panel switches to the OFF or neutral position. Set the service brake using the trailer brake hand valve.



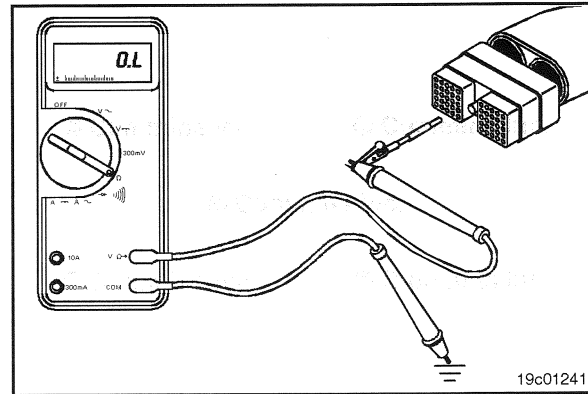
**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

**Engine Protection Override Switch Circuit**  
**Page 19-17:**

Adjust the multimeter to measure resistance. Insert a test lead into the engine protection override switch 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 engine protection override switch circuit, provided that the switch has been previously checked.

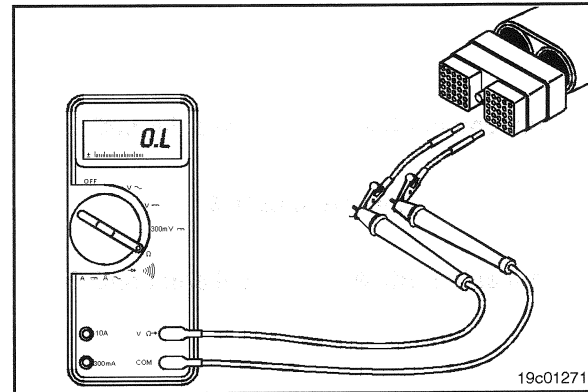
Repair or replace the wire connected to cruise control input wire in the OEM harness according to the vehicle manufacturer's procedure.



19c01241

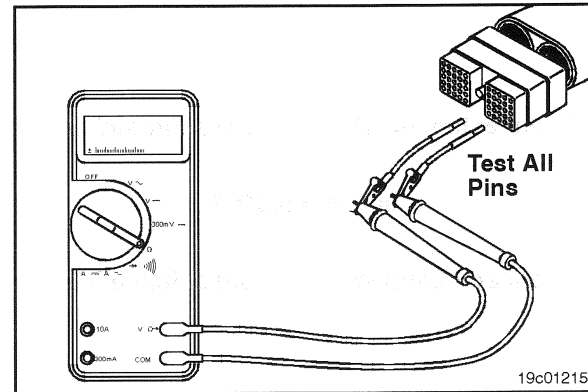
**Check for Short Circuit from Pin to Pin**

Check for a short circuit from pin-to-pin. Isolate the engine protection override circuit by setting the switches as in the previous section. Set the engine protection override switch to the override position. Insert the lead into the engine protection override switch pin. Connect the alligator clip to the multimeter. With the other lead inserted into the cab switch return negative (-) pin, measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).



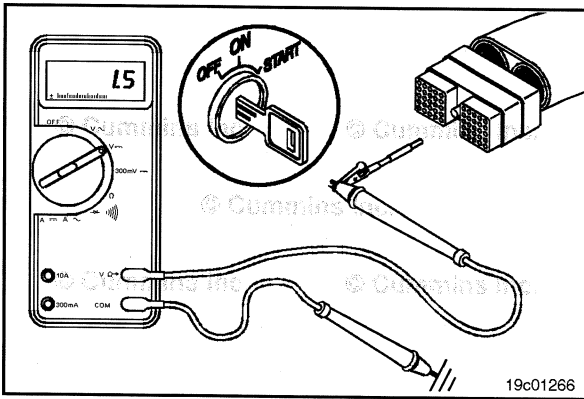
19c01271

Remove the lead from the engine protection override switch 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 engine protection override switch circuit and any pin that shows a closed circuit, provided the switch has previously been checked.



19c01215

Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



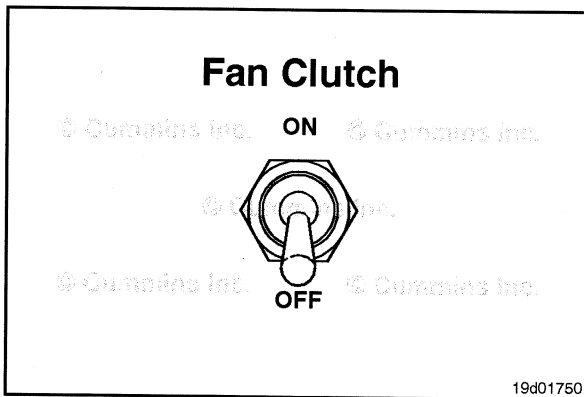
### Check for Short Circuit to External Voltage Source



Turn the keyswitch to the ON position. Set the engine protection override switch to the override position. Adjust the multimeter to measure VDC. Insert a test lead into the engine protection override switch 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.

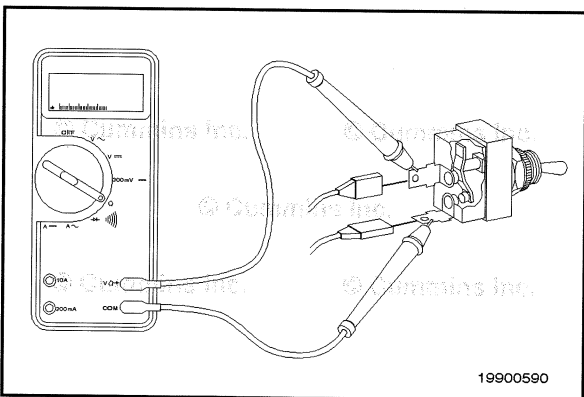
If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the engine protection override switch circuit and a wire carrying power in the OEM harness. Remove the voltage source or repair the wiring in the OEM harness. Refer to Procedure 019-071. Connect all components after completing the repair.

**NOTE:** If the engine protection override switch circuit was approved in all of the previous tests, it is functioning properly.



### Fan Clutch Switch (019-329) General Information

The fan clutch switch allows the driver to control the operation of the engine's fan.



### Resistance Check



If INSITE™ electronic service tool is available, monitor the fan clutch switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate the fan clutch switch. Remove and tag the two connectors from the terminals on the switch.

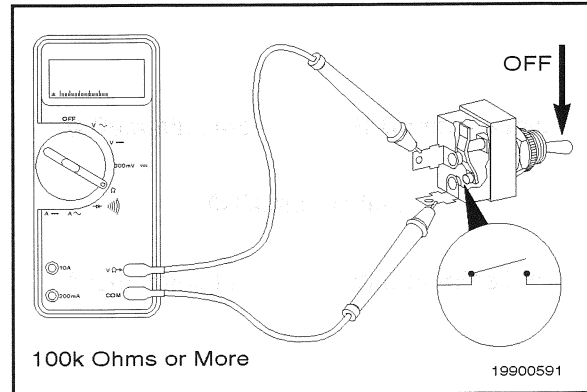
Touch the multimeter probes to the terminals on the switch.

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 instructions.

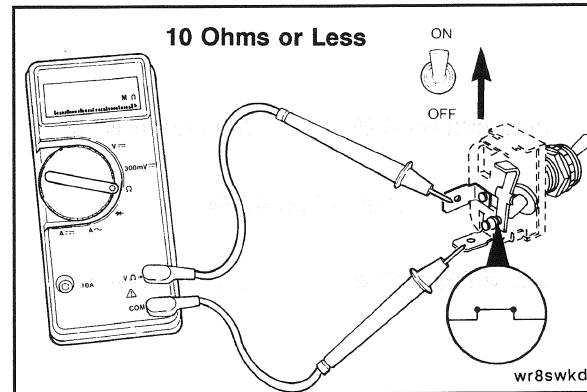


Move the switch to the ON position, and measure the resistance.

The multimeter **must** show 10 ohms or less (closed circuit).

If the circuit is **not** closed, the switch is damaged and **must** be replaced. Refer to the OEM repair manual for the replacement instructions.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.



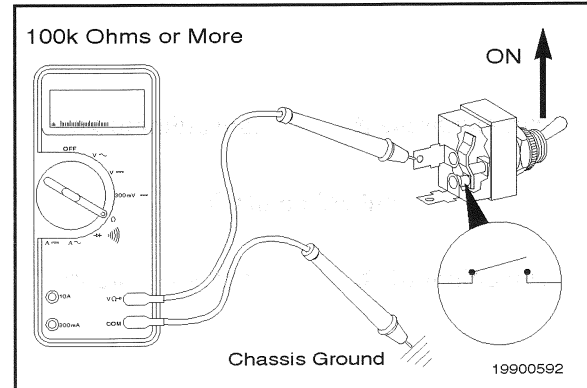
### Check for Short Circuit to Ground

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 100k ohms or more (open circuit).

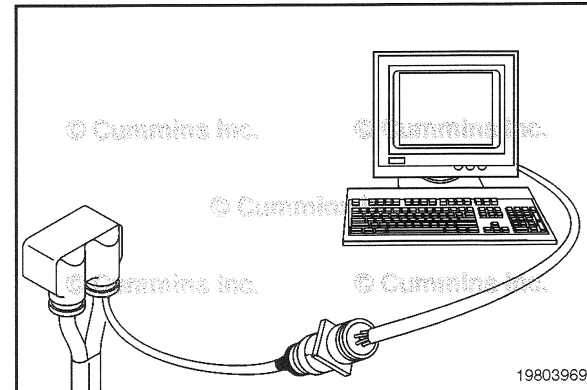
If the circuit is **not** open, the switch is damaged and **must** be replaced. Refer to the OEM repair manual for replacement procedures.



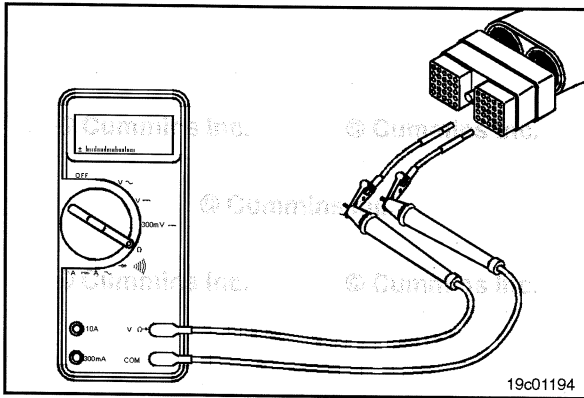
### Fan Clutch Switch Circuit (019-330) Resistance Check

**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 INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the following procedure.







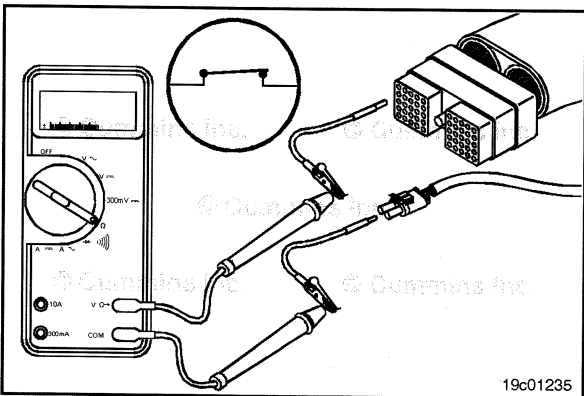
Disconnect the OEM harness connector from the ECM connector. Set the multimeter to measure resistance.



Insert a test lead into the manual fan clutch switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

Insert the other lead attached to the multimeter probe to the switch return (-) pin of the OEM harness connector.

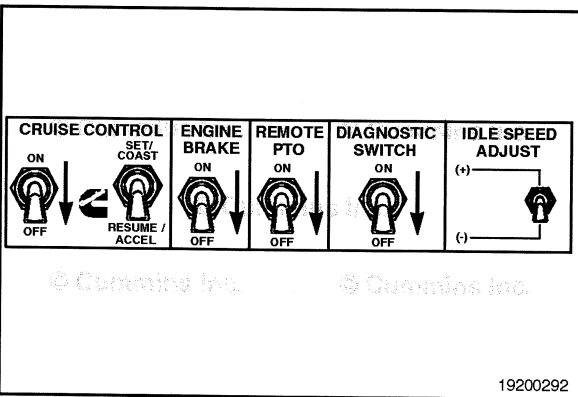
Set the manual fan clutch switch to the OFF position and measure the resistance.



The multimeter **must** show a value of 10 ohms or less (closed circuit).

If the specification is **not** correct, there is an open circuit in the return (-) wire or input wire, provided the switch has previously been checked.

If the resistance is within specification, the return (-) wire and switch wire **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

Disconnect the OEM harness connector from the ECM connector.

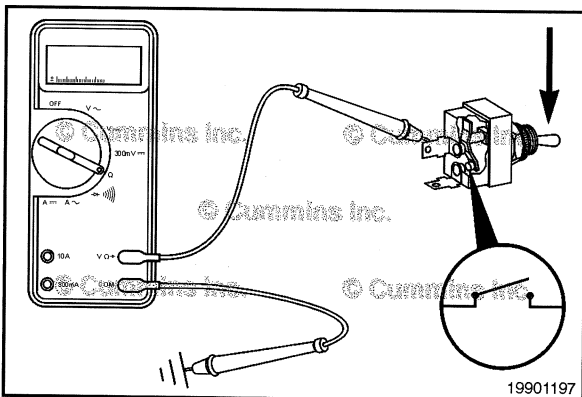


Disconnect the manual fan clutch switch from the OEM harness.

Disconnect the clutch switch and the idle validation switch.

Set all cab switches to the OFF or neutral position.

Set the service brake using the trailer brake hand valve. Set the multimeter to measure resistance.



Insert a test lead into the manual fan clutch switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

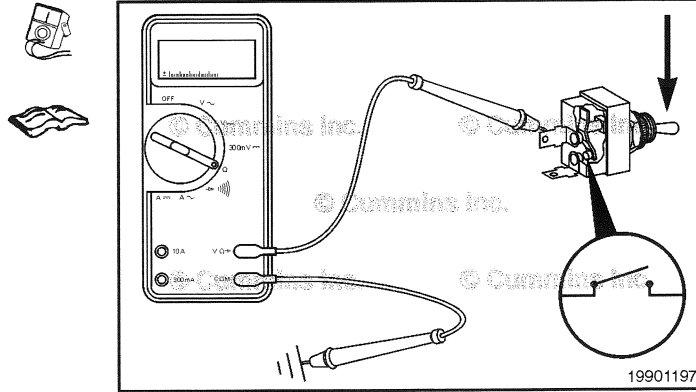


Touch the other multimeter probe to engine block ground and measure the resistance.

The multimeter **must** show a value of 100k ohms or more (open circuit).

If the circuit is **not** open, there is a short circuit to ground in the manual fan clutch circuit, provided the switch has been previously checked and is good.

Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.



### Check for Short Circuit from Pin to Pin

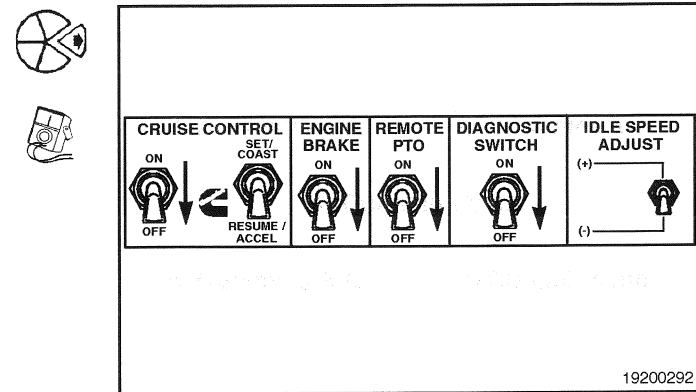
Disconnect the OEM harness connector from the ECM connector.

Disconnect the manual fan clutch switch from the OEM harness.

Disconnect the clutch switch and the idle validation switch.

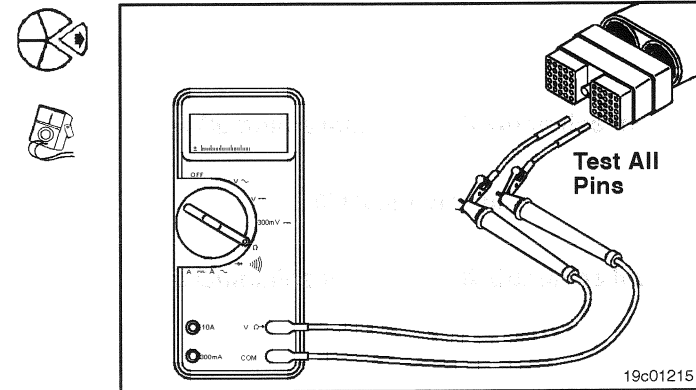
Set all cab switches to the OFF or neutral position.

Set the service brake using the trailer brake hand valve.  
 Set the multimeter to measure resistance.



Insert a test lead into the manual fan clutch switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

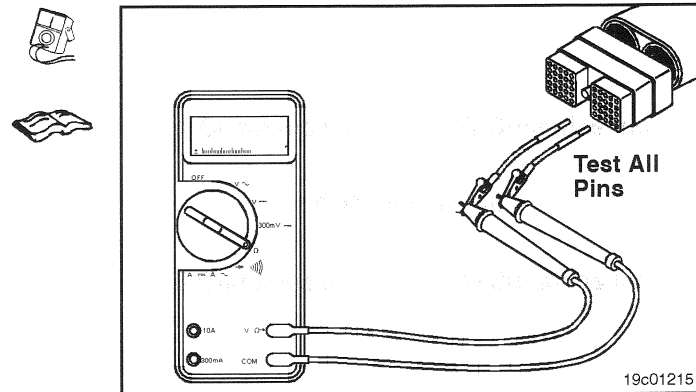
Touch the other multimeter probe with attached test lead to all other pins in the connector. Measure the resistance.

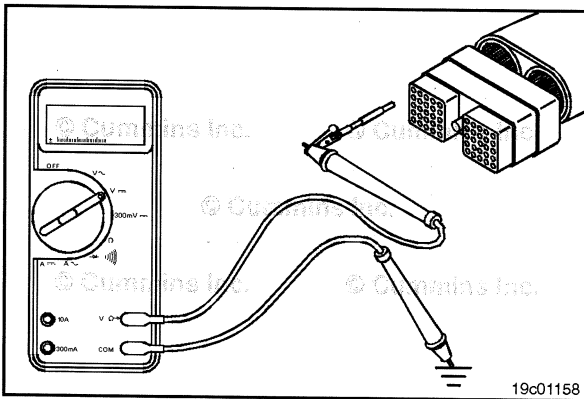


The multimeter **must** show a value of 100k ohms or more (open circuit) at all pins.

If any circuit is **not** open, there is a short circuit between the input pin and the applicable pin, provided the switch has been checked and is good.

Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.





### Check for Short Circuit to External Voltage Source



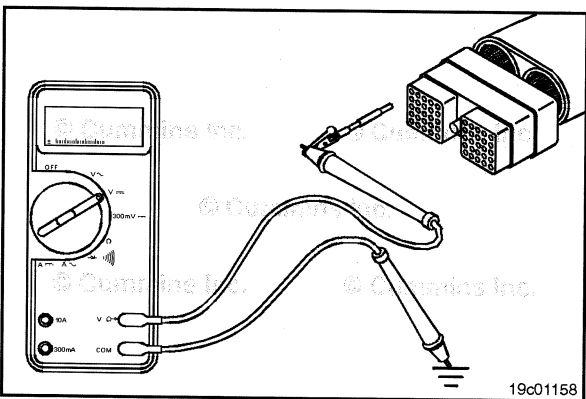
#### CAUTION

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 connector from the ECM connector. Set the multimeter to measure VDC. Turn the keyswitch to the ON position.

Insert a test lead into the manual fan clutch switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

Touch the other multimeter probe to engine block ground and measure the voltage.

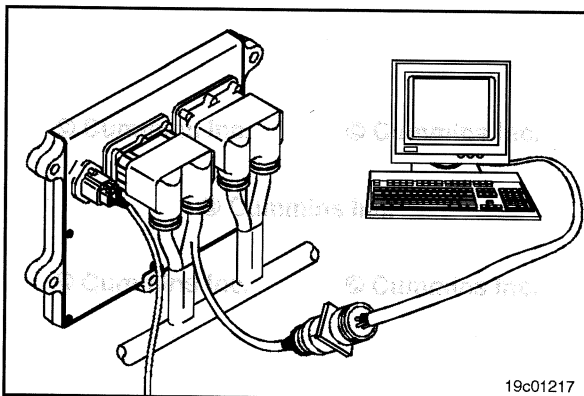


The multimeter **must** show a value of 1.5-VDC or less.

If the voltage is more than 1.5-VDC, there is a short circuit to an external voltage source.



Remove the external voltage source.



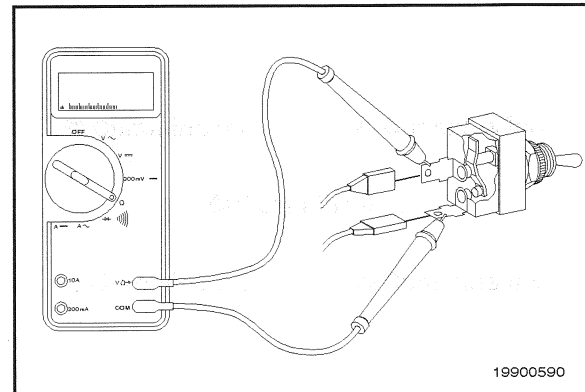
## Remote Accelerator Switch (019-333) General Information

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 INSITE™ is available, monitor the switch for proper operation. If INSITE™ is **not** available, follow the troubleshooting procedures in this section.

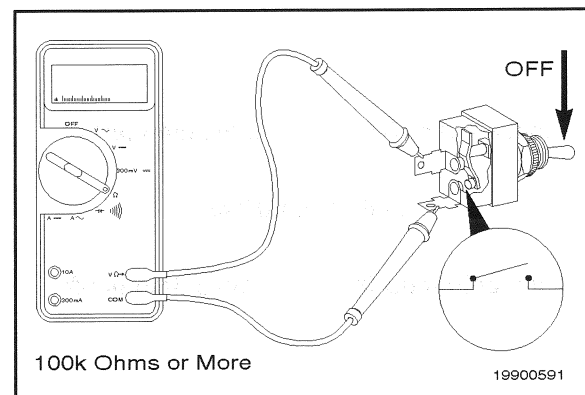
Locate the remote accelerator switch. Remove and tag the two connectors from the terminals on the switch.



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).

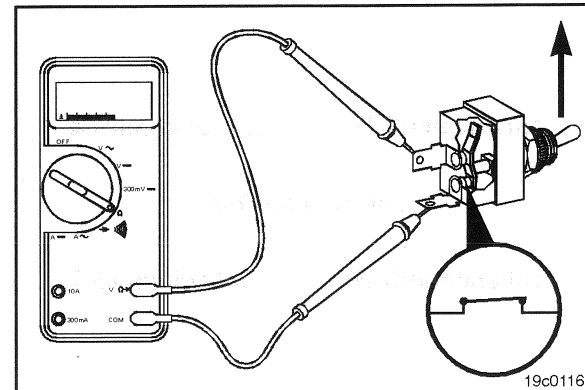
If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.



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.

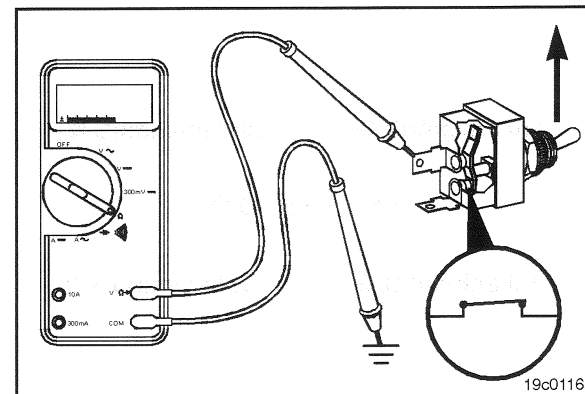
If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

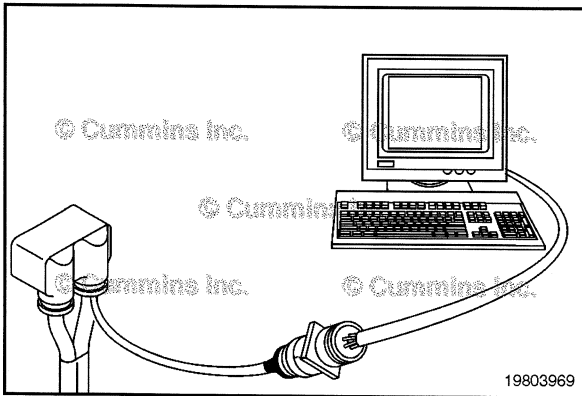


## Check for Short Circuit to Ground

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.





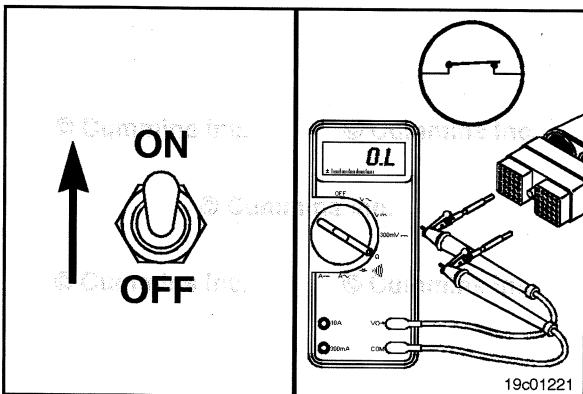
## Remote Accelerator Switch Circuit (019-334)

### 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 INSITE™ electronic service tool is available, monitor the switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



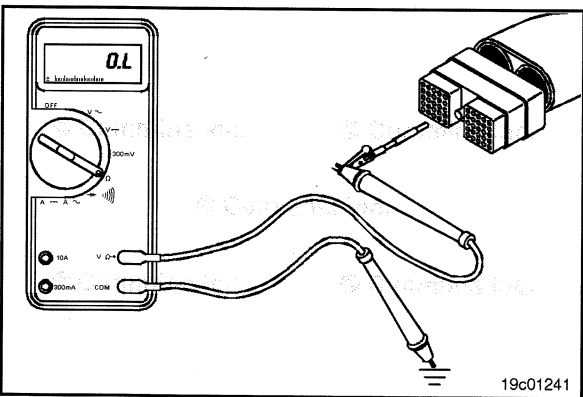
Disconnect the original equipment manufacturer (OEM) harness from the electronic control module (ECM).



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.

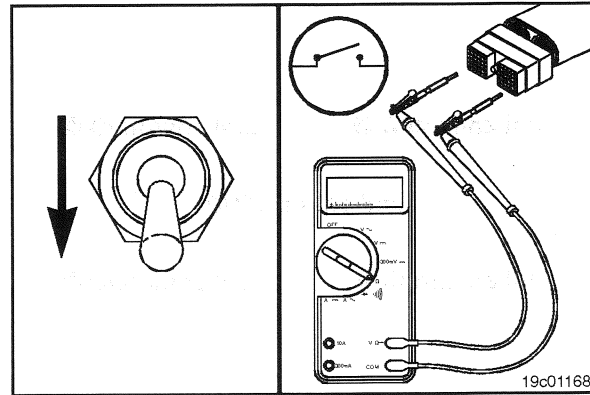
Repair or replace the wire connected to the remote accelerator switch signal. Refer to the OEM troubleshooting and repair manual.

### 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).

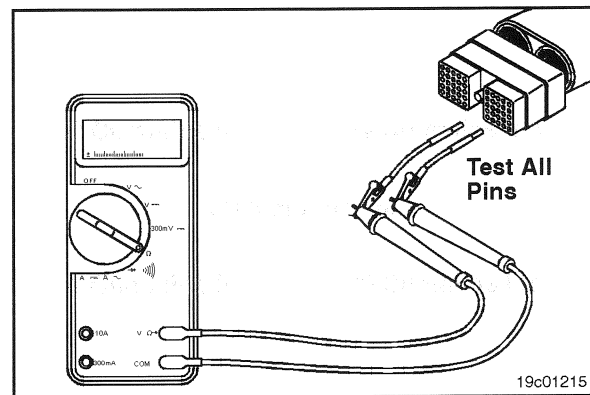


19c01168

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.

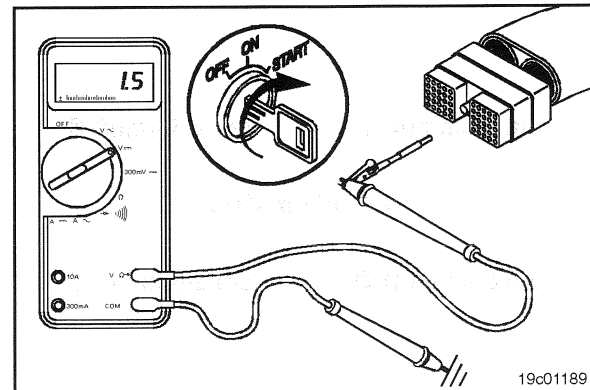


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### Check for Short Circuit to External Voltage Source

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.



19c01189

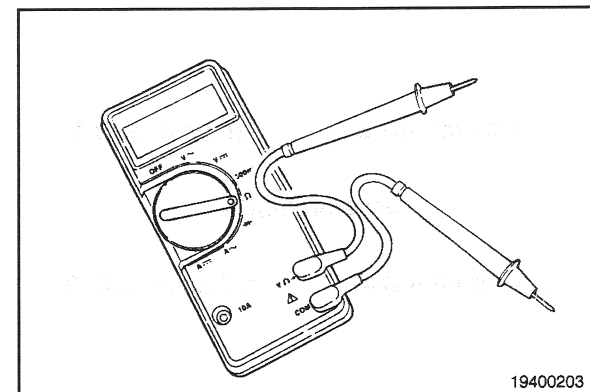
## Multimeter Usage (019-359)

### 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.



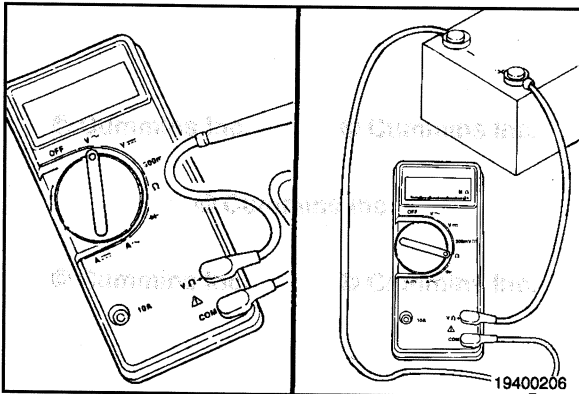
19400203

### 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.



#### How to Measure Amperage

Make an open circuit at the place where the current is to be measured.

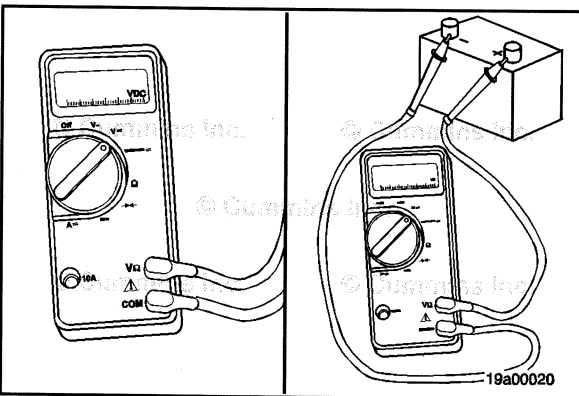


Select the AC current (A ~) or DC current (A-) function on the meter.

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.



#### How to Measure Voltage

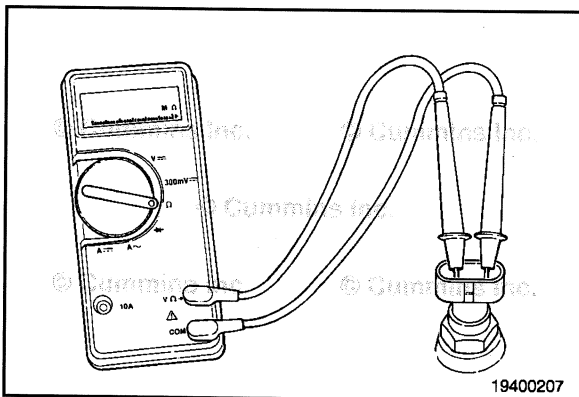
Select the AC voltage (V ~) or DC voltage (V-) function on the meter.



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.



#### 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.

### How to Find the Internal Resistance of the Meter

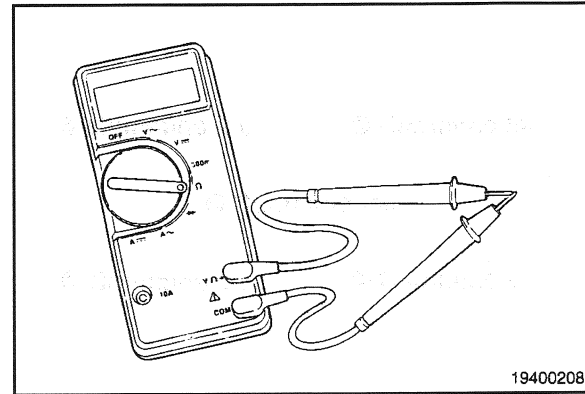
It is important to know the internal resistance of the meter when measuring small resistances. To measure small resistances accurately, the internal resistance of the meter **must** be subtracted from the measured resistance.

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.



19400208

### How to Test for Continuity

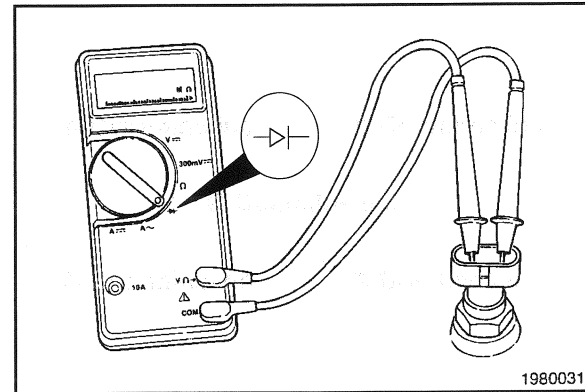
Select the continuity function on the meter (usually marked with a diode symbol).

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.



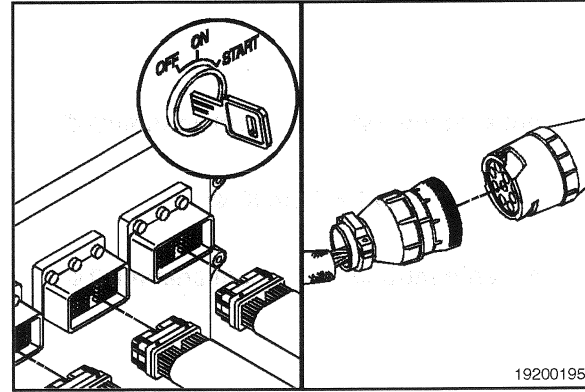
1980031

### Short Circuit to Ground - Check

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.



19200195

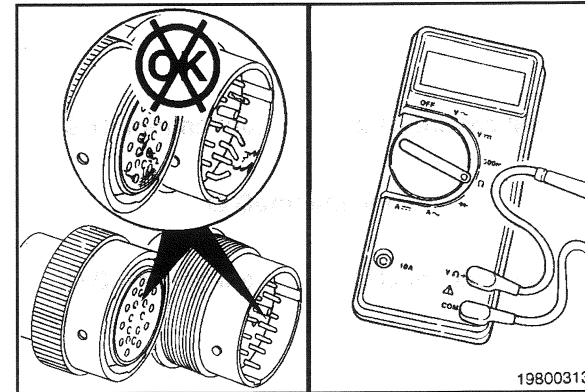
When testing a sensor, **only** the sensor connection is required to be disconnected.

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.

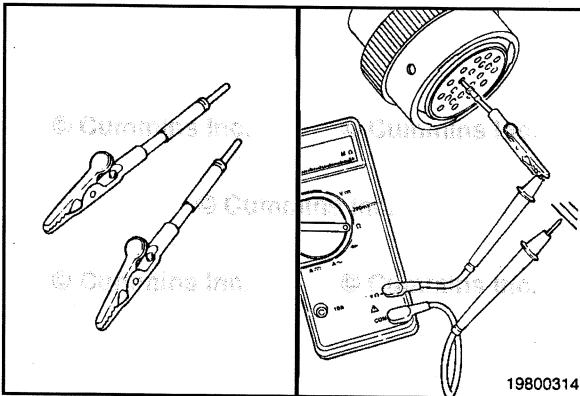
Inspect the connector pins. 019-361.

Adjust the multimeter to measure resistance.



19800313





**⚠CAUTION⚠**

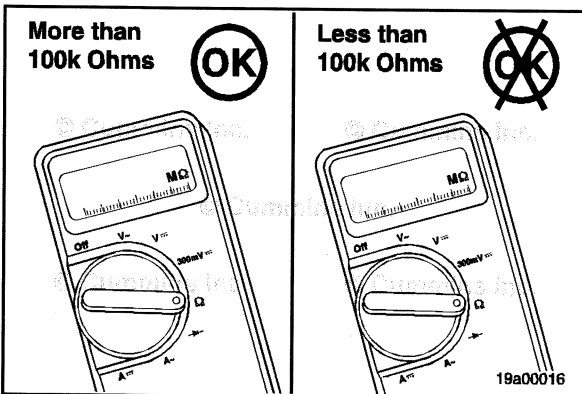
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.



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.

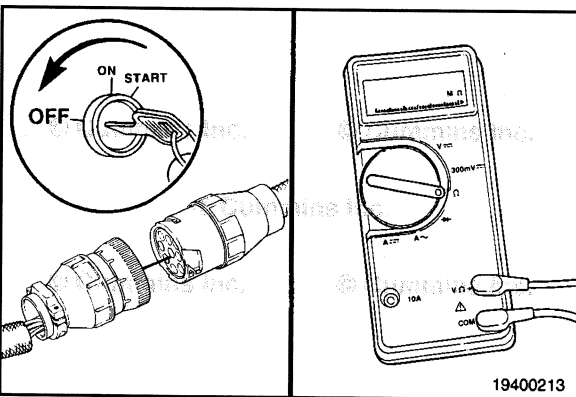
Read the value on the multimeter display.



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**

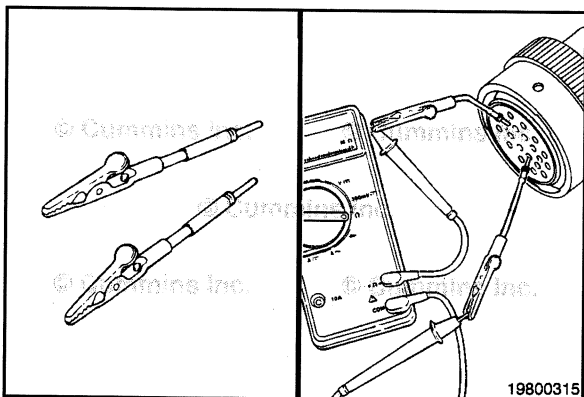
Short circuit from pin to pin is a condition in which an electrical path exists between two pins where it is **not** intended to exist.



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.

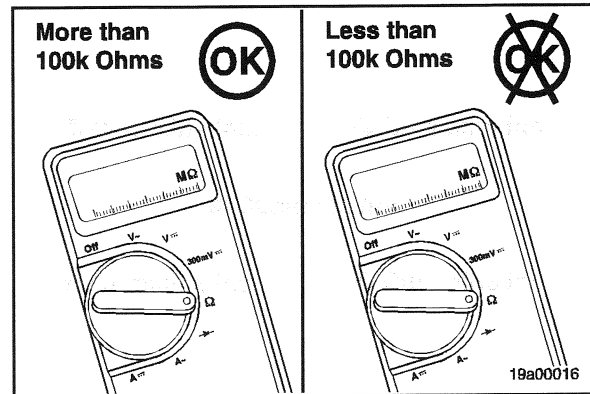


- 1 Touch one of the multimeter probes to the correct pin to be tested on the harness side of the connector.
- 2 Touch the other probe of the multimeter to all other pins on the harness side of the connector.

- 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.

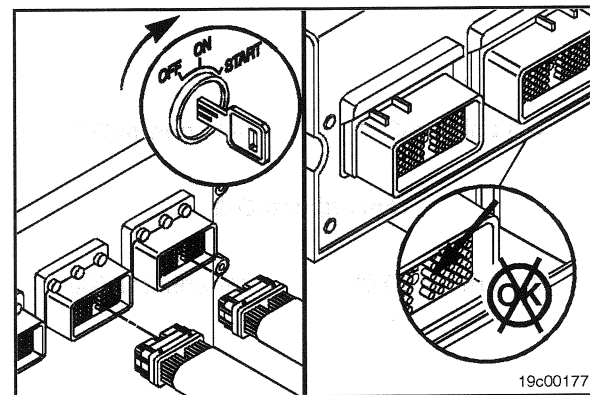


### Voltage Checking

Voltage check is a procedure to measure the difference in voltage potential between two points.

The procedure for checking voltage is as follows:

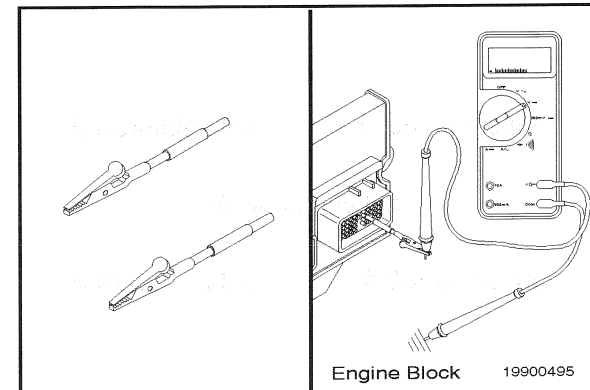
- 1 Disconnect the connectors that are to be tested.
- 2 Turn keyswitch ON.
- 3 Identify the pins that are to be tested.
- 4 Adjust the multimeter to AC voltage (V<sup>~</sup>) or DC voltage (V<sup>-</sup>).



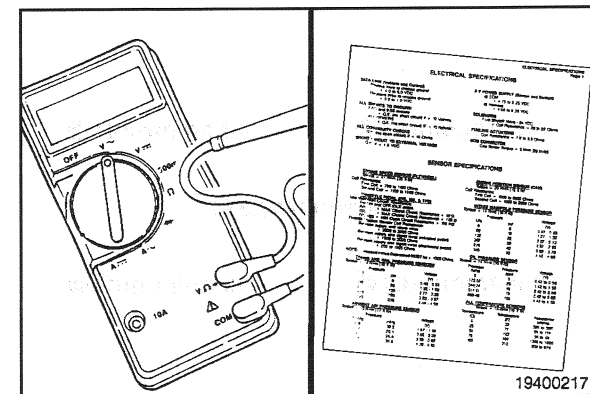
### ⚠ CAUTION ⚠

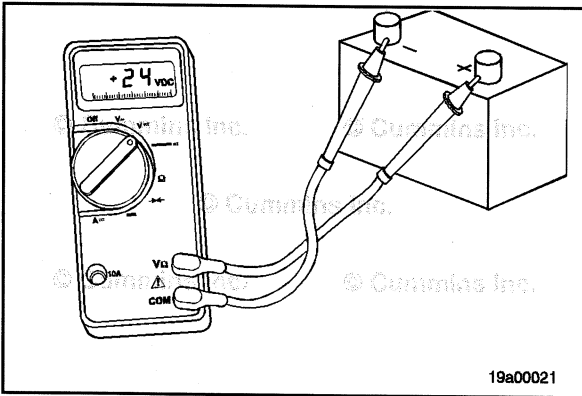
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

- 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.



- 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.

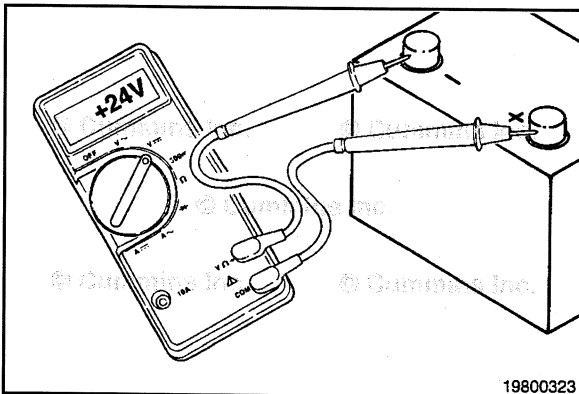




### Polarity Check

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).

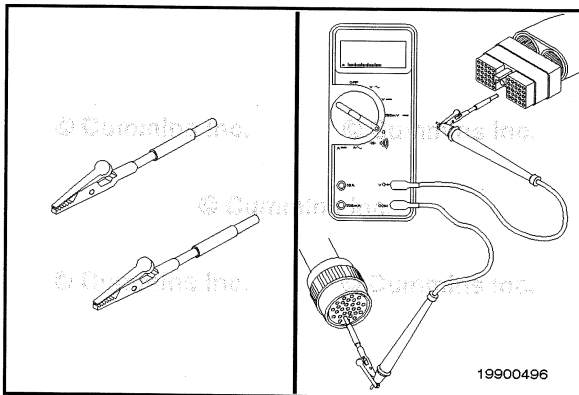


The polarity is correct when the positive (red) probe of the multimeter is on the positive (+) terminal of the battery and the negative (black) probe of the multimeter is on the negative (-) terminal of the battery.



The multimeter will display positive voltage if the polarity is correct.

If the multimeter probes are reversed, the multimeter displays a negative voltage.

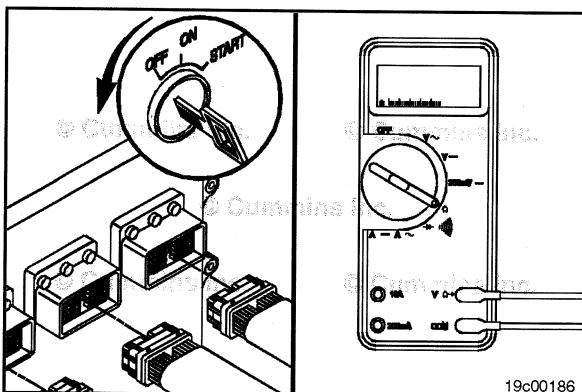


### Continuity Check

#### ⚠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:

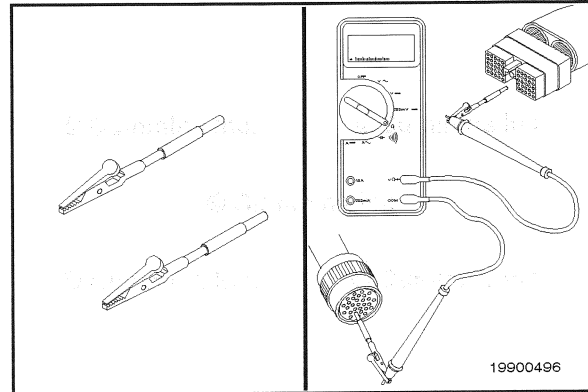
- 1 Turn keyswitch OFF.
- 2 Disconnect the harness connectors that are to be tested.
- 3 Adjust the multimeter to measure resistance.



**⚠ 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.

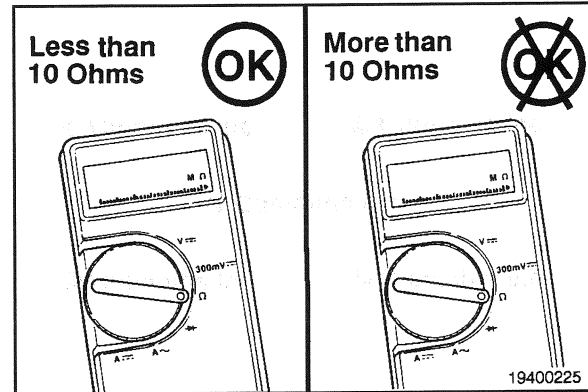
- 1 Insert test lead to the pin of the wire being tested and connect the alligator clip to the multimeter probe.
- 2 Insert the other test lead to the pin at the other end of the wire being tested and connect the alligator clip to the other multimeter probe.
- 3 Read the value on the multimeter display.



19900496

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.



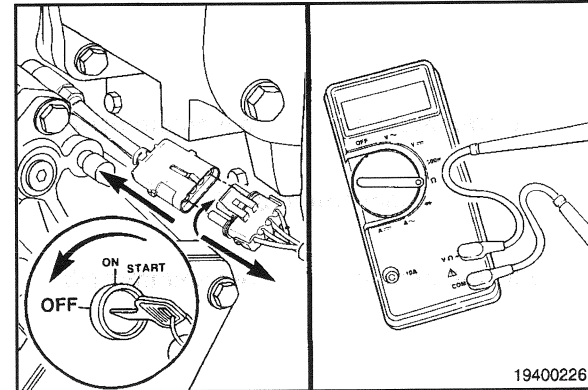
19400225

**Resistance Check - Coil**

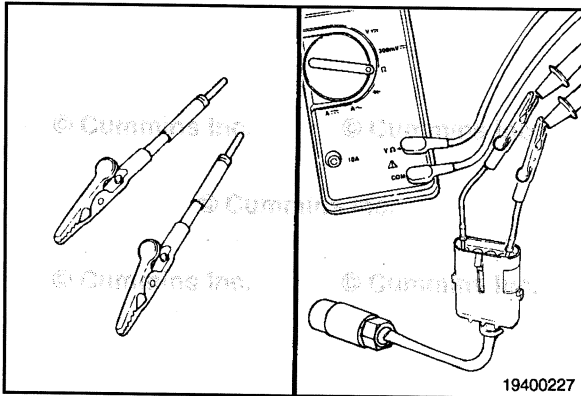
Turn keyswitch OFF.

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.

## 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.

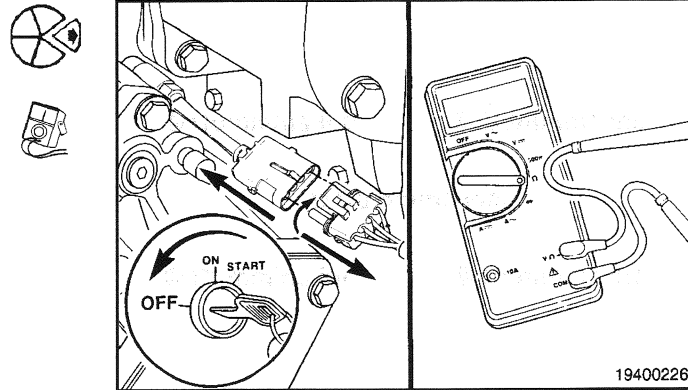
### Resistance Check

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.

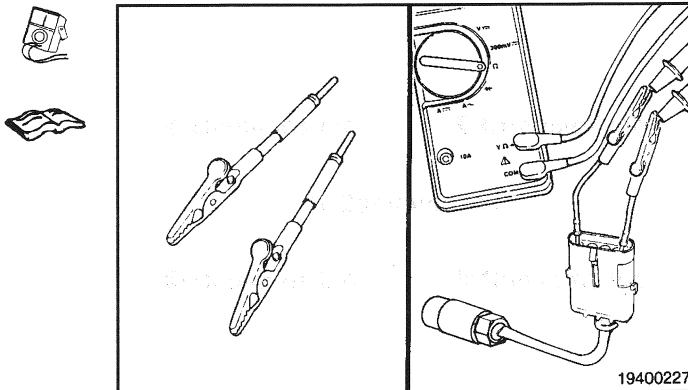


### ⚠ CAUTION ⚠

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.

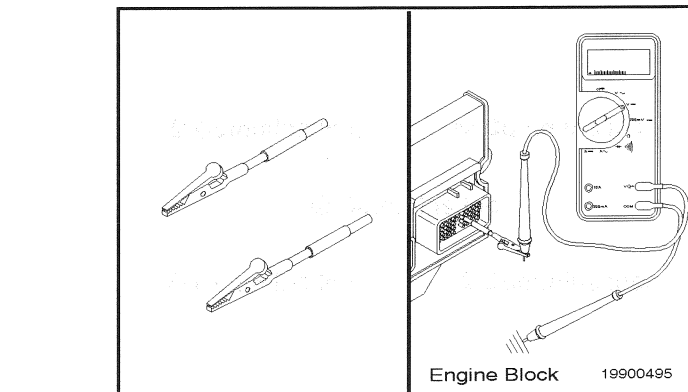
Connect the appropriate connector test leads to the connector pins and connect the alligator clips to the multimeter probe. Measure the resistance.

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

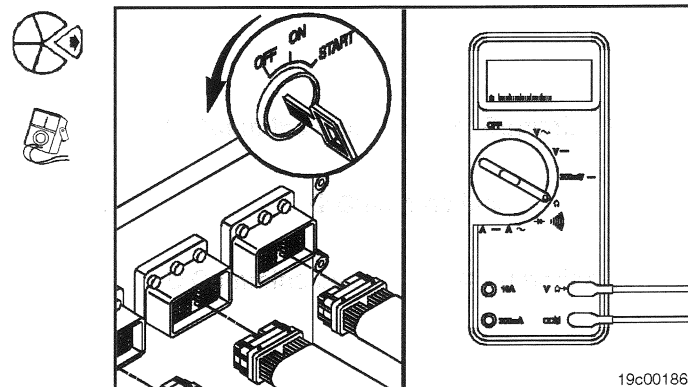
Continuity is an electrical connection between two pins that is less than a certain value. For harness wires, the specification is less than 10 ohms.

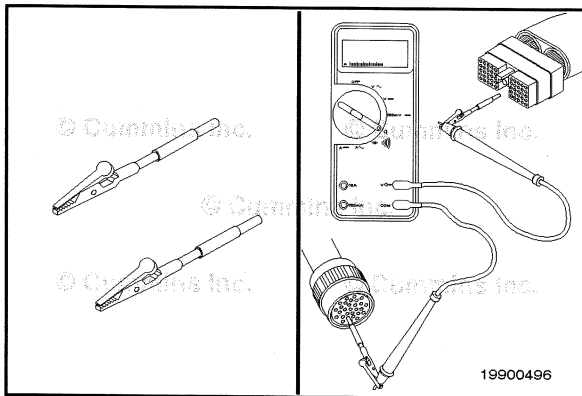


Turn the key switch to the OFF position.

Disconnect the harness connectors that are to be tested.

Adjust the multimeter to measure resistance.

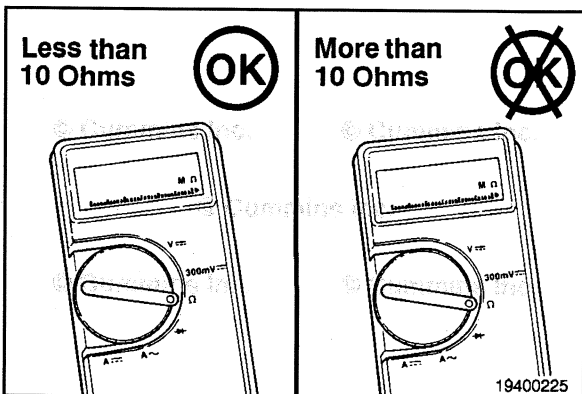




**⚠ CAUTION ⚠**

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.

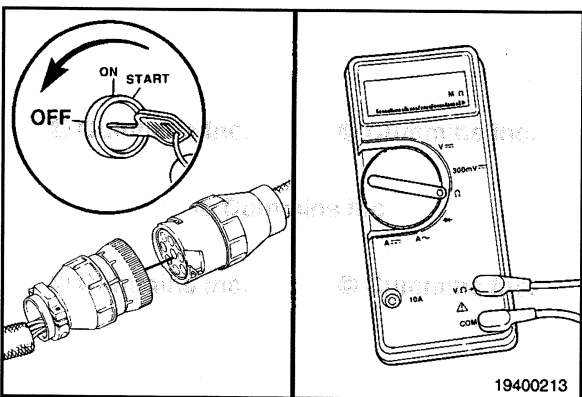
Connect the appropriate connector test leads to the connector pins and connect the alligator clips to the multimeter probe. Measure the resistance.



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**

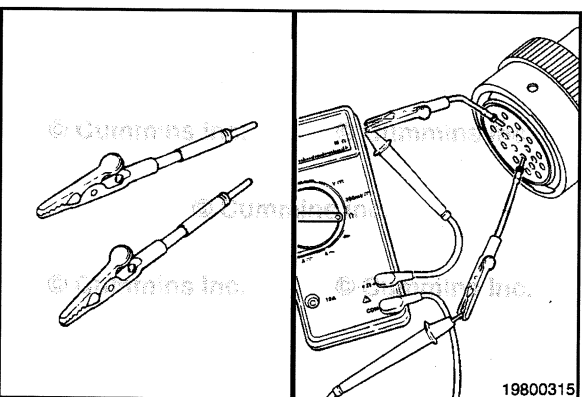
Short circuit from pin to pin check is a condition in which an electrical connection exists between two pins where it is **not** intended to exist.



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.

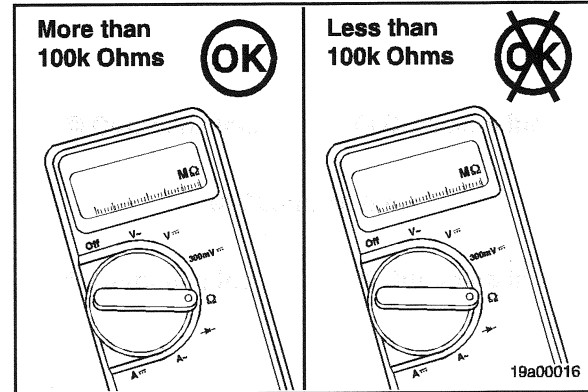
Connect the appropriate connector test leads to the connector pins and connect the alligator clips to the multimeter probes. Measure the resistance.

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.

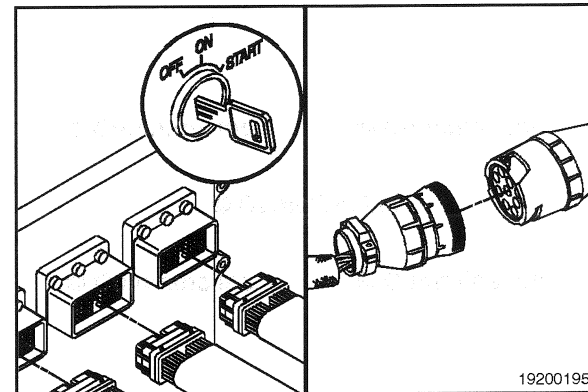


### Check for Short Circuit to Ground

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.

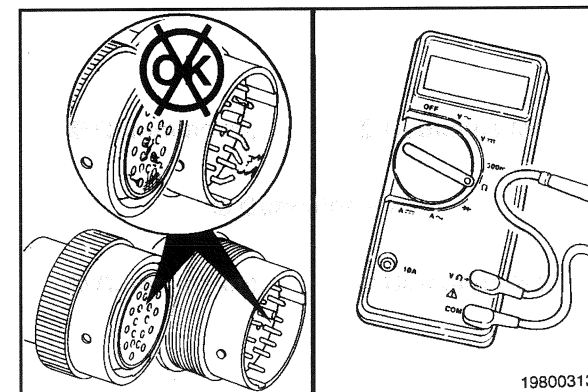


When testing a sensor, **only** the sensor connection is required to be disconnected.

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.

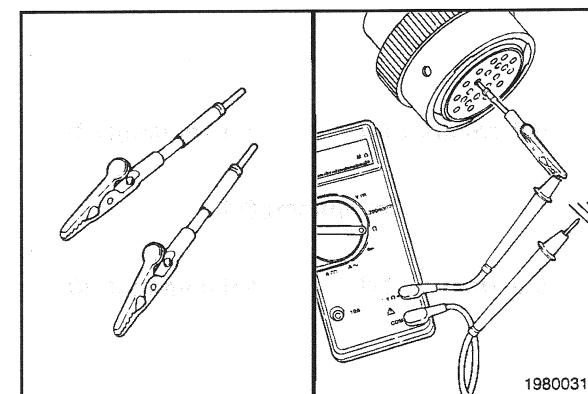


### ⚠CAUTION⚠

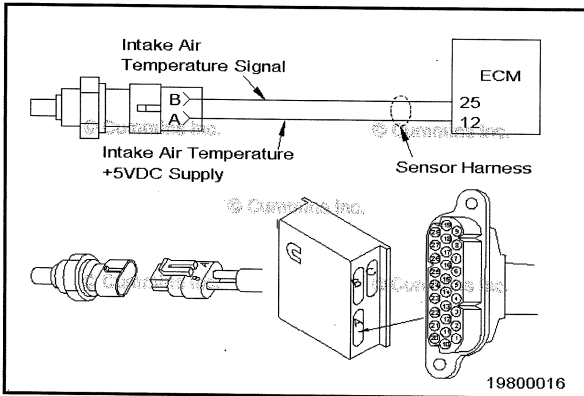
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit.

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.

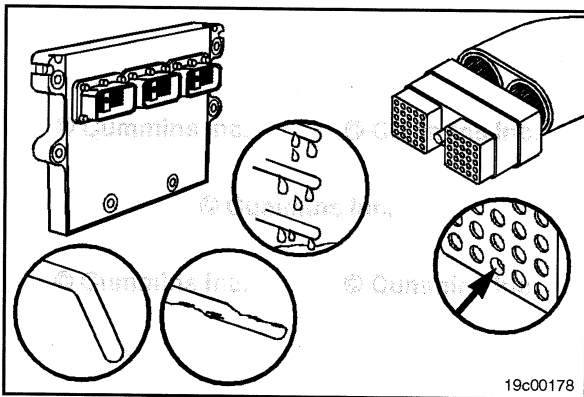


## Component Connector and Pin Inspection (019-361)

### 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.

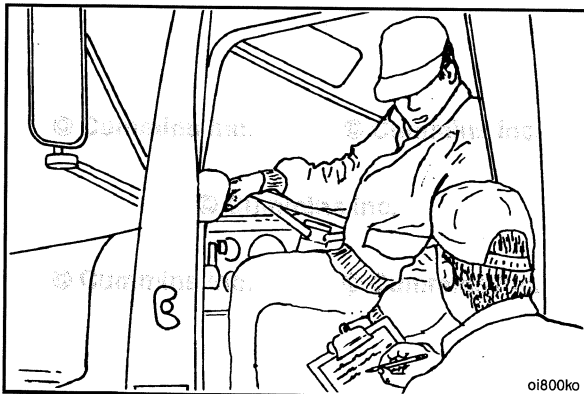
## Inactive or Intermittent Fault Code (019-362)

### 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 troubleshooted 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.

**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

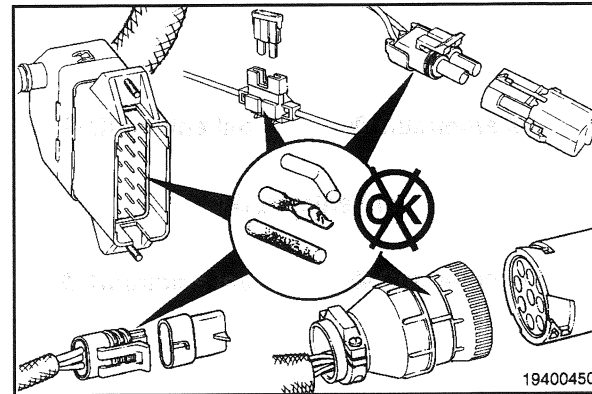
Disconnect the sensor or actuator related to the intermittent condition.

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.

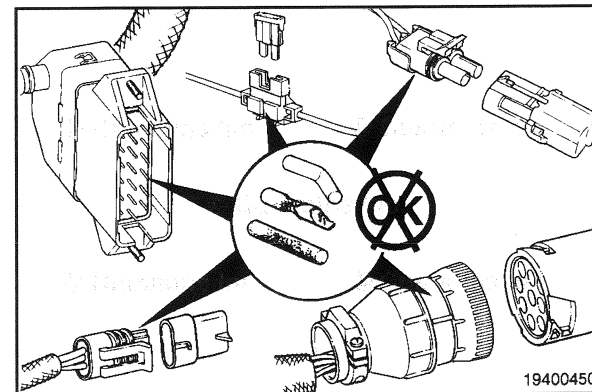
Thoroughly inspect the wiring harness between the suspected component and ECM connection. Check for the proper strain relief on the wiring harness.

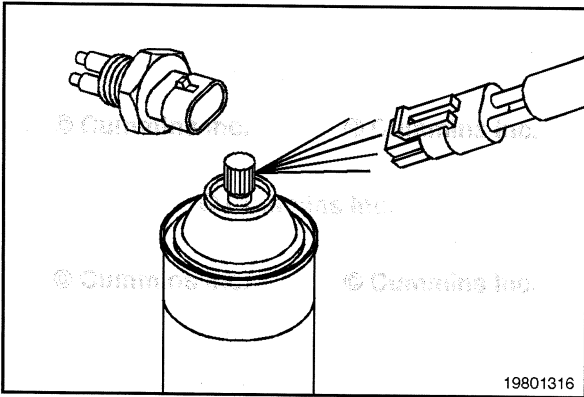
A dark powder found inside the connector may be a sign of pin fretting. Clean the pin contacts and reconnect the connector.



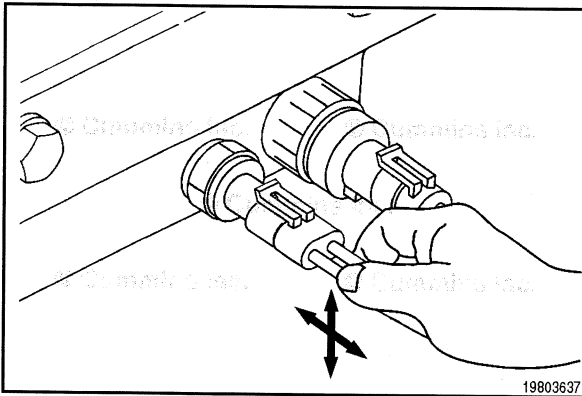
Disconnect the wiring harness connector from the ECM. Inspect the ECM connector for the following:

- 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.



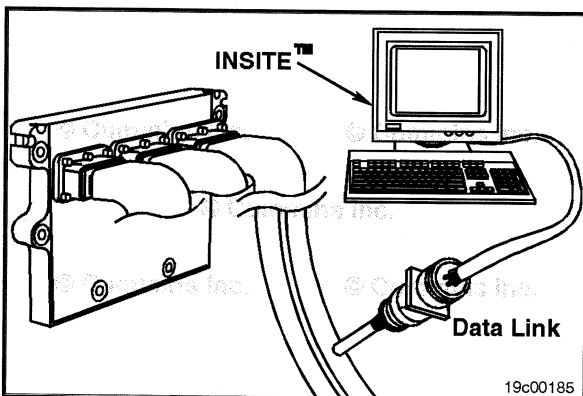
### Harness Shake Test

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.

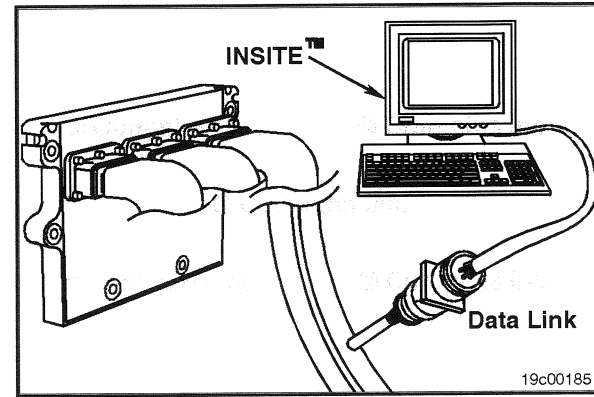
Start the engine.

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.

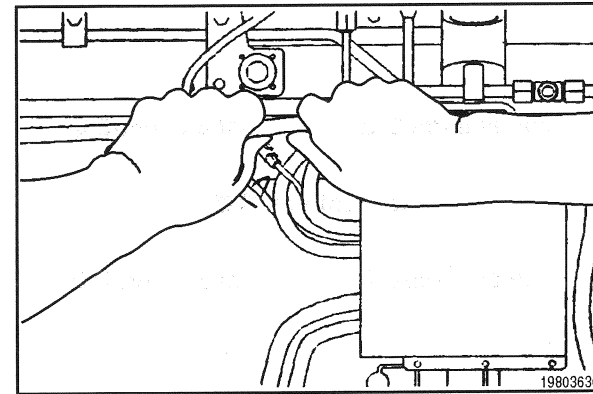


### Ground Circuit Check

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:

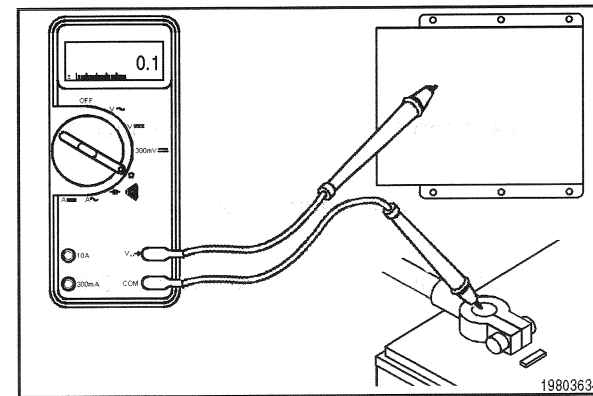
- engine block grounds
- chassis (or frame rail) grounds
- ECM grounds
- alternator and starter negative posts

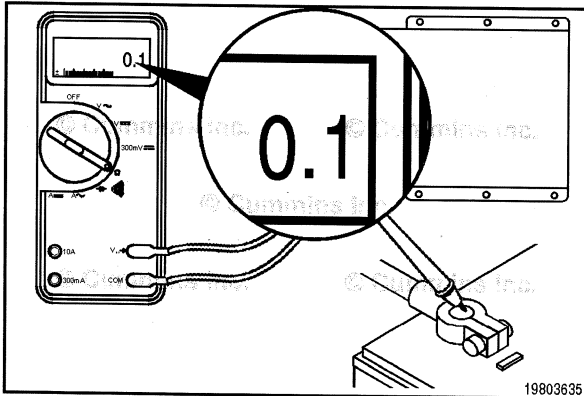
While performing this step, check to see if the fault code goes active, or if inactive counts increase. If this happens, there is a loose connection or damaged wire at that location. Disconnect, clean grounding cables and grounding surfaces, then reconnect. Repair or replace grounding cables or wires if necessary.



Measure resistance from the battery negative (-) post to:

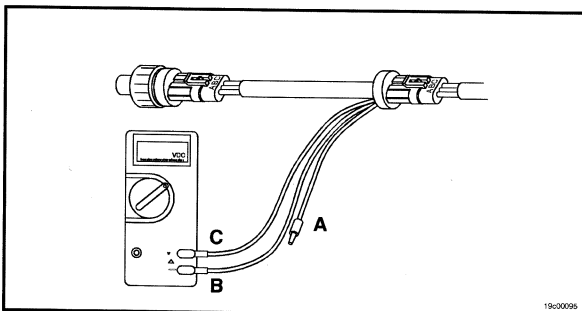
- ECM casing (clean, non-painted surface)
- Engine Block (clean, non-painted surface)
- Starter (-) post
- Alternator (-) post
- Firewall grounding post
- Cab ground (dash switches, common ground)
- Vehicle frame rail.





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.

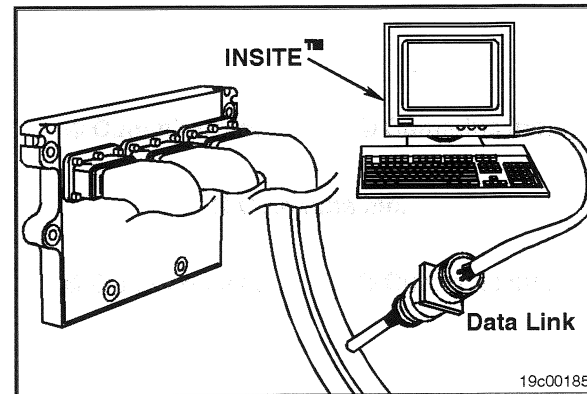
### Sensor Accuracy Check

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.

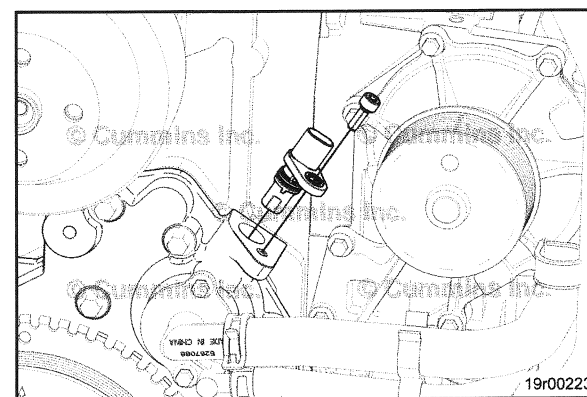


## Camshaft Position Sensor (019-363) Remove

Disconnect the sensor from the engine harness. Slide the locking tab sideways. 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 front cover.

Remove the sensor from the mounting location.

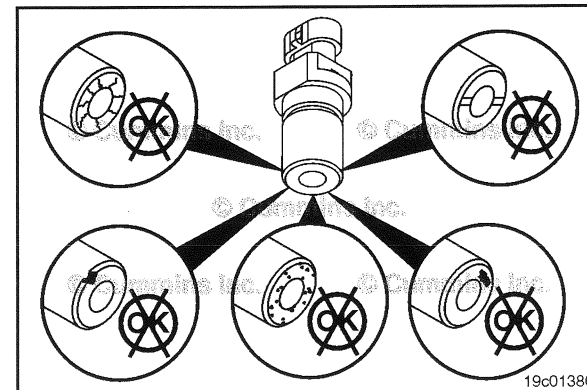


## Inspect for Reuse

Inspect the camshaft position sensor for debris, cracks, or 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, replace the sensor with a new sensor.



## Install

Install a new o-ring onto the sensor.

Apply clean engine oil to the o-ring.

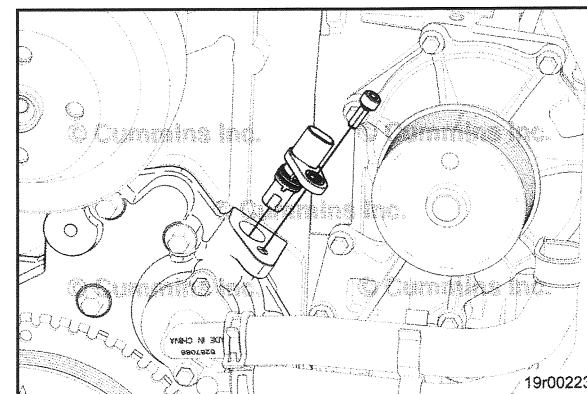
Install the new sensor into the mounting hole on the front cover.

Install and tighten the capscrew.

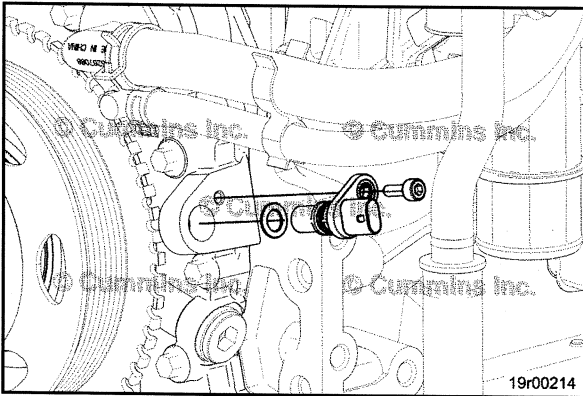
**Torque Value:** 8 N•m [ 71 in-lb ]

Connect the sensor to the engine harness.

Slide the lock tab sideways to lock the connector to the sensor.







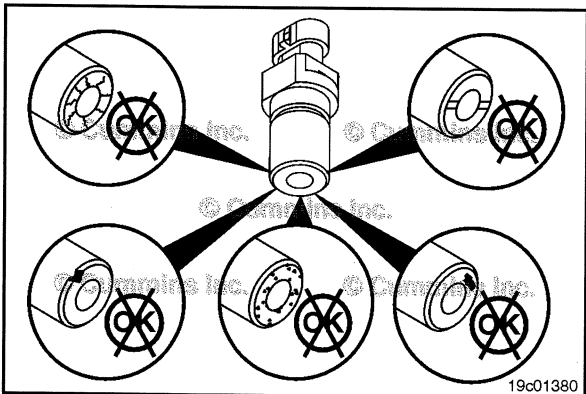
## Crankshaft Position Sensor (019-365) Remove



Disconnect the sensor from the engine harness. Slide the locking tab sideways. 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 front gear cover.

Remove the sensor from the mounting location.

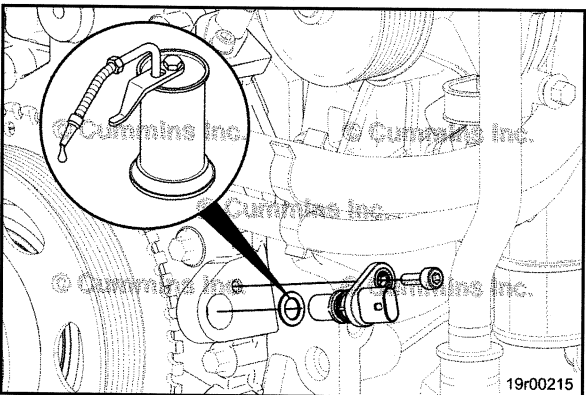


## Inspect for Reuse

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, replace the sensor with a new sensor.



## Install

Install a new o-ring onto the sensor.



Apply clean engine oil to the o-ring.

Install the new sensor into the mounting hole on the front cover.

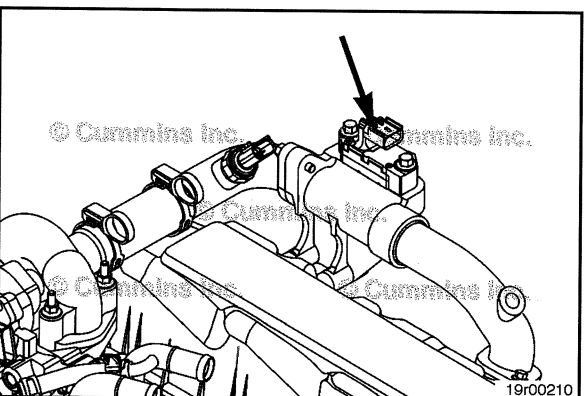


Install and tighten the capscrew.

**Torque Value:** 8 N•m [ 71 in-lb ]

Connect the sensor to the engine harness.

Slide the lock tab sideways to lock the connector to the sensor.



## EGR Differential Pressure Sensor (019-370)

### General Information

The exhaust gas recirculation (EGR) differential pressure sensor has two ports that sense a pressure drop across the EGR gas entrance to the intake connection.

The EGR differential pressure sensor is mounted on the EGR crossover tube.

Use the following procedure for a detailed component location view. Refer to Procedure 100-002 in Section E.

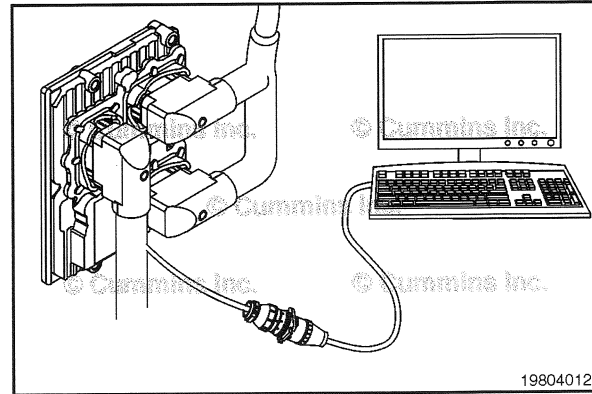
### Initial Check

Use an electronic service tool to monitor the value of the EGR differential pressure sensor with the key in the ON position and the engine off.

The sensor should meet the following specification:

EGR Differential Pressure		
kPa		in Hg
± 3	NOM	± 0.90

If the value is **not** within specification, remove the EGR differential pressure sensor and inspect the EGR supply ports in the EGR differential pressure sensor adaptor for blockage. Refer to Procedure 011-028 in Section 11.

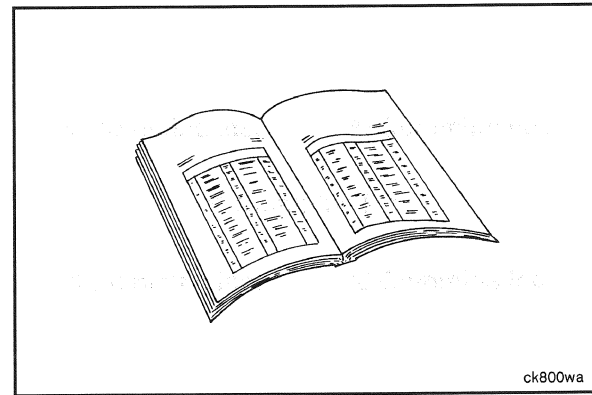


### Preparatory Steps

#### ⚠ 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.

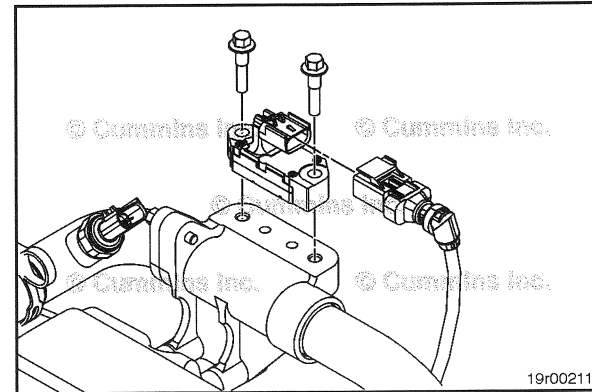
- Disconnect the batteries. See equipment manufacturer service information.
- Clean the area around the EGR differential pressure sensor.



### Remove

Disconnect the EGR differential pressure sensor from the engine wiring harness.

Remove the two capscrews from the base of the sensor and remove the sensor from the EGR differential pressure sensor adaptor.

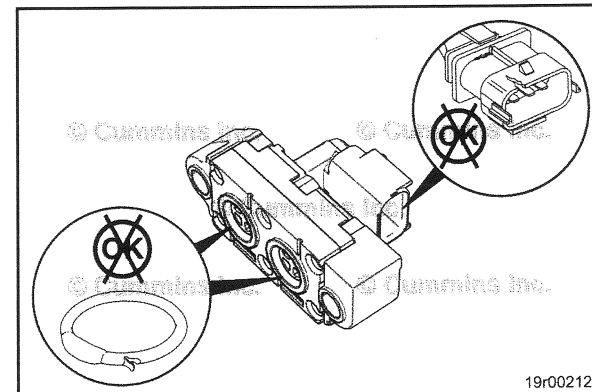


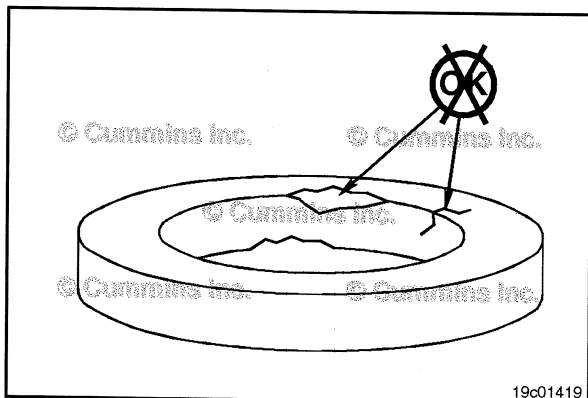
### Clean and Inspect for Reuse

Inspect the engine harness connector and sensor for the following:

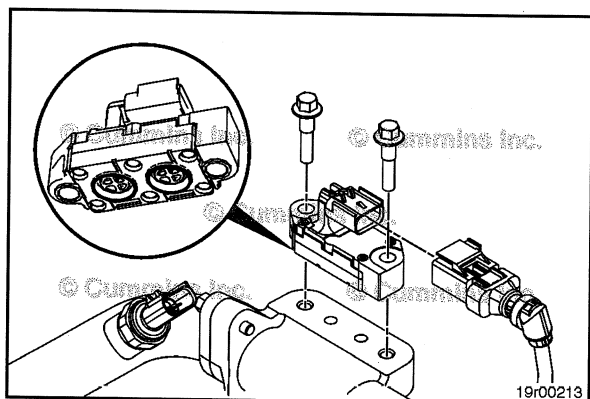
- Cracked or broken connector shell.
- Missing or damaged connector seals.
- Dirt, debris, or moisture in or on the connector pins.
- Corroded, bent, broken, pushed back, or expanded pins.
- Chipped, cracked, extruded, or damaged sensor.

Repair or replace parts as necessary.





Inspect the o-rings for cracks and other damage.  
Replace the o-rings if cracks or other damage is found.



### Install

Make sure the new sensor has an o-ring in each of the two grooves at the base of the sensor..



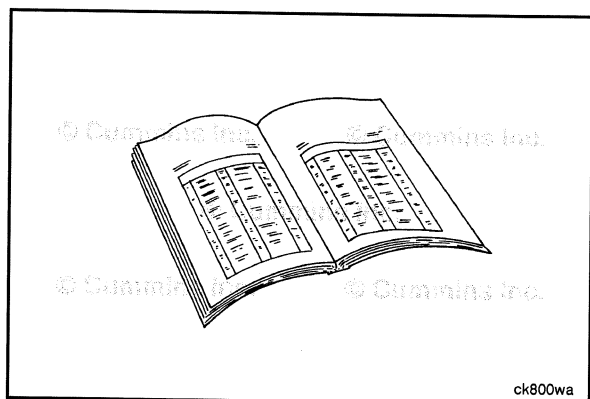
Install a new sensor into the engine.

Tighten the sensor.



**Torque Value:** 18 N•m [ 159 in-lb ]

Connect the EGR differential pressure sensor to the engine wiring harness.



### 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.

## Exhaust Gas Pressure Sensor (019-376)

### General Information

The exhaust gas pressure sensor monitors the pressure from the exhaust and passes that information on to the engine control module (ECM) through the engine harness. If the exhaust gas pressure sensor becomes too low, it will cause a derate condition.

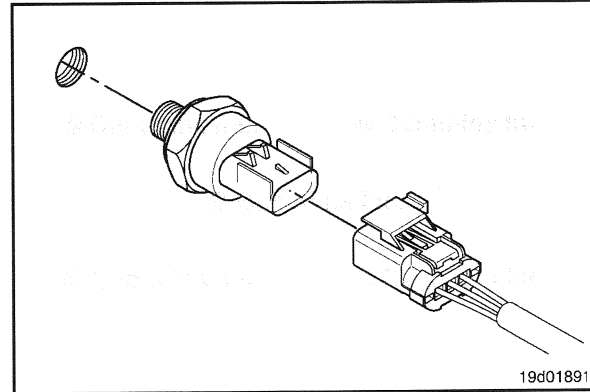
The exhaust gas pressure sensor is located on the exhaust gas recirculation (EGR) cooler on the exhaust side of the engine.

## Remove

Slide the locking tab on the connector sideways. Push down on the button toward the rear of the connector and disconnect it from the sensor.

Remove the exhaust pressure sensor insulation tube. Do **not** peel apart the adhesive of the tube to remove.

Remove the sensor from the engine.



## Install

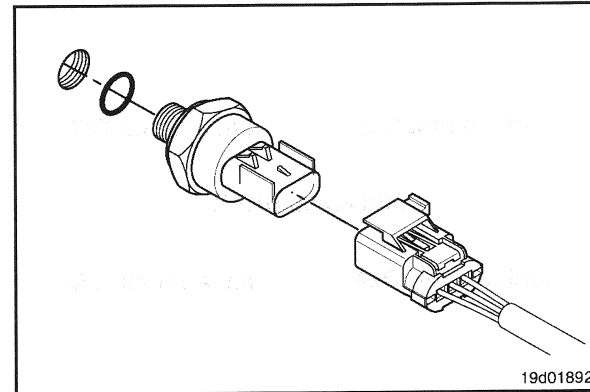
Make sure the new sensor has an o-ring.

Lubricate the o-ring with clean engine oil.

Install the sensor into the engine. Tighten the sensor.

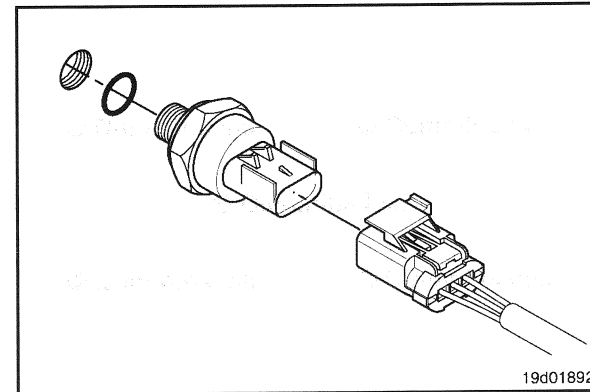
Use a deep well socket, being careful **not** to overtighten the sensor.

**Torque Value:** 18 N•m [ 159 in-lb ]



Push the connectors together until they lock.

Slide the locking tab to the lock position.

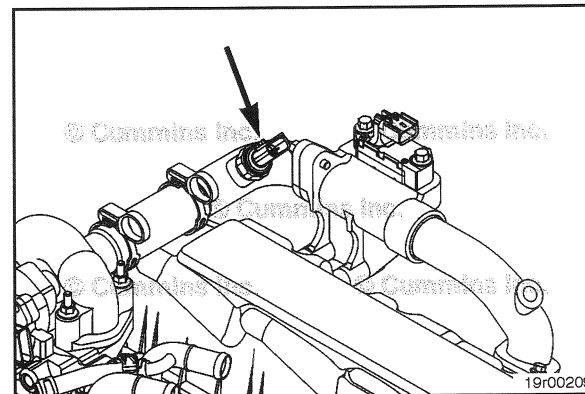


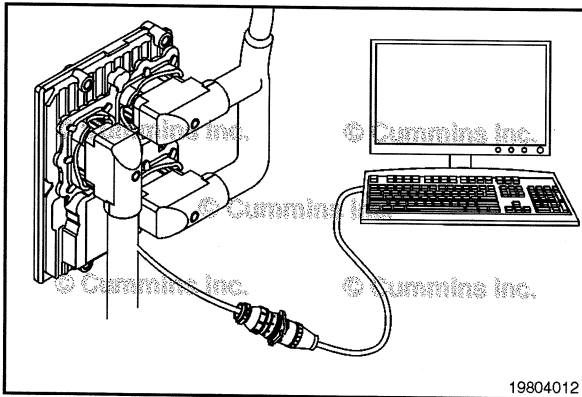
## EGR Temperature Sensor (019-378)

### General Information

The exhaust gas recirculation (EGR) sensor is used to measure the temperature of the exhaust gas that exits the EGR cooler.

The EGR temperature sensor is located on the EGR crossover tube. Refer to Procedure 100-002 in Section E.





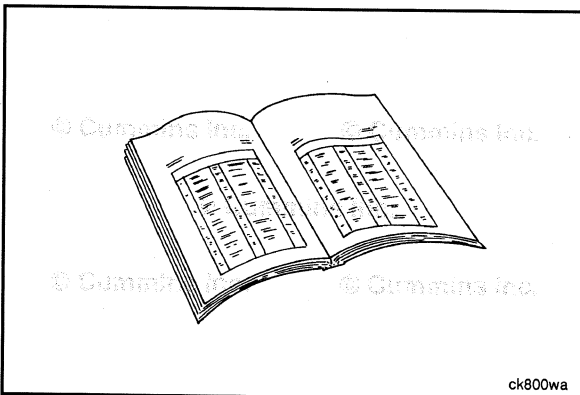
### Initial Check

Use an electronic service tool to monitor the value of the EGR temperature sensor with the key in the ON position and the engine off.

**NOTE:** The value of the EGR temperature sensor should be checked when the engine is cold.

The value of the EGR temperature sensor should read within 5.5°C or 10°F of the local ambient air temperature.

Replace the EGR temperature sensor if the value is out of specification.



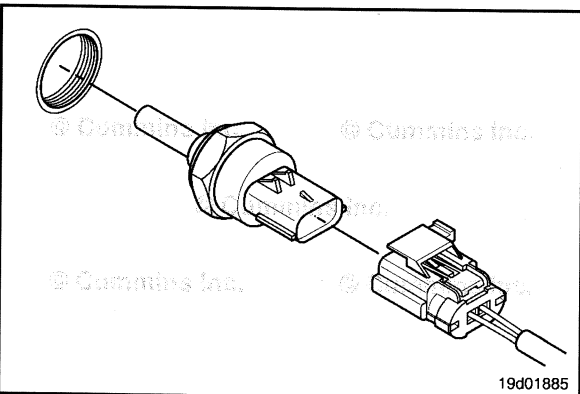
### Preparatory Steps

#### ⚠ 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.**

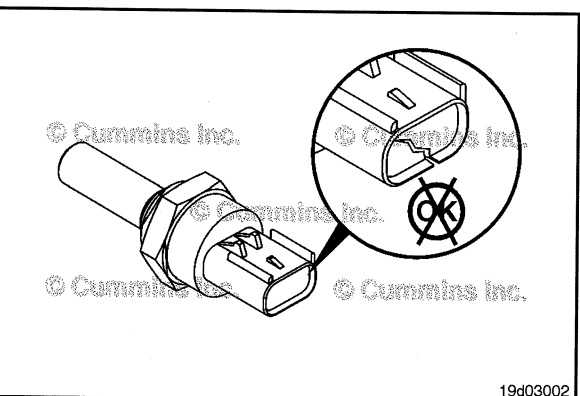
- Disconnect the batteries. See equipment manufacturer service information.
- Clean the area around the EGR temperature sensor.



### Remove

Disconnect the EGR temperature sensor from the engine harness.

Remove the sensor from the engine.



### Clean and Inspect for Reuse

Inspect the engine harness connector and 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.
- Chipped, cracked, extruded, or damaged sensor.

Repair or replace parts as necessary.

## Install

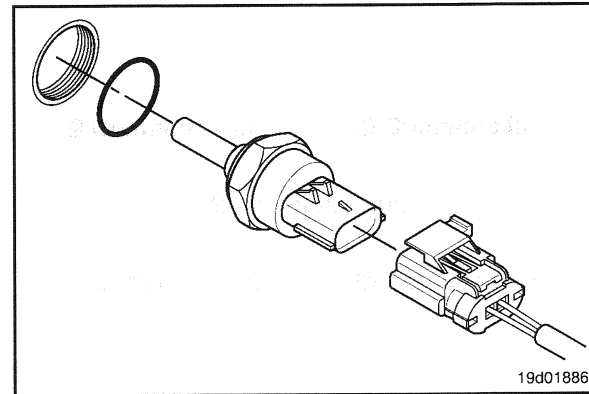
Check to make sure the sensor has a metal sealing washer.

Install the sensor into the EGR crossover tube.

Tighten the sensor.

**Torque Value:** 20 N•m [ 177 in-lb ]

Connect the engine harness connector to the sensor.

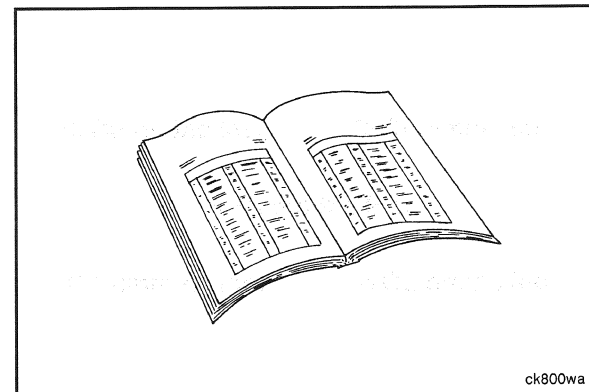


## Finishing Steps

### ⚠ 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.
- Operate the engine and check for leaks.

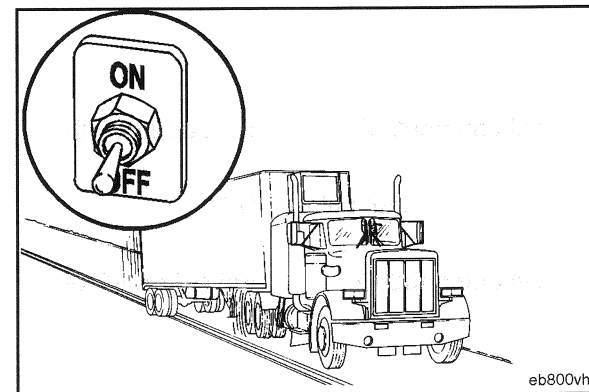


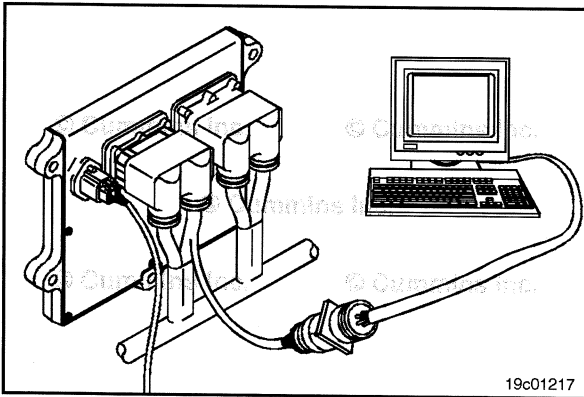
## Fan Control Switch (019-380)

### General Information

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.

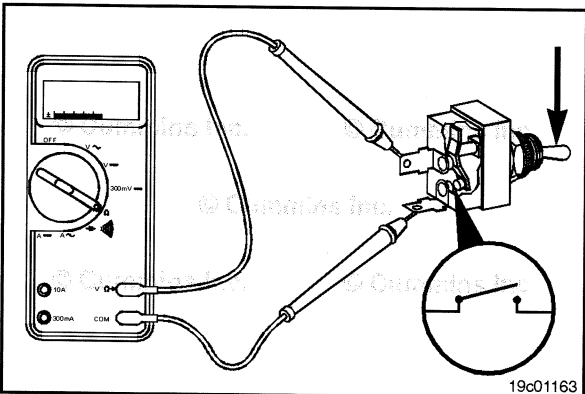
**NOTE:** This procedure is **only** valid if the fan control switch is wired through the ECM and the feature manual fan switch is enabled in the ECM. If the fan control switch is wired in series with the fan control relay, the ECM could log fan circuit errors during normal operation. Please verify the circuit is wired properly before performing this procedure.





### Resistance Check

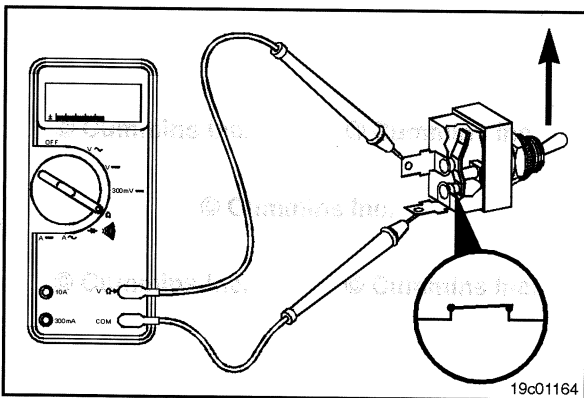
If INSITE™ is available, monitor the fan control switch for proper operation. If **not** operating properly, follow the troubleshooting procedures in this section.



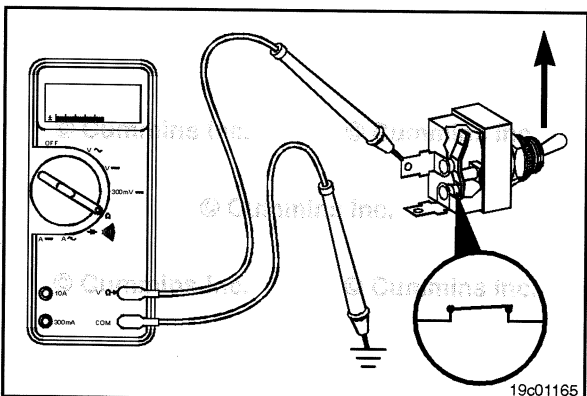
Locate the fan control switch. Label the wires with the location of the switch or the wire number. Remove the electrical connectors from the switch. Adjust the multimeter to measure resistance. Touch one multimeter probe to one of the terminals on the switch. Touch the other multimeter probe to the other 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.



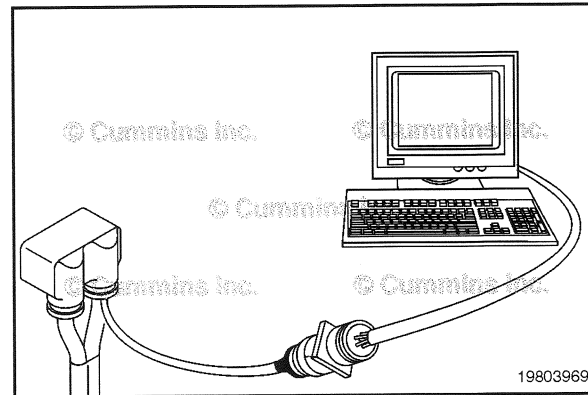
## Fan Control Switch Circuit (019-381)

### Resistance Check

#### ⚠CAUTION⚠

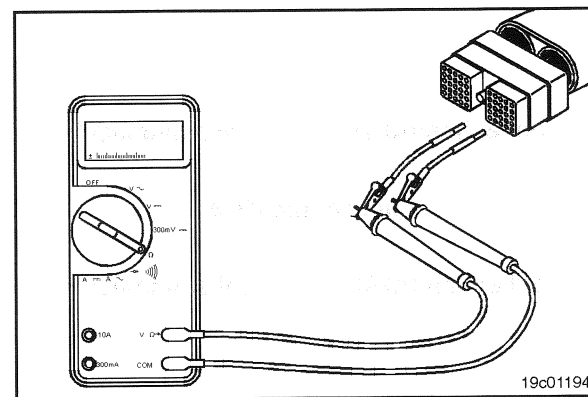
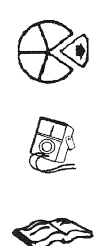
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If INSITE™ electronic service tool is available, monitor the fan control switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



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Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). 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.

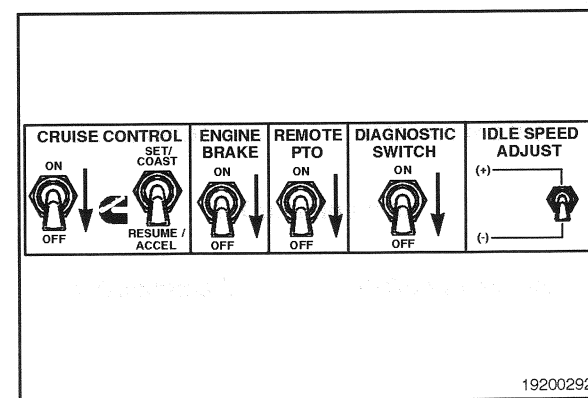


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Move the fan control switch to the OFF position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the fan control switch, switch return wire, and the fan control switch signal wire for an open 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.

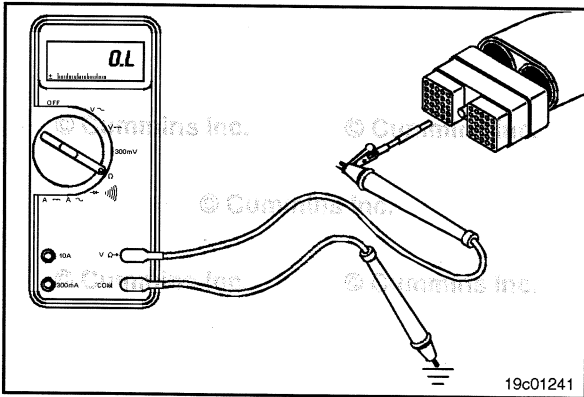
### Check for Short Circuit to Ground

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.



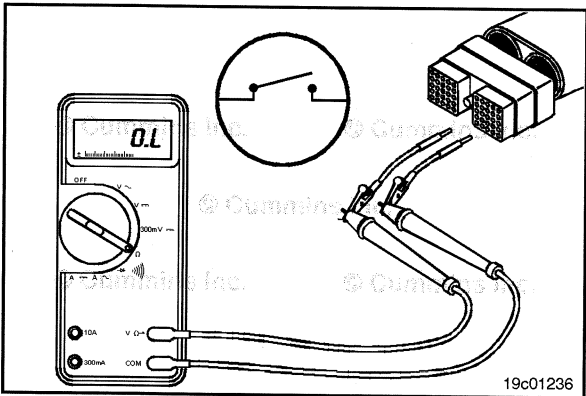
19200292





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.

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.

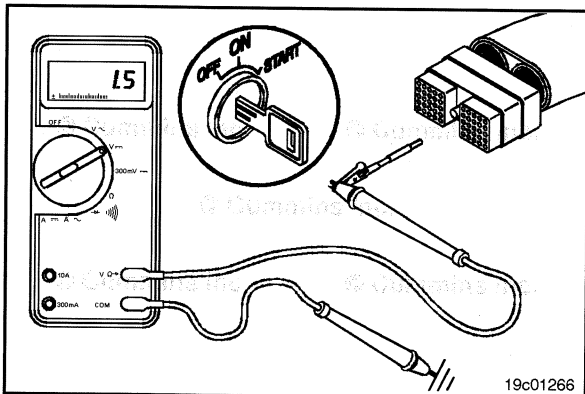


### Check for Short Circuit from Pin to Pin



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

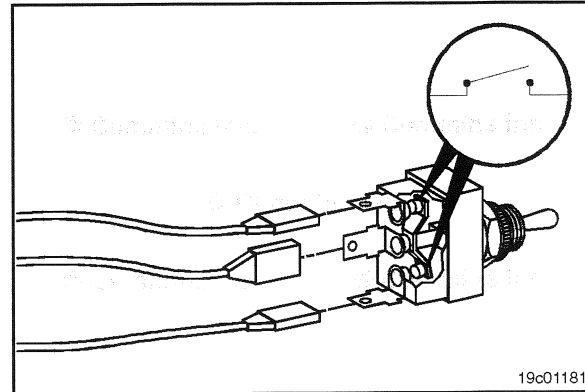
Turn the keyswitch to the ON position. Set the fan control switch to OFF. Adjust the multimeter to measure VDC. Insert a test lead into the fan control switch signal pin and attach it to a multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the voltage. The voltage **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.



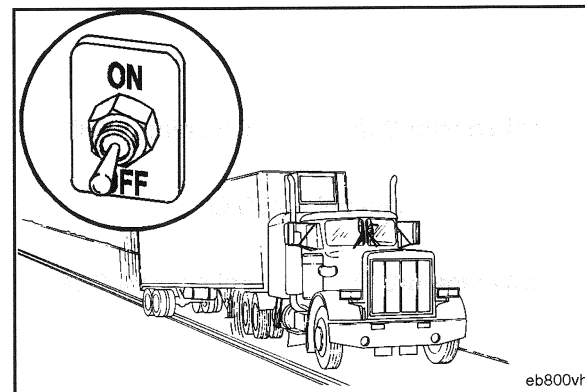
19c01181

## Maximum Engine Speed Switch (019-382)

### General Information

The maximum engine speed switch is an 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 may need to be protected from an overspeed condition. The operator may toggle this switch and limit the maximum engine RPM to a lower value that is safe for the hydraulic system to operate in.

**NOTE:** The switch is now programmable, meaning the speed limit and normal positions can either be open or closed depending on the configuration. Confirm which configuration the specific switch is and adjust the troubleshooting failure criteria before deeming the switch failed.



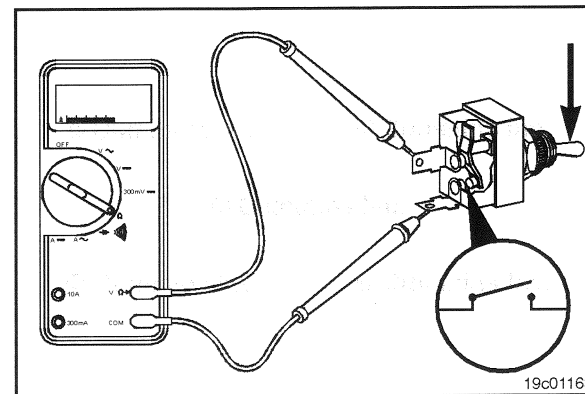
eb800vh

### Resistance Check

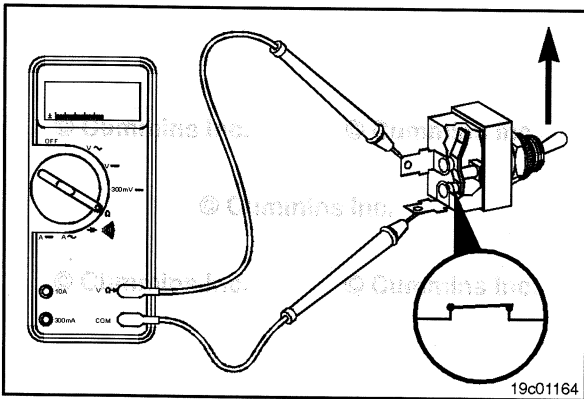
If INSITE™ is available, monitor the maximum engine speed switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate the maximum engine speed switch. Label the wires with the location 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.

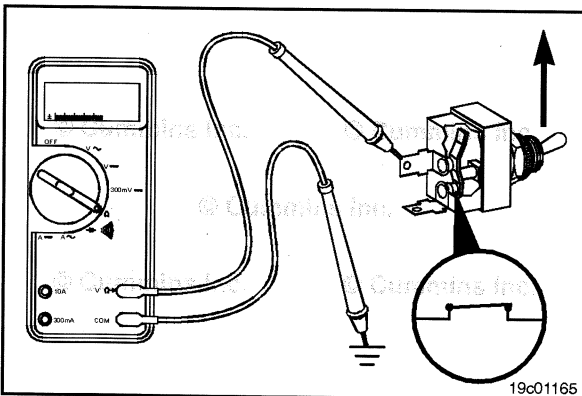
Place the switch in the open position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.



19c0116c

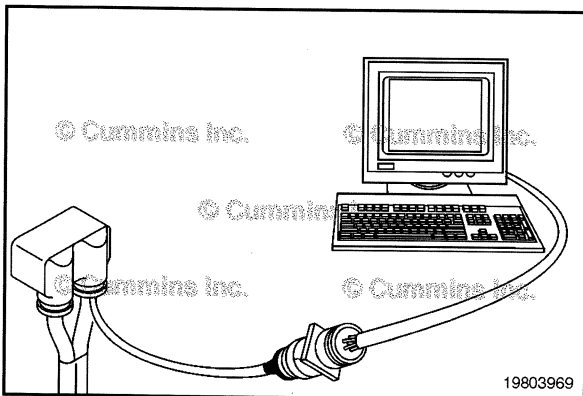


Place the switch in the closed position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the resistance value is correct, 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 closed 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.



### Maximum Engine Speed Switch Circuit (019-383)

#### Resistance Check

#### ⚠CAUTION⚠

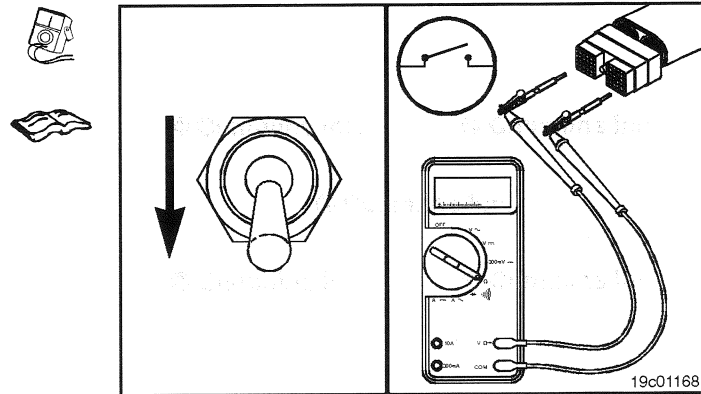
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If INSITE™ 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 connector from the electronic control module (ECM). 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.

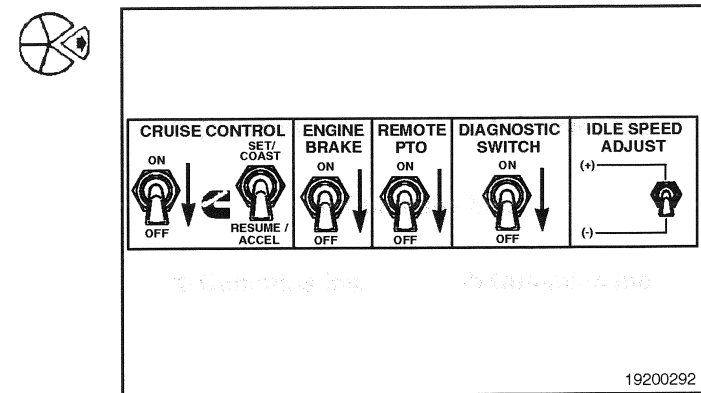
**NOTE:** The maximum engine speed switch is programmed by the OEM. The open or closed position of the switch can represent "Normal" or "Speed Limit" depending on how the OEM programs the switch. Before continuing to troubleshoot refer to the OEM troubleshooting and repair manual to determine how the 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

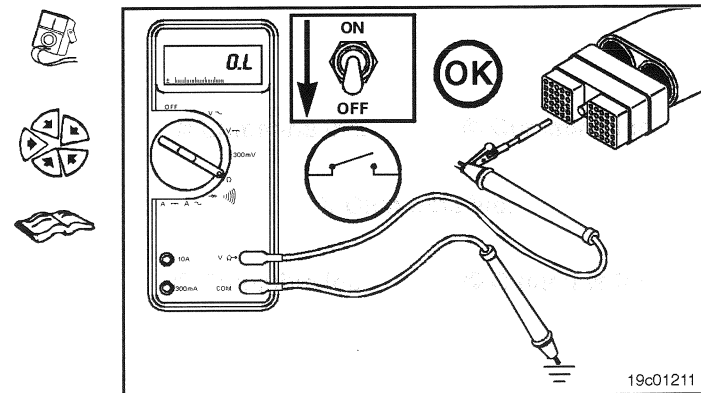
To isolate the maximum engine speed switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM and the OEM harness from the maximum engine speed switch. Disconnect the clutch pedal position switch/engine protection override switch and the accelerator pedal assembly switch. Set all cab panel switches to the OFF or neutral position. Set the service brake using the trailer brake hand valve.

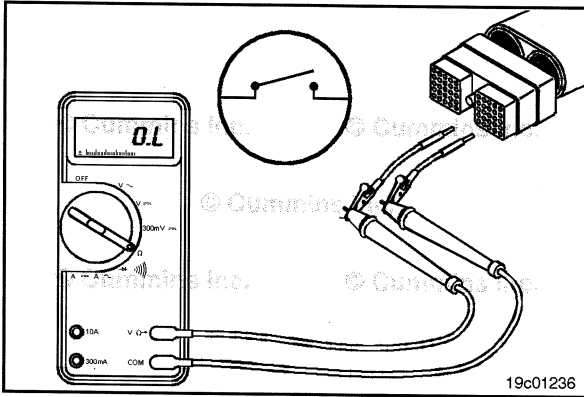


Adjust the multimeter to measure resistance. Insert a test lead into the maximum engine speed switch signal pin of the OEM harness connector and connect it to a multimeter probe. Touch the other multimeter probe to the engine block ground.

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.



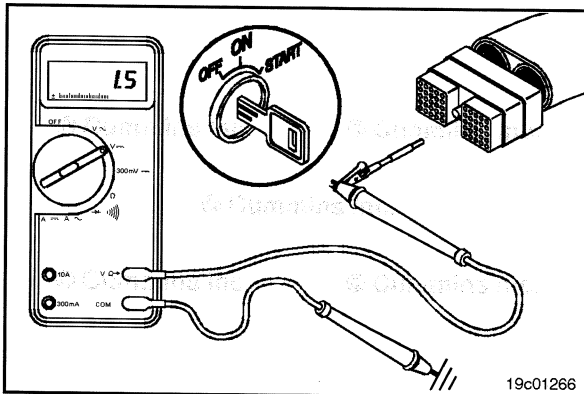


### Check for Short Circuit from Pin to Pin

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).

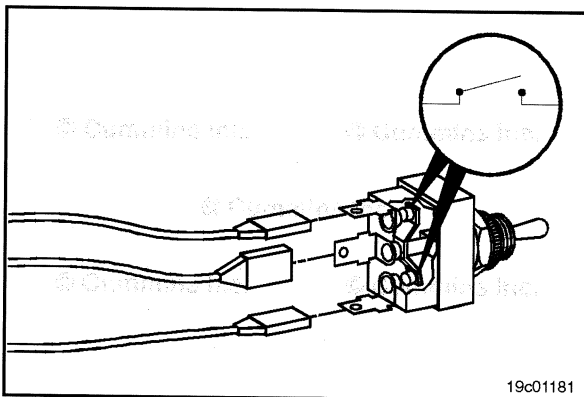
Remove the lead from the maximum engine speed switch signal pin and check all other pins. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit between the manual fan switch circuit and any pin that shows a closed circuit, provided the switch has previously been checked.

Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



### 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.

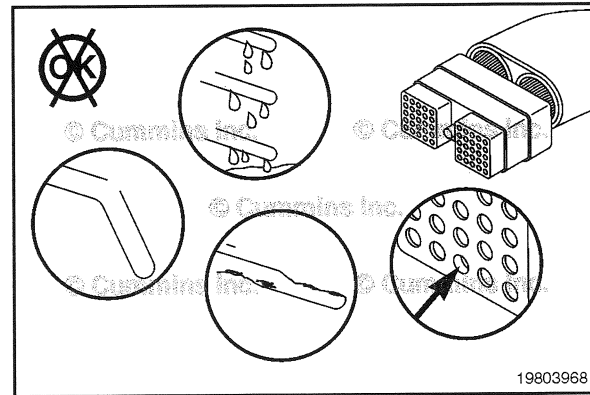
## Intake Air Heater Control Relay Circuit (019-408)

### Initial Check

Disconnect the intake air heater control relay from the OEM harness.

Disconnect the OEM harness connector from the ECM connector.

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.



### 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 connector from the ECM 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.

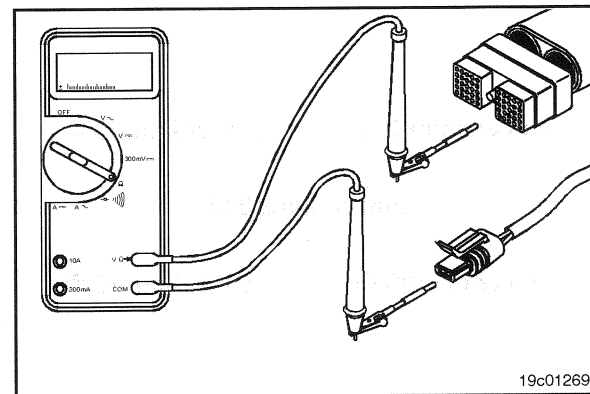
The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

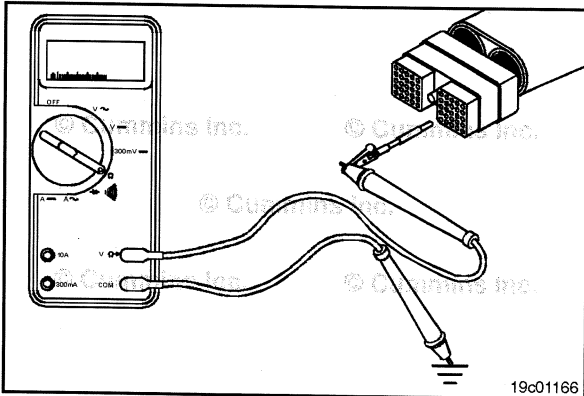
If the measured value is more than 10 ohms, there is an open circuit in the signal wire. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

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 connector from the ECM 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.

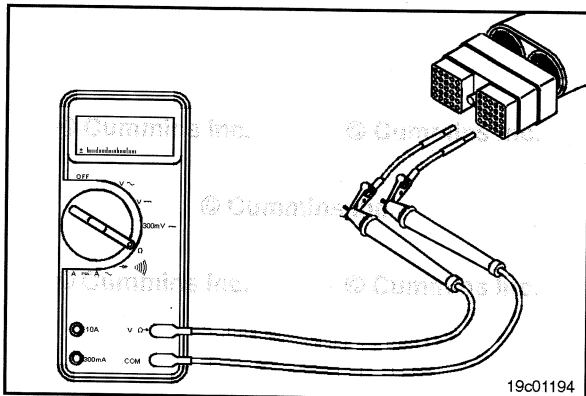
The multimeter **must** show a measurement of 100k ohms or more (open circuit).

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 connector from the ECM 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.

### Check for Short Circuit to External Voltage Source

Disconnect the OEM harness connector from the ECM connector. Disconnect the intake air heater control relay from the OEM harness.

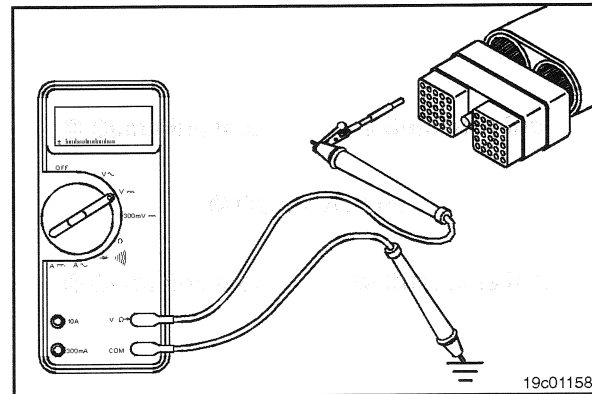
Set the multimeter to measure VDC. Turn the keyswitch to the ON position.

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.



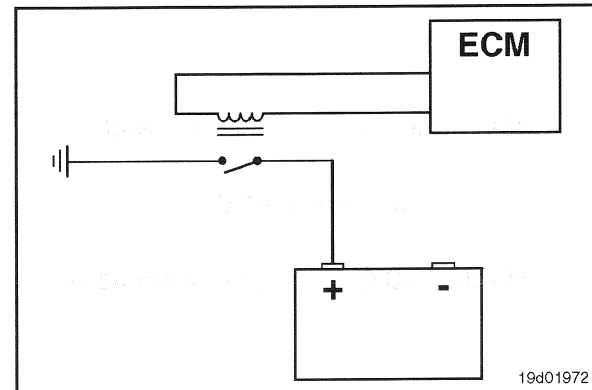
### Starter Lockout/Switched Outputs Relay Circuit (019-419)



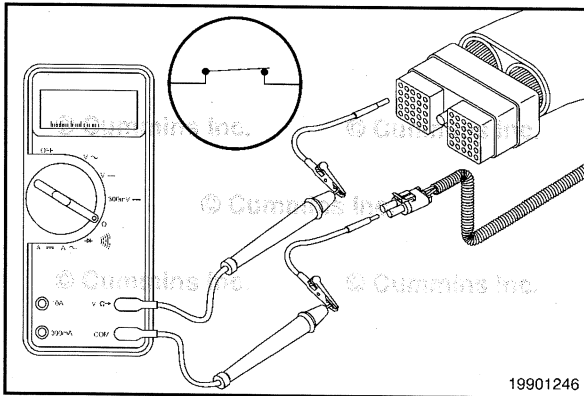
#### General Information

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 OEM harness connector from the ECM connector. 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

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 connector from the ECM connector.

Set the multimeter to measure resistance.

Disconnect the starter lockout or OEM relay from the OEM harness.

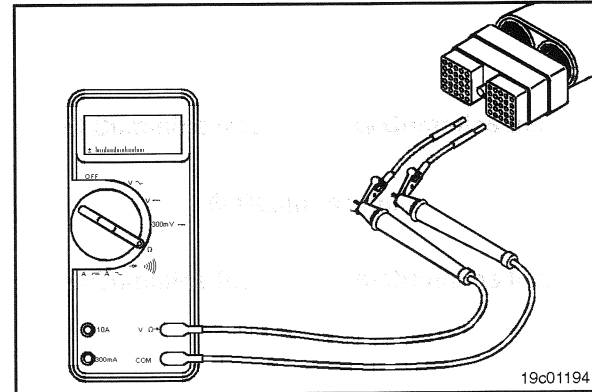
Insert a test lead into the signal pin of the OEM harness connector, and connect the alligator clip to a multimeter probe. Insert the second test lead to the first pin in the OEM harness connector, and connect the alligator clip to the other multimeter probe.

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.

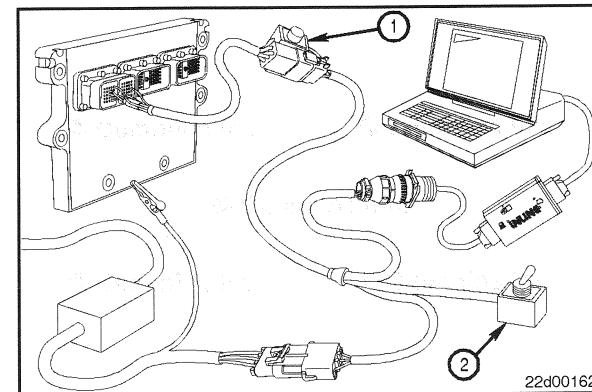


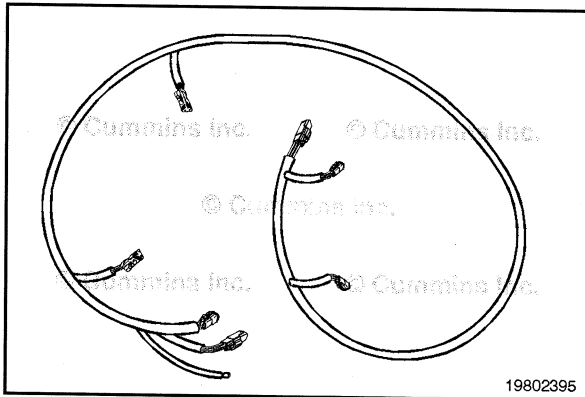
## Engine Control Module ROM Boot (019-427)

### 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.
- Calibrate the ECM. Refer to Procedure 019-032 in Section 19.
- Remove the ROM boot cable from the ECM.





## 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.

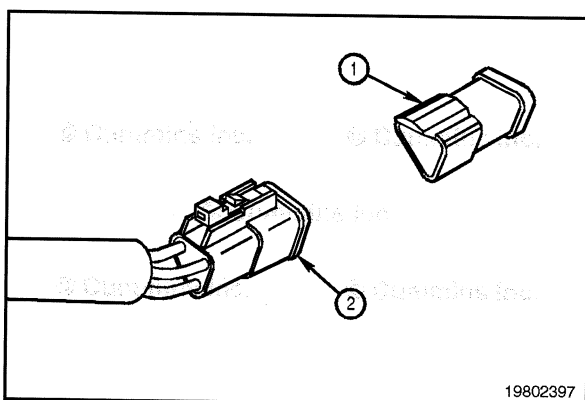
#### SAE J1939 Backbone Harness Overview:

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.

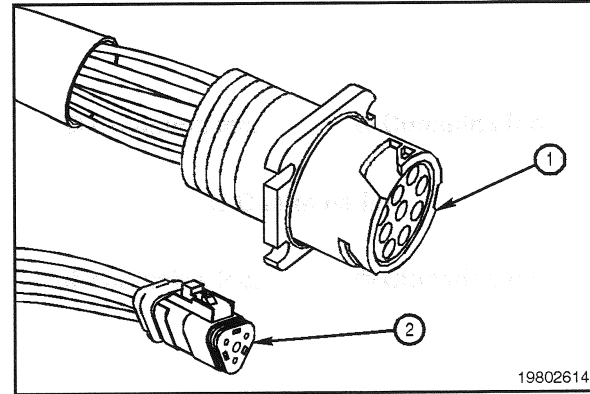
The terminating resistor caps (1) **must** be in place on the OEM backbone harness plugs (2) to maintain proper communication. Each resistor is 120 ohms and is located in a removable cap. This resistance is required when communicating with INSITE™ electronic service tool over the J1939 data link.



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.

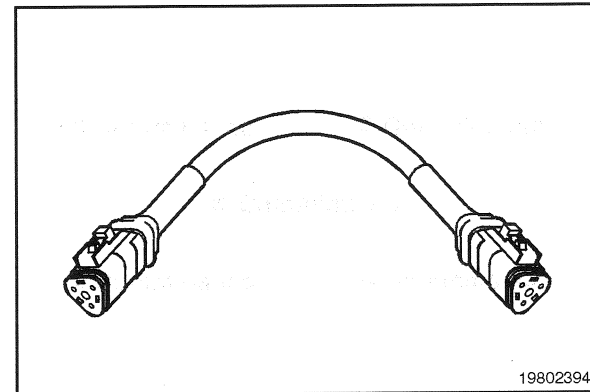
To check for the J1939 backbone, turn the keyswitch to the OFF position. Measure the resistance from the SAE J1939 data link positive (+) pin to the SAE J1939 data link negative (-) pin of the 3-pin Deutsch™ connector.

The multimeter will show 60 ohms when the engine harness has provided a backbone on the data link bus.



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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.

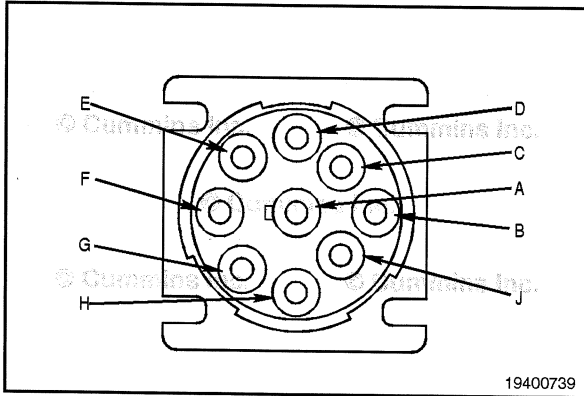


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Engine Data Link Connectors

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.

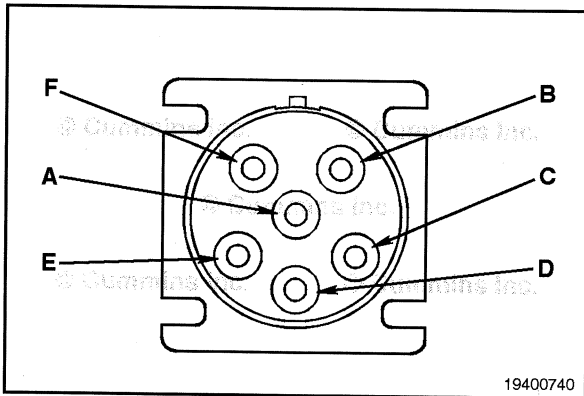
Connector Type	Data Link Protocols Supported
2-pin Weather Pack™	J1587/J1708
3-pin Deutsch™	J1939
6-pin Deutsch™	J1587/J1708
9-pin Deutsch™	J1587/J1708, J1939



Each connector type is described in more detail in the following information.

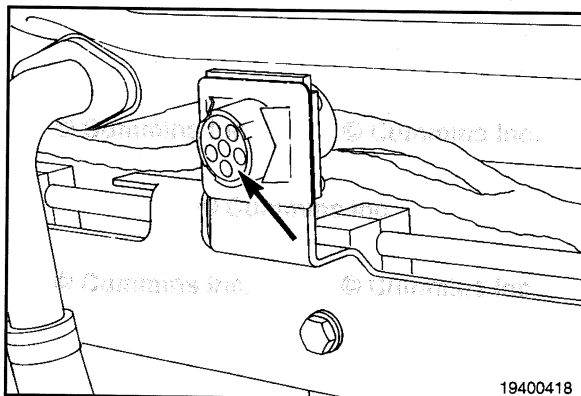
The 9-pin Deutsch™ connector, Part Number 3824018, connector can supply SAE J1587/SAE 1708 and SAE J1939 communications, and battery voltage. The following are pin-outs for the 9-pin connector:

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 6-pin Deutsch™ connector, Part Number 3824805, is found on some engines. This connector supplies SAE J1587/J1708, as well as the battery voltage. The following are pin-outs for the 6-pin connector:

Pin	Signal
A	J1708 data link (+)
B	J1708 data link (-)
C	Unswitched battery (+)
D	Open
E	Ground
F	Open



**NOTE:** For SELECT Plus™ engines, do **not** use the in-cab 6-pin data link connector to calibrate the ECM. Use the data link connector found on the engine.

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.

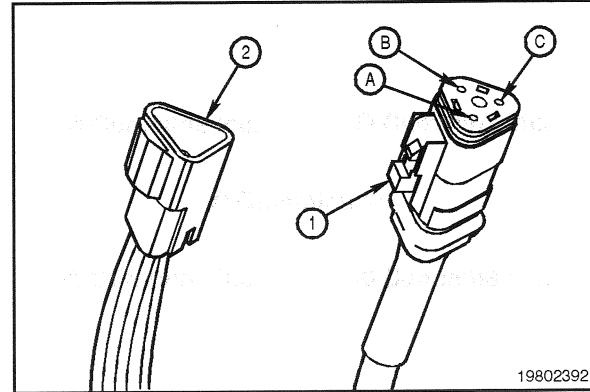
**NOTE:** If there is 60 ohm resistance measured between pins A and B of the 3-pin connector, a backbone is on the data link.

The 2-pin connector is on many older engines, and **only** supplies SAE J1587/J1708 support (no battery voltage supply). The following are the pin-outs for the 2-pin connector:

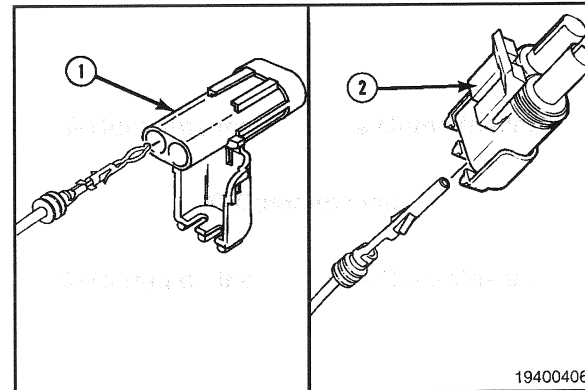
Pin	Signal
A	J1587/J1708 data link (+)
B	J1587/1708 data link (-)

Some engines have a 2-pin service tool power supply Weather Pack™ receptacle located in the engine harness. It can be used to power up any service tool device.

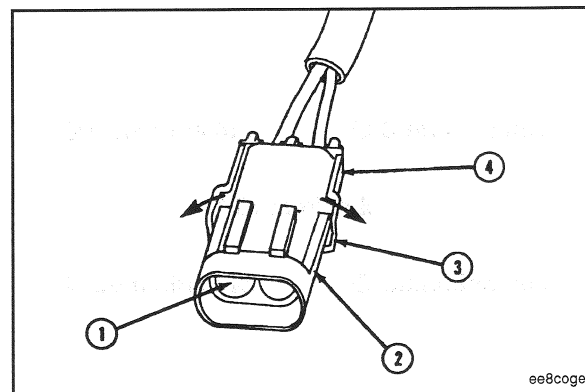
Pin	Signal
A	Unswitched battery (+)
B	Ground (-)



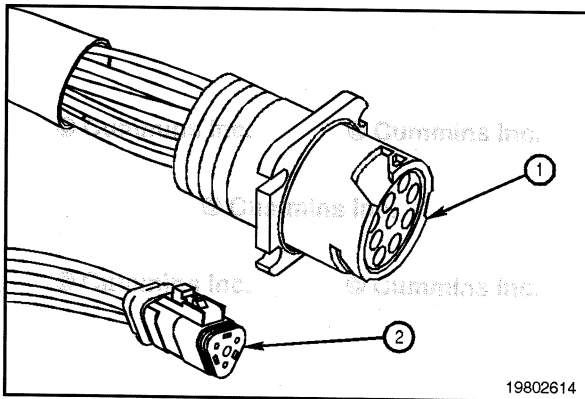
19802392



19400406



ee8coge



## 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 ⚠

For the J1939 engine data link, use test lead, Part Number 3822758, 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.

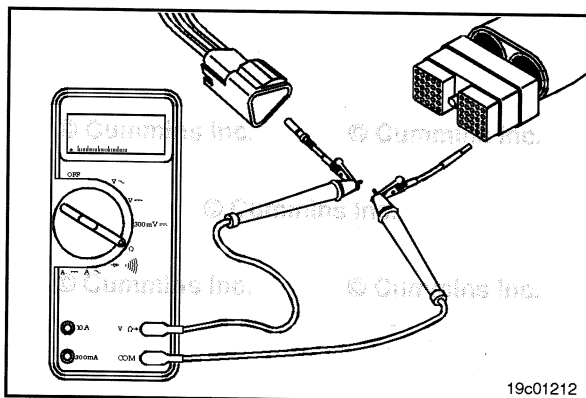
### ⚠ CAUTION ⚠

For the J1587/J1708 engine data link, use test lead, Part Number 3622758, on the ECM connector to reduce the possibility of damage to the connector pins. Use test lead 3824800 for the 6-pin Deutsch™ connector. Use test lead 3823995 for the 2-pin Packard™ 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.

### J1939 Engine Data Link

- Disconnect the batteries.
- Disconnect the engine harness connector from the ECM. Turn the keyswitch to the OFF position.



Insert a test lead into the SAE J1939 data link positive (+) pin of the engine harness ECM connector, and connect it to the multimeter probe. 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.

Insert the multimeter lead into the SAE J1939 data link negative (-) of the engine harness ECM connector. 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.

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 data link negative (-) pin of the engine harness ECM connector and insert it into the SAE J1939 data link (shield) pin. Touch the negative multimeter lead to the SAE J1939 data link (shield) 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 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.

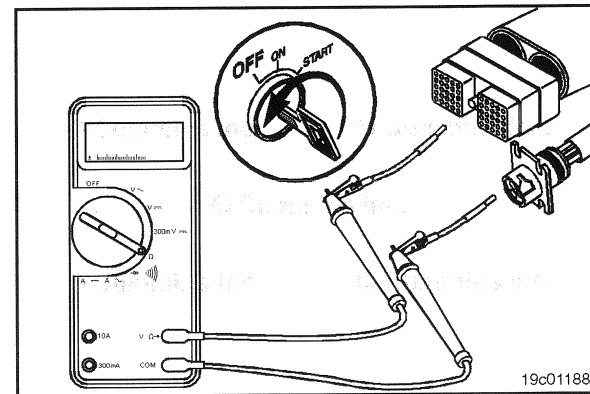
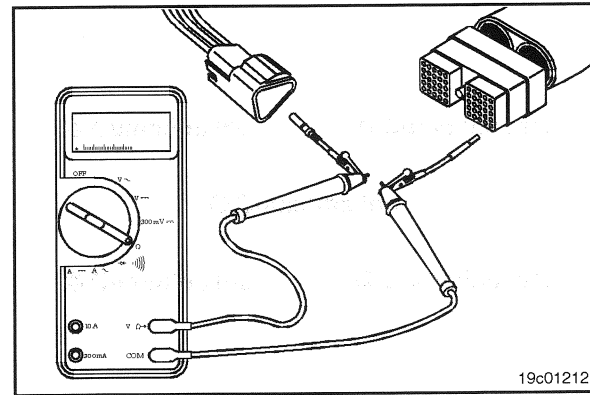
#### J1587/J1708 Engine Data Link

Turn the keyswitch to the OFF position. Disconnect the engine harness from the ECM.

Insert a test lead into the SAE J1587 data link positive (+) pin of the engine harness ECM connector and connect it to a multimeter probe. Insert the other test lead into the SAE J1587 data link positive (+) pin of the 2-pin or 6-pin connector and connect it to the other multimeter probe. 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.





Remove the test lead from the SAE J1587 data link positive (+) pin and insert it into the SAE J1587 data link negative (-) pin of the ECM connector. Remove the other test lead from the SAE J1587 data link positive (+) pin and insert it into the SAE J1587 data link negative (-) pin of the 2-pin or 6-pin connector. Measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).

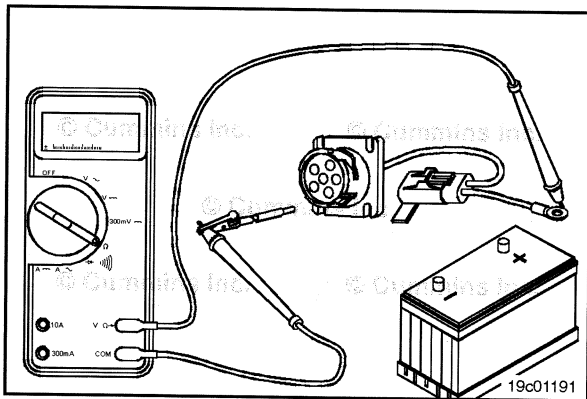
If the circuit is **not** closed, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.

Remove the test lead from the SAE J1587 data link negative (-) pin and insert it into the battery negative (-) pin of the 6-pin Deutsch™ connector. Remove the test lead from the SAE J1587 data link negative (-) pin of the engine connector and disconnect it from the multimeter probe. Touch the multimeter probe to the engine block ground. Measure the resistance. The multimeter should 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.



**▲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▲**

Use test lead, Part Number 3824811, for the 6-pin Deutsch™ connector.

Disconnect the batteries.

Measure the resistance from the positive (+) battery terminal to battery positive (+) of the 6-pin Deutsch™ connector. 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.

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

### ⚠ CAUTION ⚠

For the J1939 engine data link, use test lead, Part Number 3822758, on the ECM connector to avoid damage to the connector pins.

### ⚠ CAUTION ⚠

For the J1587/J1708 engine data link, use test lead, Part Number 3822758, on the ECM connector to avoid damage to the connector pins.

Determine the type of engine data link available on the engine, either J1939 or J1587/J1708. Follow the instructions provided for short circuit to ground check for the type of engine data link identified.

#### J1939 Engine Data Link

Disconnect the engine harness connector from the ECM. Insert a test lead into SAE J1939 data link positive (+) pin of the engine harness ECM connector and connect 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, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.

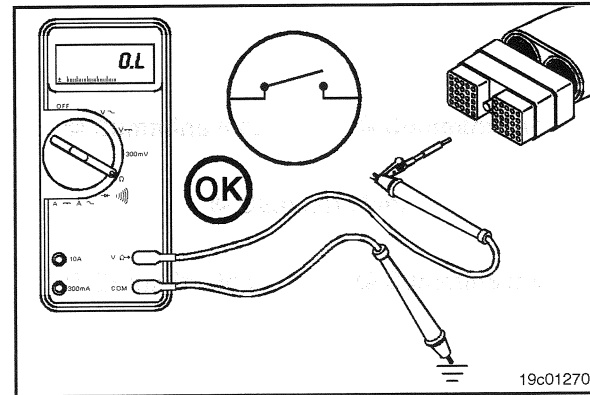
Remove the test lead from the SAE J1939 data link positive (+) pin and insert it into the SAE J1939 data link negative (-) pin of the ECM connector. Measure the resistance from the SAE J1939 data link negative (-) pin of the engine harness ECM connector to the engine block ground. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, repair or replace the engine harness.

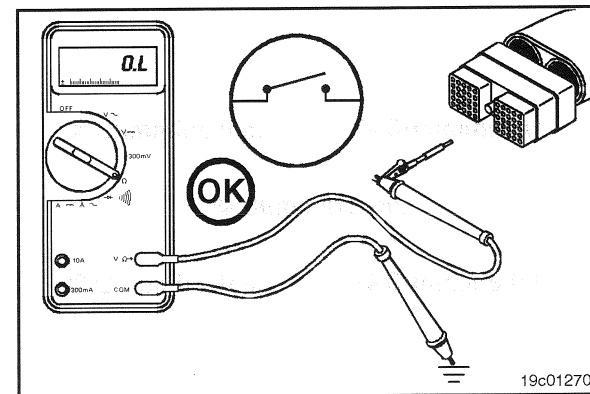
See the Troubleshooting and Repair manual for additional information.

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.

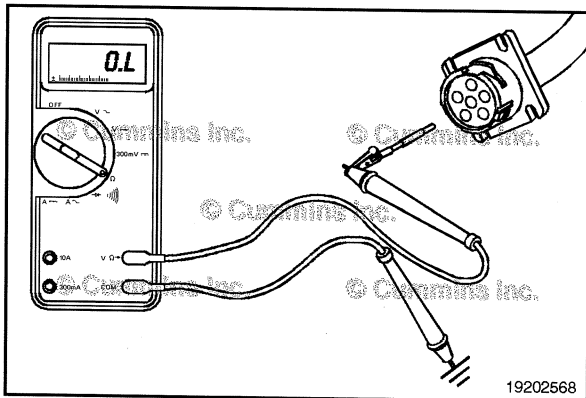
See the Troubleshooting and Repair manual for additional information.



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19c01270



### J1587/J1708 Engine Data Link

Disconnect the engine harness connector from the ECM.

Insert a test lead into the SAE J1587 data link positive (+) pin of the engine harness ECM 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, repair or replace the engine harness.

See the Troubleshooting and Repair manual for additional information.

Remove the test lead from the SAE J1587 data link positive (+) pin and insert it into the SAE J1587 data link negative (-) pin of the engine harness ECM connector. Touch the other multimeter probe to the engine block ground. Measure the resistance from the SAE J1587 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.

### 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.

#### ⚠CAUTION⚠

For the J1587/J1708 engine data link, use test lead, Part Number 3822758, on the ECM connector to avoid damage to the connector pins.

### J1939 Engine Data Link

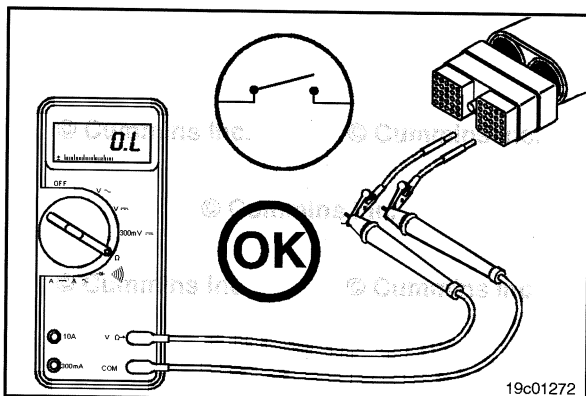
Disconnect the engine harness connector from the ECM.

Insert a test lead into the SAE J1939 data link positive (+) pin of the engine harness ECM connector and connect it to the multimeter probe. Insert the other test lead into another pin in the connector of the engine harness ECM connector and connect it to the other multimeter probe.

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.



Remove the lead from the first pin in the connector and 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. 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.

Remove the test lead from the J1939 data link positive (+) pin and insert it into the J1939 data link (shield) pin of the engine harness ECM 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 engine harness.

See the Troubleshooting and Repair manual for additional information.

Measure the resistance from the SAE J1939 data link (shield) pin 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 engine harness.

See the Troubleshooting and Repair manual for additional information.

Remove the test lead from the SAE J1939 data link (shield) pin and insert it into the SAE J1939 data link negative (-) pin of the engine harness ECM 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 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. 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.

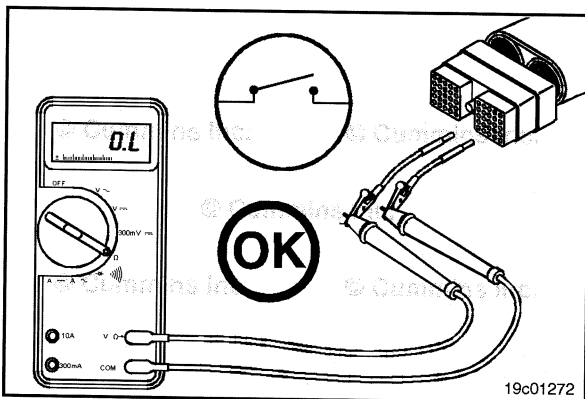
### J1587/J1708 Engine Data Link

Disconnect the engine harness connector from the ECM.

Insert a test lead into the SAE J1587 data link positive (+) pin of the engine harness ECM connector and connect it to the multimeter probe. Insert the other test lead into another multimeter probe. 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.



Remove the lead from the first pin in the connector and test all other pins in the connector. Measure the resistance from the SAE J1587 data link positive (+) pin of the engine harness ECM connector to all other pins in the connector, one at a time. The multimeter **must** show an open circuit (100k ohms or more).

Remove the test lead from the SAE J1587 data link positive (+) pin of the engine harness ECM connector and insert it into the SAE J1587 data link negative (-) pin.

Measure the resistance from the SAE J1587 data link negative (-) pin to 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, repair or replace the engine harness.

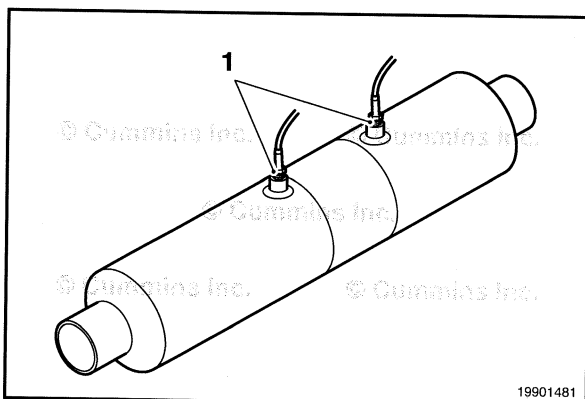
See the Troubleshooting and Repair manual for additional information.

## Aftertreatment Exhaust Gas Temperature Sensor (019-449) General Information

The exhaust gas temperature sensors (1) are located in the exhaust muffler, on either side of the catalyst brick.

The temperature sensors are part of the aftertreatment system and are used to monitor the catalyst inlet and outlet temperatures.

**NOTE:** Some SCR catalysts will contain two temperature sensors and other applications will **only** contain one temperature sensor. Refer to Procedure 011-999 in Section 11.



## Remove

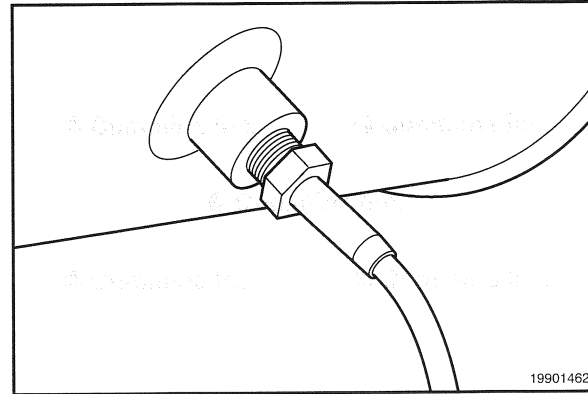
### ⚠ CAUTION ⚠

The exhaust catalyst will stay hot to touch for long periods of time after the engine has been turned off.

Lift up on the locking tab and pull the electrical connectors apart.

Disconnect the exhaust gas temperature sensor from OEM wiring harness.

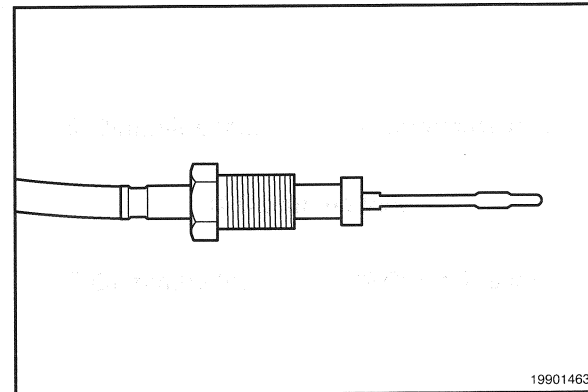
Loosen the retaining nut and remove the exhaust gas temperature sensor from the exhaust catalyst.



## Clean and Inspect for Reuse

Inspect the exhaust gas temperature sensors for damage to the wiring or the body.

Inspect the tip of the exhaust gas temperature sensor for damage and carbon buildup.



## Install

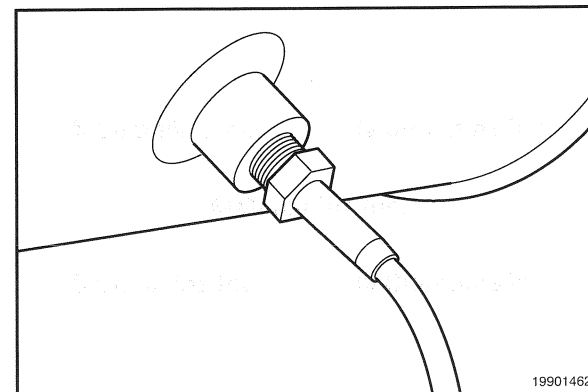
Apply anti-seize compound to the sensor threads of the exhaust gas temperature sensor.

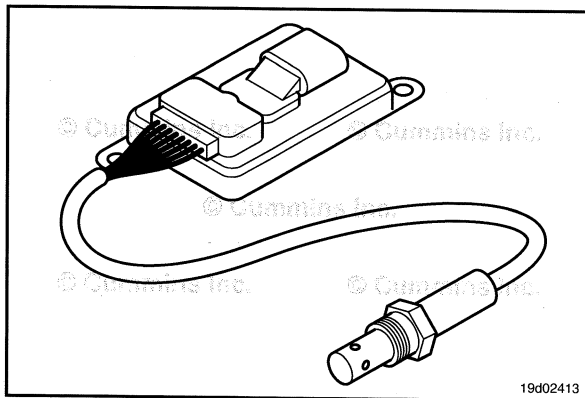
Make sure the exhaust gas temperature sensors are connected in the correct position on the OEM wiring harness. Swapped inlet and outlet temperature sensors will result in active fault codes.

Push the sensor and sensor harness connectors together until they lock.

Tighten the nut that secures the sensor to the aftertreatment system.

**Torque Value:** 30 N•m [ 22 ft-lb ]





## Aftertreatment Outlet NOx Sensor (019-451)

### General Information

#### ⚠ WARNING ⚠

The aftertreatment system will stay hot to the 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.

#### ⚠ WARNING ⚠

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 ON.

#### ⚠ WARNING ⚠

Wear goggles and protective clothing to reduce the possibility of personal injury.

#### ⚠ CAUTION ⚠

Do not underseal or coat/paint any part of the NOx sensor.

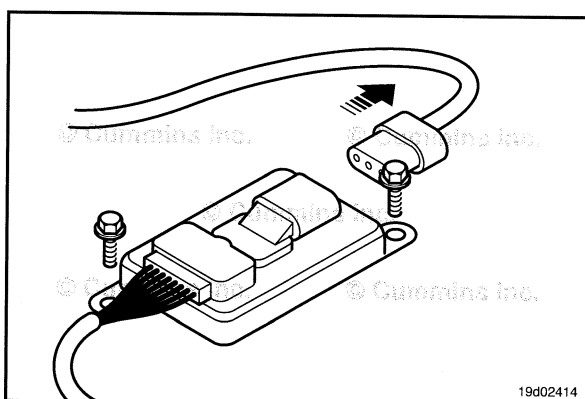
The aftertreatment outlet NOx sensor is located after the aftertreatment selective catalytic reduction (SCR) catalyst.

The aftertreatment outlet NOx sensor is made up of two parts: a small electronic module with a wired connection to the sensor body that is installed in the exhaust system. The two parts are permanently connected and can not be separated.

The aftertreatment outlet NOx sensor is available in both 12 volt and 24 volt configurations. The electronic module for the 24 volt version is larger than the module for the 12 volt version. The original equipment manufacturer (OEM) wiring harness connector on the aftertreatment outlet NOx sensor is **always** black in color.

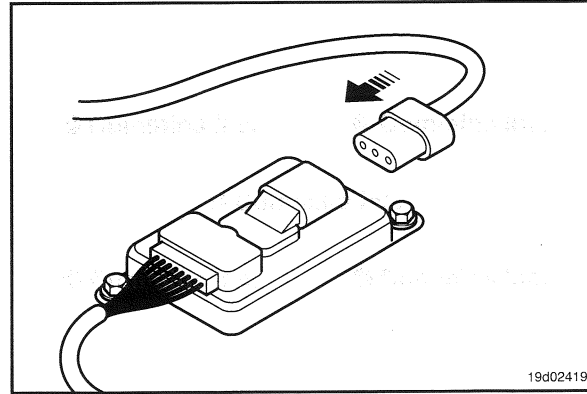
### Test

Unplug the NOx sensor from the vehicle harness.

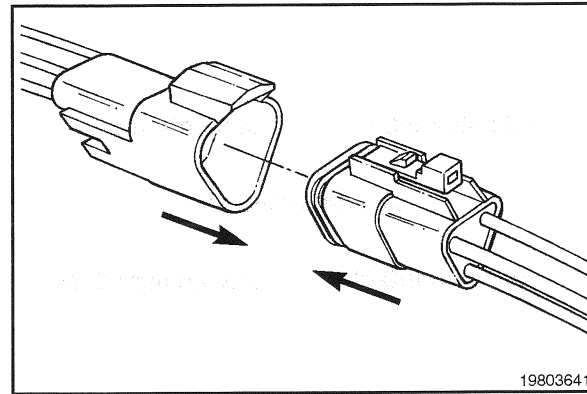


**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

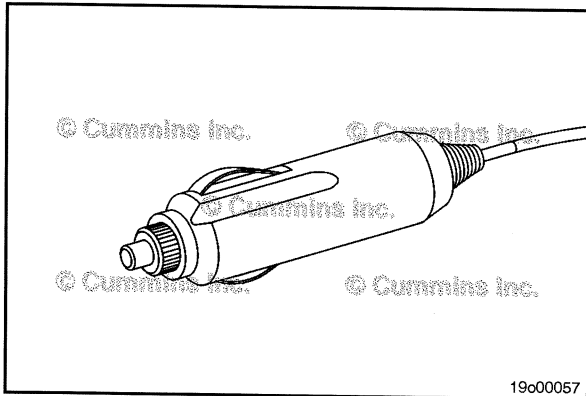
Connect the service tool, Cummins® Part Number 2892467, to the NOx sensor module.



Connect the service tool data link (3-pin Deutsch™) to the engine 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, Cummins® 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].

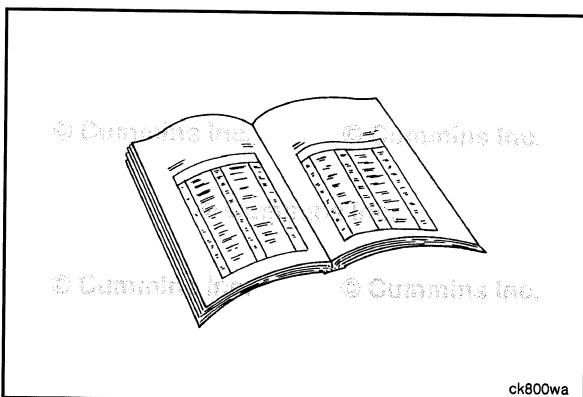
For Fault Codes 2771 and 3232, the following conditions **must** be met before checking the status of the active fault code.

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, Cummins® Part Number 3823955, will need to be used to provide power from the vehicle battery supply.

Check 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▲

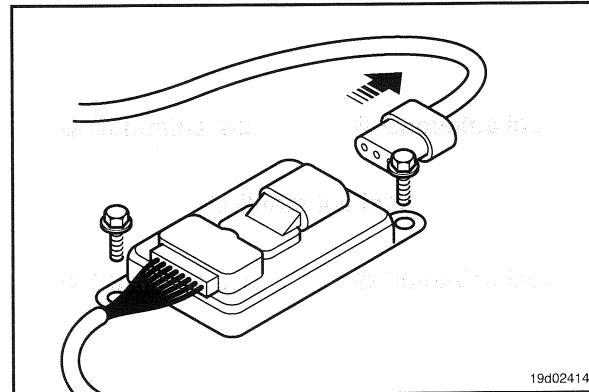
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Disconnect the batteries. See equipment manufacturer service information.

### Remove

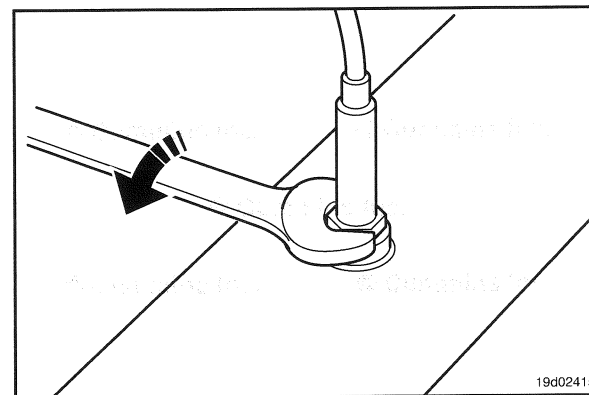
Disconnect the aftertreatment outlet NOx sensor from the OEM harness.

Remove the two retaining capscrews.



19d02414

Loosen the retaining nut and remove the aftertreatment outlet NOx sensor from the exhaust.



19d02415

### Clean and Inspect for Reuse

#### ⚠ CAUTION ⚠

Do not clean the NOx sensor with any kind of fluid.

#### ⚠ CAUTION ⚠

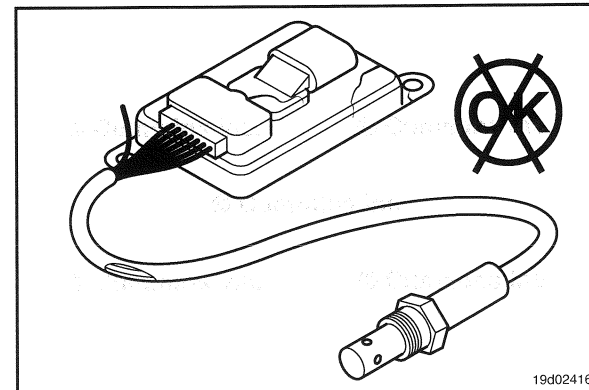
Do not immerse the NOx sensor in water or any kind of chemical wash.

#### ⚠ CAUTION ⚠

Do not jet-wash or steam clean the NOx sensor.

Inspect the NOx sensor for damage to the wiring or to the body of the sensor.

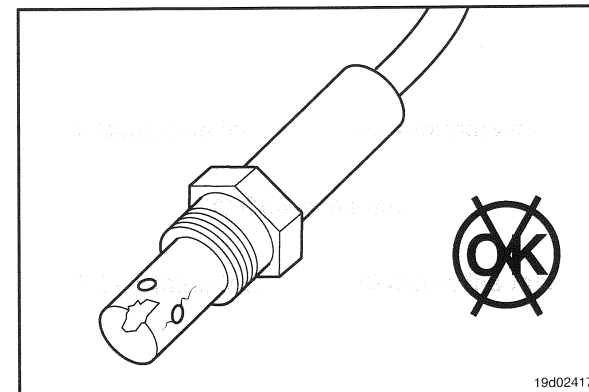
Replace the aftertreatment outlet NOx sensor if any damage is found.



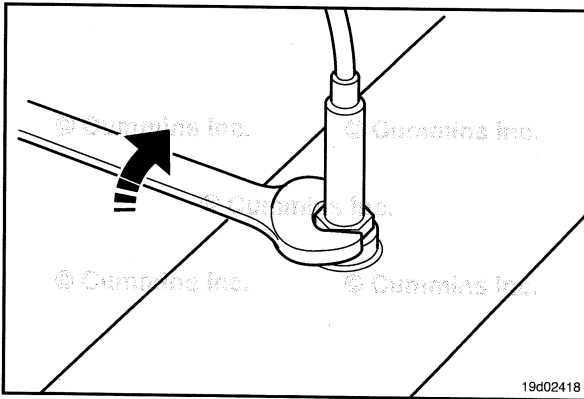
19d02416

Inspect the tip of the NOx sensor for damage.

Replace the aftertreatment outlet NOx sensor if any damage is found.



19d02417



### Install

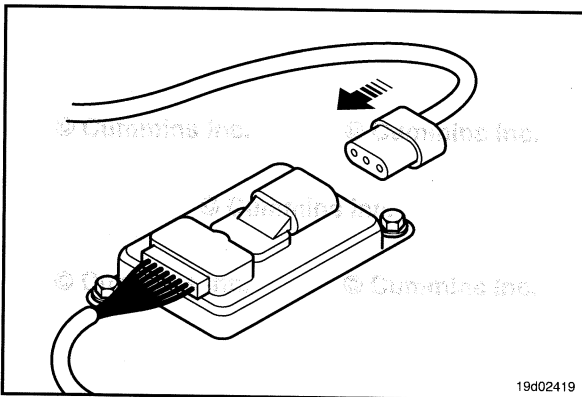
Apply a light coating of anti-seize compound, Cummins® Part Number 3824879, to the threads of the NOx sensor.



Install the NOx sensor to the exhaust system and tighten the retaining nut.



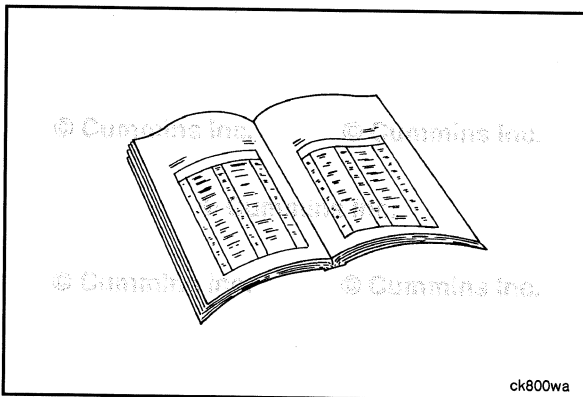
**Torque Value:** 50 N•m [ 37 ft-lb ]



Connect the aftertreatment outlet NOx sensor to the OEM wiring harness.



Install the retaining cap screws. 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.

- Connect the batteries. See equipment manufacturer service information.

## Aftertreatment Intake NOx Sensor (019-463)

### 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. 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.

#### ⚠ WARNING ⚠

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

#### ⚠ CAUTION ⚠

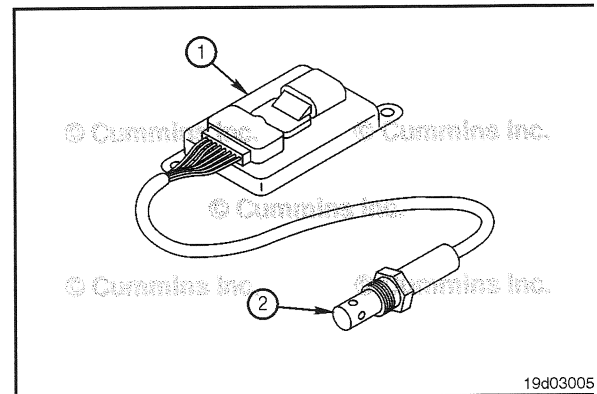
Do not underseal or coat/paint any part of the NOx sensor. Doing so can result in sensor damage.

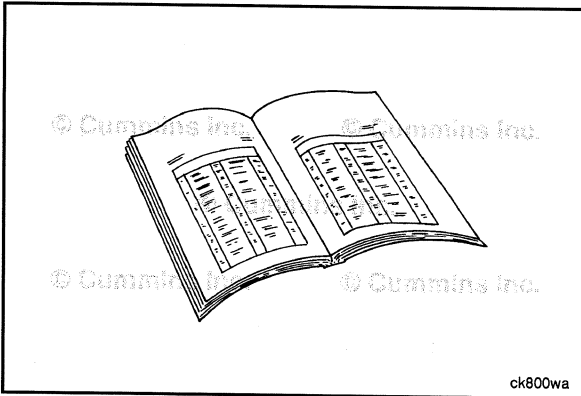
The aftertreatment intake nitrogen oxides (NOx) sensor is located after the turbocharger, and is mounted to the selective catalytic reduction (SCR) inlet just before the diesel exhaust fluid (DEF) dosing valve.

The aftertreatment intake NOx sensor is made up of two parts: (1) a small electronic module with a wired connection to the (2) sensor body that is installed in the exhaust system. These two parts are permanently connected and can **not** be separated.

The aftertreatment intake NOx sensor is available in both 12-volt and 24-volt configurations. The electronic module for the 24-volt version is larger than the module on the 12-volt version.

Due to the number of different sensor mounting locations, this procedure has been written to be generic. The Remove and Install sections of this procedure are common regardless of the intake NOx sensor mounting configuration.





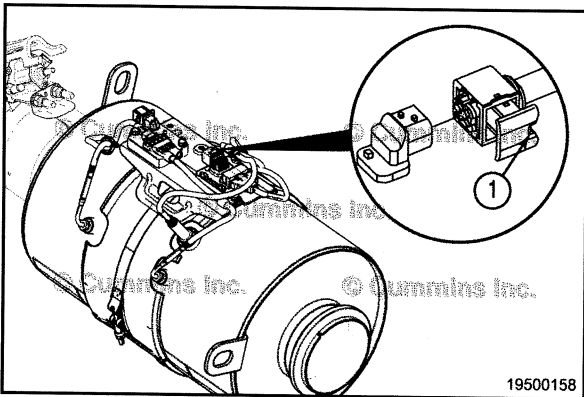
### Preparatory Steps

#### ⚠ WARNING ⚠



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

- Disconnect the battery cables. See equipment manufacturer service information.



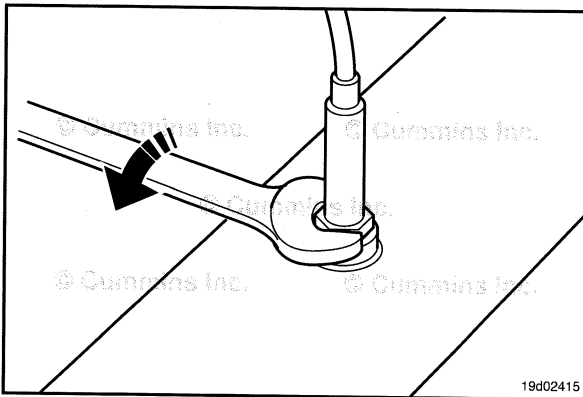
### Remove

Disconnect the aftertreatment intake NOx sensor from the aftertreatment interface harness.

To assist in removing the connector, a small screwdriver can be inserted into the top notch (1) on the locking slide for leverage as the locking slide is pulled out by hand.

If the locking slide does **not** move freely, clean the connector using contact cleaner to free it of debris.

Remove the two retaining capscrews.



Loosen the retaining nut and remove the aftertreatment outlet NOx sensor from the exhaust system.

### Clean and Inspect for Reuse

#### ⚠ CAUTION ⚠

Do not clean the NOx sensor with any kind of fluid. Damage to the sensor can occur.

#### ⚠ CAUTION ⚠

Do not immerse the NOx sensor in water or any kind of chemical wash. Damage to the sensor can occur.

#### ⚠ CAUTION ⚠

Do not jet wash or steam clean the NOx sensor. Damage to the sensor can occur.

Inspect the NOx sensor for damage to the wiring or to the body of the sensor.

Inspect the electrical connector pins in the sensor for signs of corrosion.

Replace the aftertreatment intake NOx sensor if any damage is found.

**NOTE:** It is **not** uncommon to have soot on the tip of the sensor. Do **not** try to clean the intake NOx sensor tip unless directed by fault codes or other troubleshooting symptoms.

Inspect the tip of the NOx sensor for damage.

Replace the NOx sensor if any damage is found.

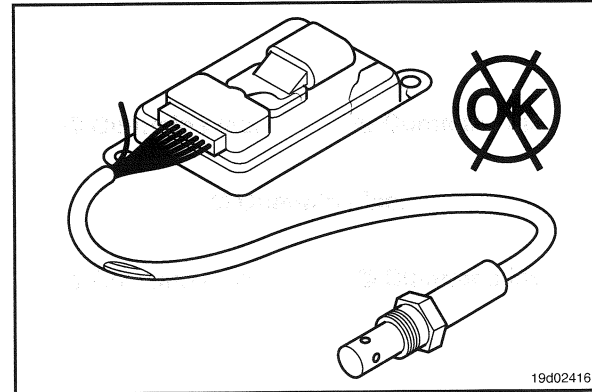
Inspect the NOx sensor for oil spray on the tip of the sensor. Refer to Procedure 010-033 in Section 10.

### Install

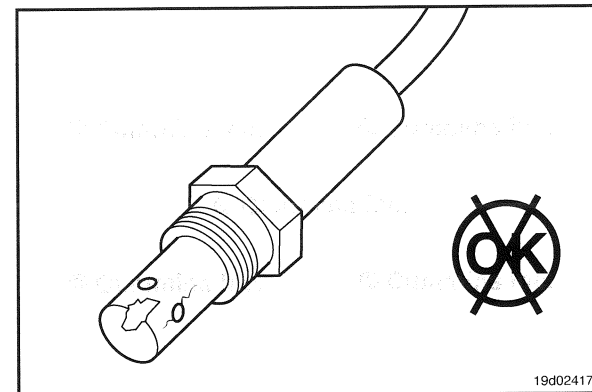
Apply a light coating of anti-seize compound, Cummins® Part Number 3824879, or equivalent, to the threads of the NOx sensor.

Install the NOx sensor to the exhaust system and tighten the retaining nut.

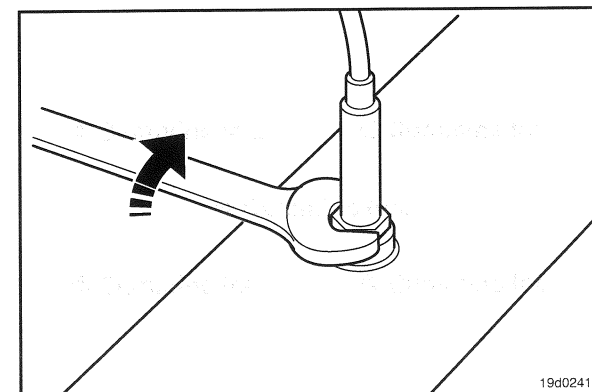
**Torque Value:** 50 N•m [ 37 ft-lb ]



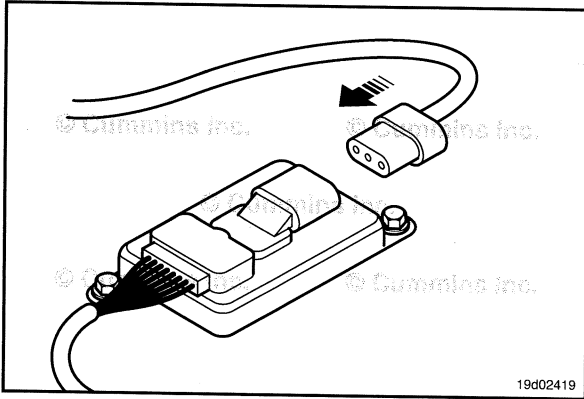
19d02416



19d02417



19d0241E

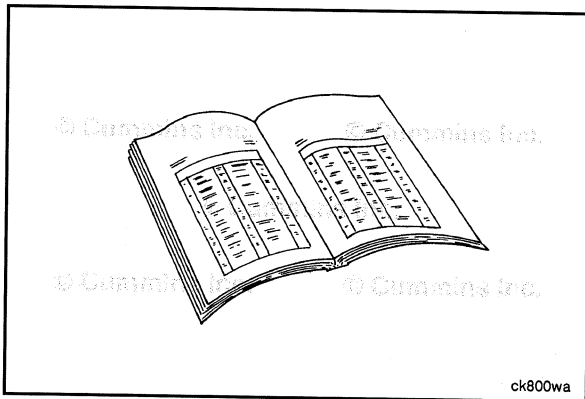


Connect the aftertreatment inlet NOx sensor to the aftertreatment interface harness.

Install and tighten the capscrews.



**Torque Value:** 14.4 N·m [ 127 in-lb ]



### Finishing Steps



#### ⚠ WARNING ⚠

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



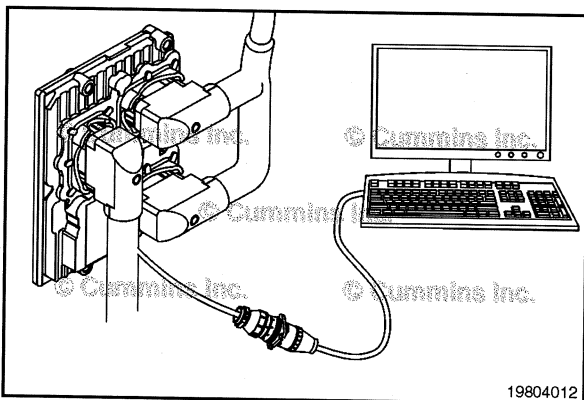
- Connect the battery cables. See equipment manufacturer service information.
- Operate the engine and check for leaks.

## 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 original equipment manufacturer (OEM) intake piping, 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 keyswitch 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.

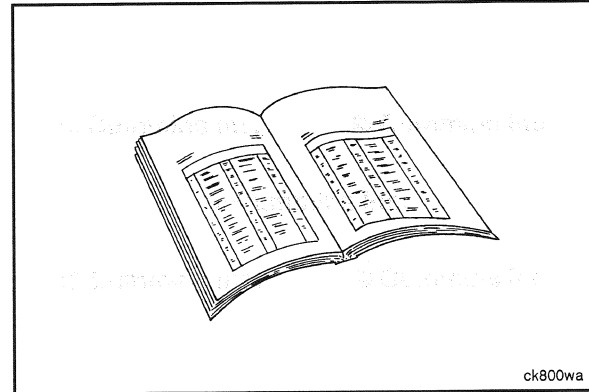
Replace the turbocharger compressor intake pressure/temperature sensor if either value is out of specification.

## 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 battery cables. See equipment manufacturer service information.
- Clean the area around the turbocharger compressor intake pressure/temperature sensor.



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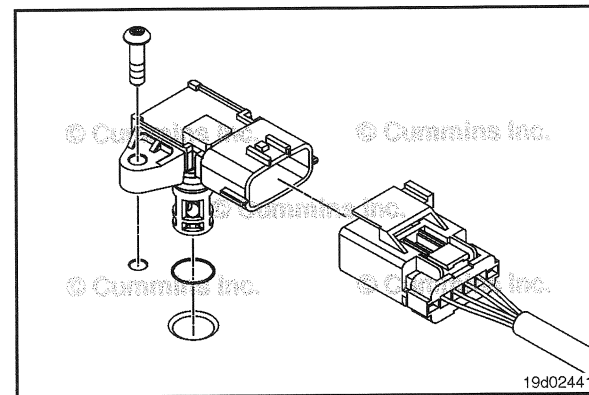
## Remove

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.



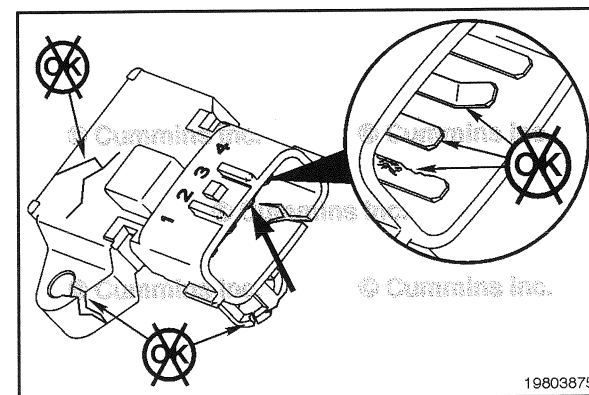
19d02441

## 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.



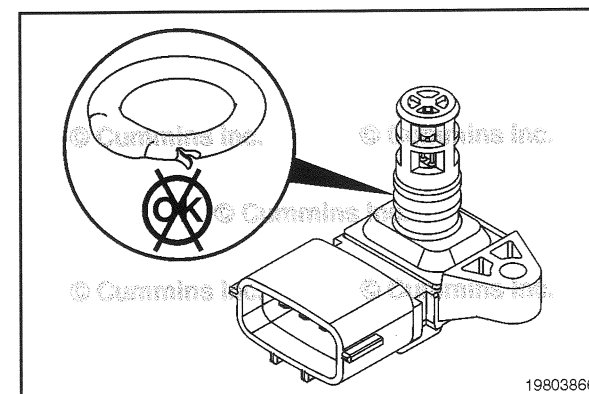
19803875

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:

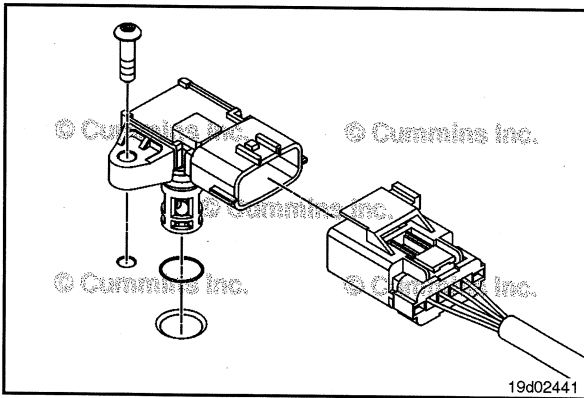
- Swollen o-ring
- Nicks or cuts in or on the o-ring.

Replace the o-ring if any damage is found.



19803866





### Install

Lubricate the o-ring with clean engine oil before installation.



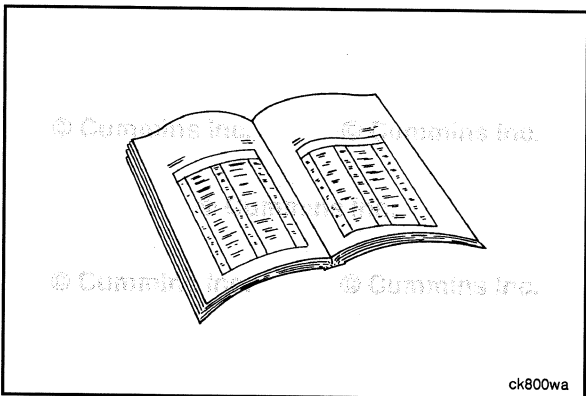
Install the turbocharger compressor intake pressure/temperature sensor by pressing firmly on the top of the sensor until the o-ring is fully seated.



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 battery cables. See equipment manufacturer service information.
- Operate the engine and check for leaks.

## Aftertreatment Diesel Exhaust Fluid Quality Sensor (019-475)

### General Information

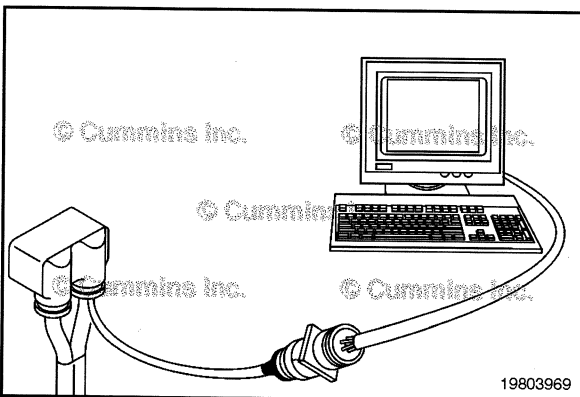
The aftertreatment diesel exhaust fluid (DEF) quality sensor is part of the DEF tank head unit assembly.

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.

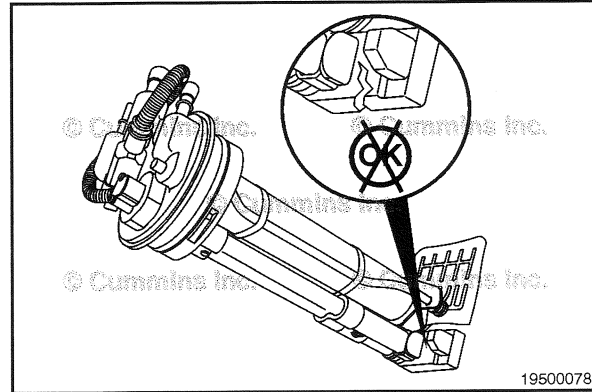
The DEF concentration should read  $32.5 \pm 4$  percent at keyswitch ON.

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.

### 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.

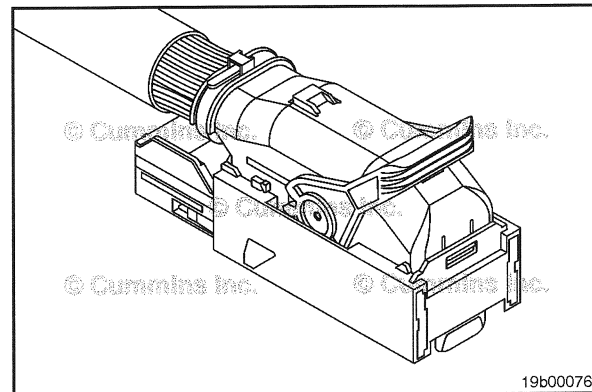


## Delphi® 96 Way Engine Control Module Connector (019-505)

### General Information

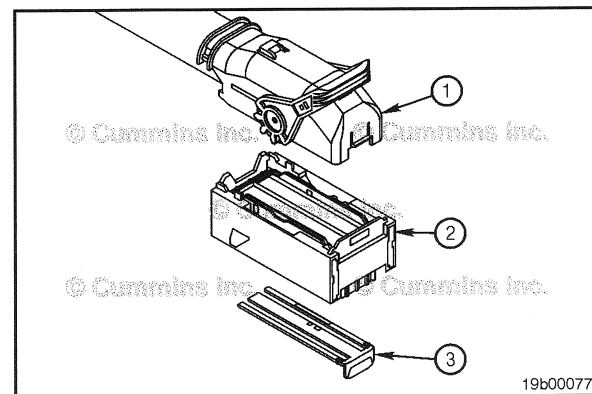
This connector is used to attach the engine wiring harness and the original equipment manufacturer (OEM) harness to the engine control module (ECM).

**NOTE:** The engine harness connector and the OEM connector are keyed differently, so they can **not** be used interchangeably.



The Delphi® 96 Way ECM connector is made up of three components:

- 1 Backshell.
- 2 Connector body.
- 3 Locking comb.

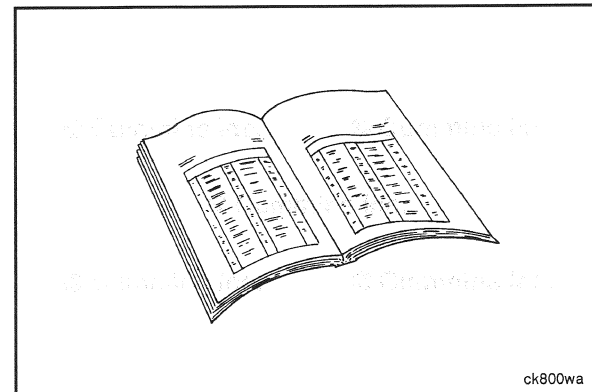


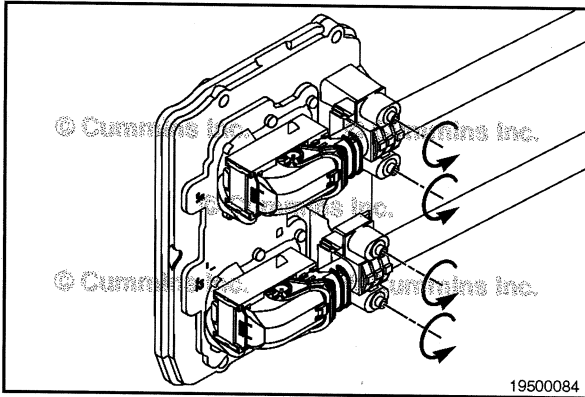
### Preparatory Steps

#### ⚠ 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. See equipment manufacturer service information.

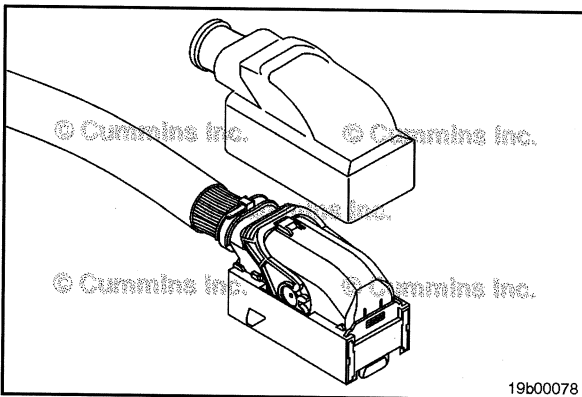




### Remove

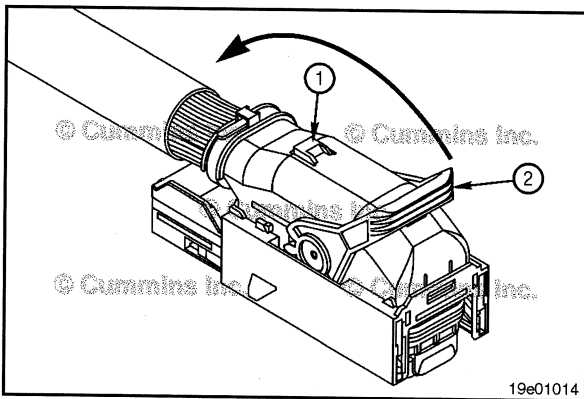
Unbolt the wire harness hold down clamp from the ECM.

**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 installed at the conclusion of the repair.

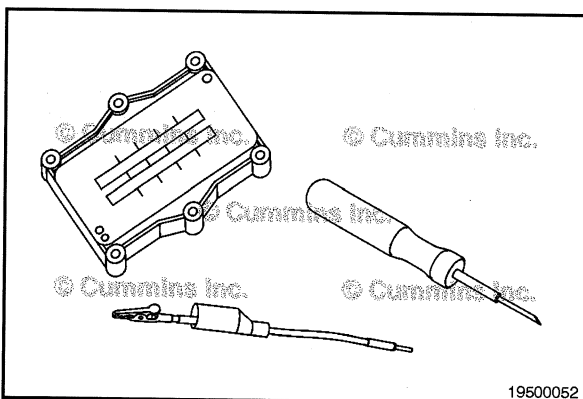


### ⚠CAUTION⚠

**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⚠

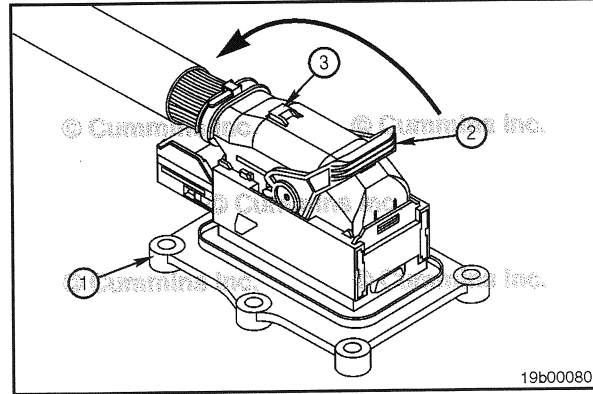
**Do not insert test leads into the ECM connector terminals. Doing so may cause terminals to spread and cause intermittent electrical connections.**

To perform pin-out diagnostic checks, use ECM connector electrical circuit tester, Part Number 2892510, and test lead, Cummins® Part Number 3164113.

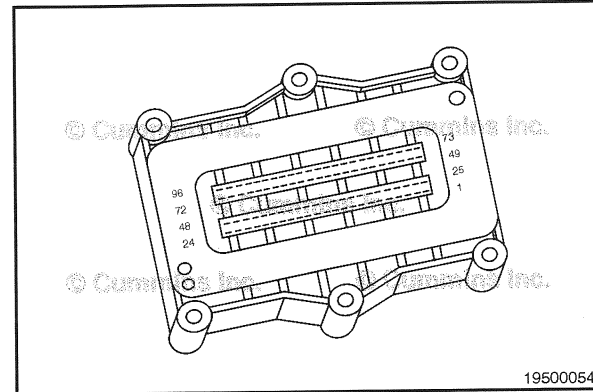
All diagnostic test leads, connector repair tools, and repair terminals can be found in Delphi® 96 way connector repair Tool kit, Cummins® Part Number 2892512.

**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

Attach the electrical circuit tester, Cummins® 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.

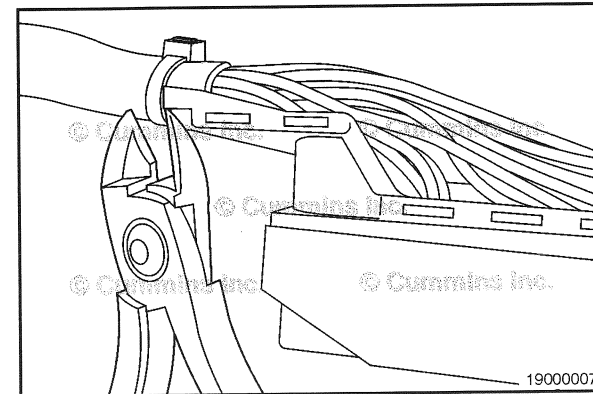


Use electrical circuit tester, Cummins® Part Number 2892510, to help identify terminal number locations. Reference the appropriate wiring diagram for circuit terminal locations.

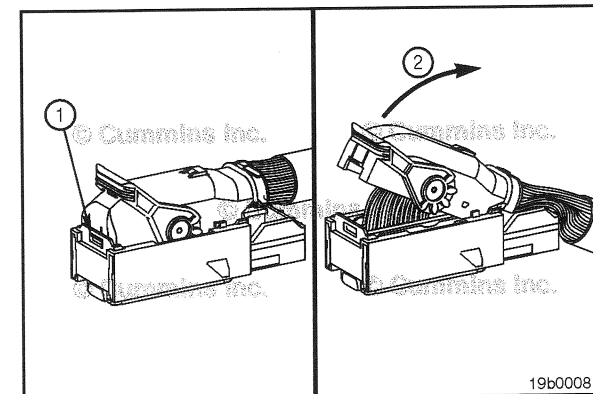


**Pin Replacement**

Cut the wire tie securing the wire bundle to the backshell.



Remove the connector backshell by pressing in on the backshell locking tab (1) and pivot the front of the backshell upward (2).





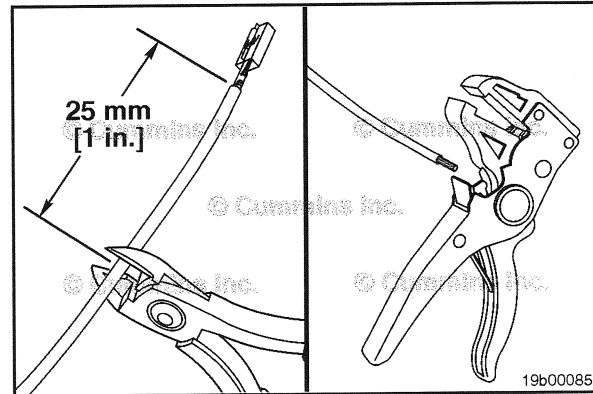
**QSF3.8 CM2350 F107**  
**Section 19 - Electronic Controls - Group 19**

Use wire cutters to remove 25 mm [1 in.] of the terminal and wire to be replaced.



Use wire stripping tool, Cummins® Part Number 3400045, or equivalent, to remove 6 mm [¼ in.] of insulation from the wire.

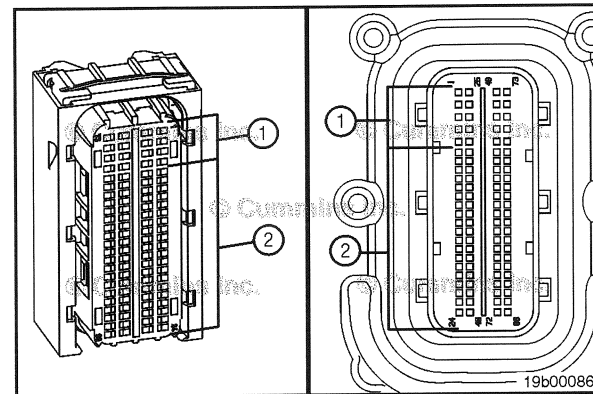
**NOTE:** It will be necessary to remove the wire ties securing the wire harness hold down clamps to the wire harness. Wire ties **must** be replaced at the conclusion of the repair.



There are two electrical connector repair terminals available for the ECM connector.

Cummins® 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).

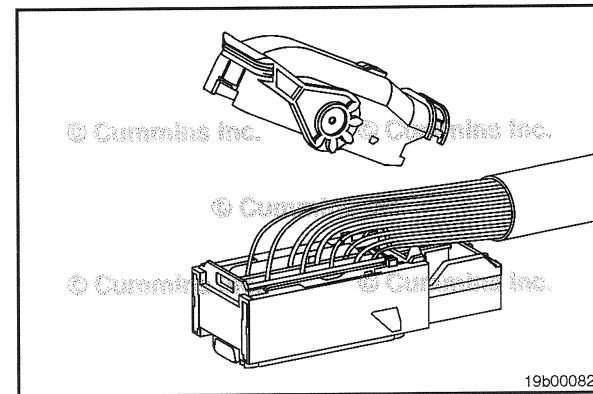


In some applications, there may **not** be enough clearance to route the repair terminal butt-splice connection into the wire harness convolute. The repair terminal will need to be cut to appropriate length to allow the butt-splice connection to be located under the backshell.

**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.

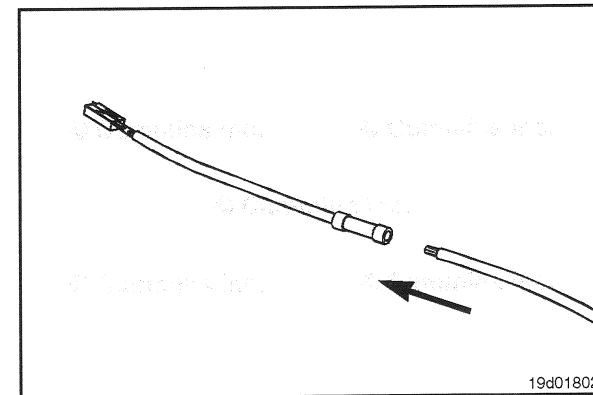


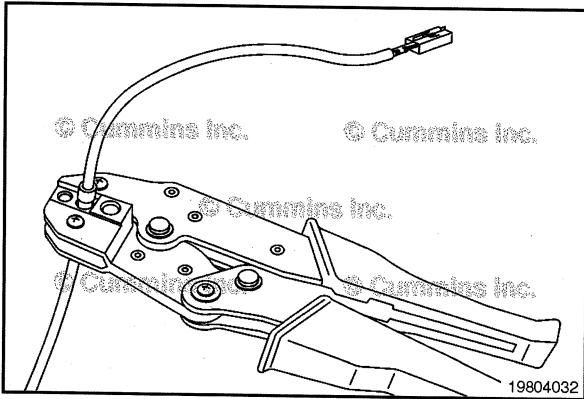
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.



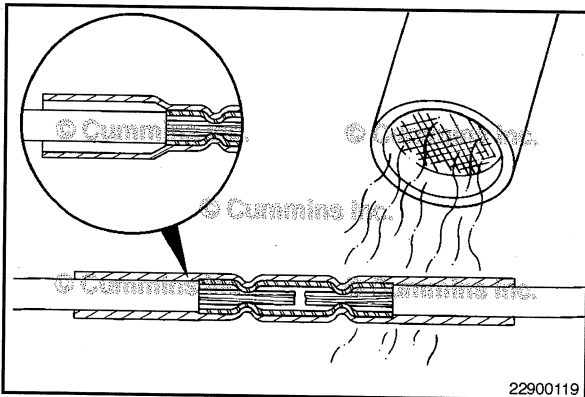
Install the repair wire on the bare wire.

Make sure the bare wire extends into the splice connector properly.



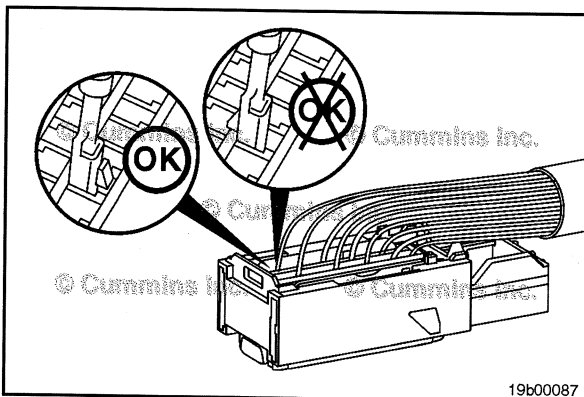


Use wire crimping tool, Cummins® Part Number 3163109, or equivalent, to crimp the repair wire onto the bare wire.



Use heat gun, Cummins® Part Number 3822860, or equivalent, to heat the shrink tubing around the wire.

The tubing will shrink and make the connection waterproof.



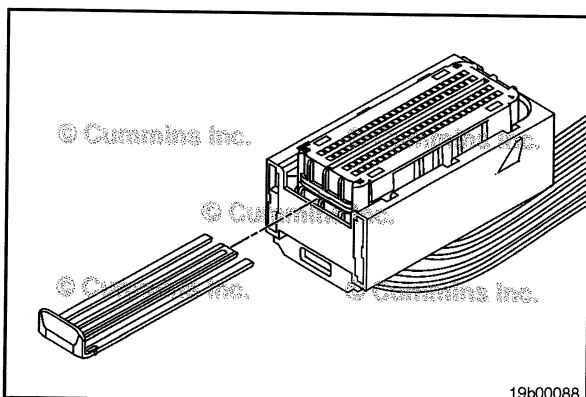
### Inserting Terminal

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.



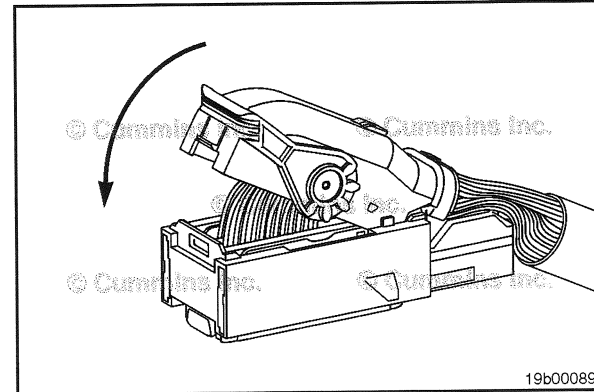
Insert the locking comb.

**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.

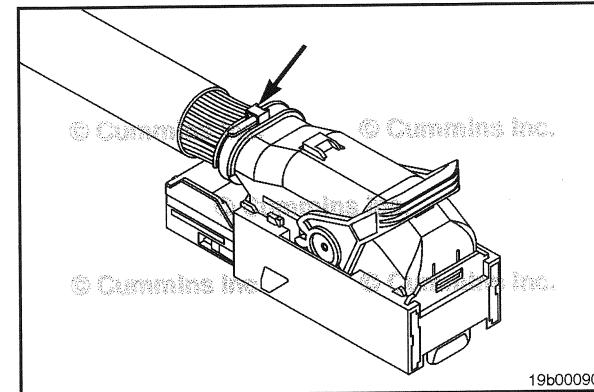
**NOTE:** Make sure the lever on the backshell is in the open position before installing the backshell onto the connector body.

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.

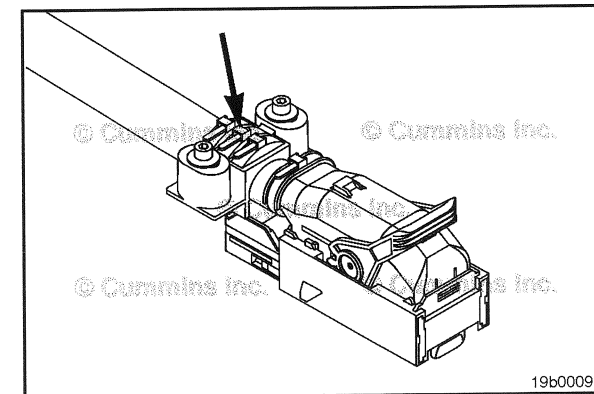


Install a wire tie to secure the wire bundle to the connector backshell.



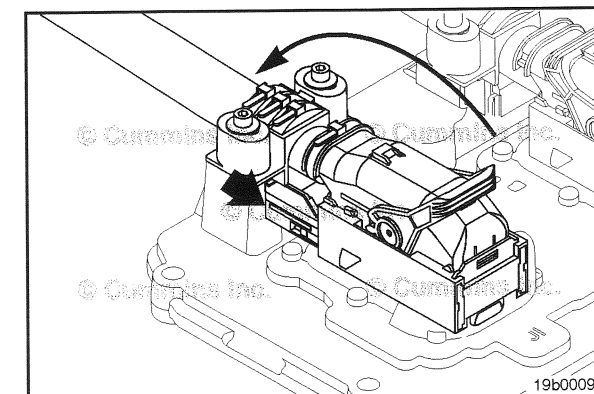
If the harness hold down clamps were removed from the harness, loosely re-attach the hold down clamps to the wire harness using wire ties.

Once the connector has been 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.

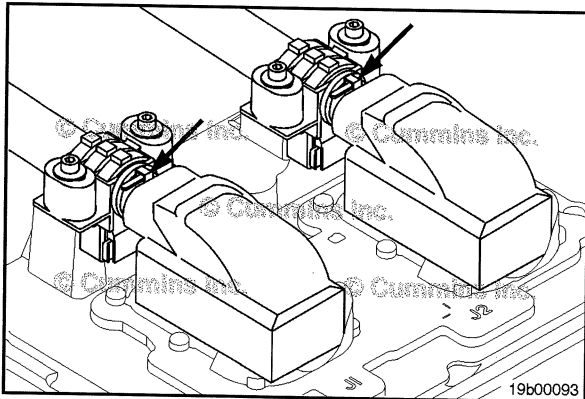


## Install

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.

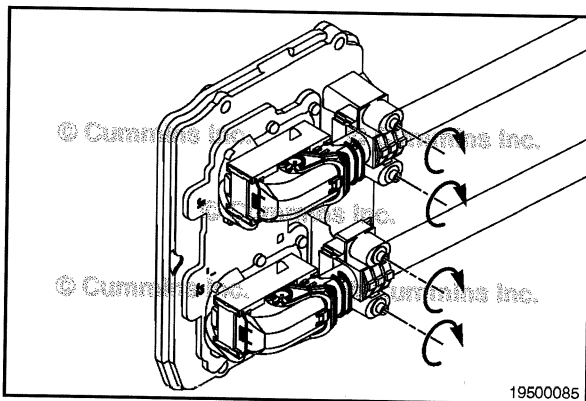






If equipped, fold the dust boot back into place over the ECM connector.

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.

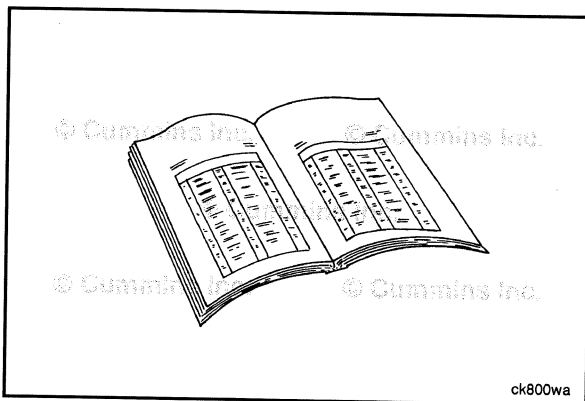


Install the harness hold-down clamps.

**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. See equipment manufacturer service information.
- Operate the engine and check for loose components and fault codes.

## Machine Constrained Engine Operation Controller (019-545)

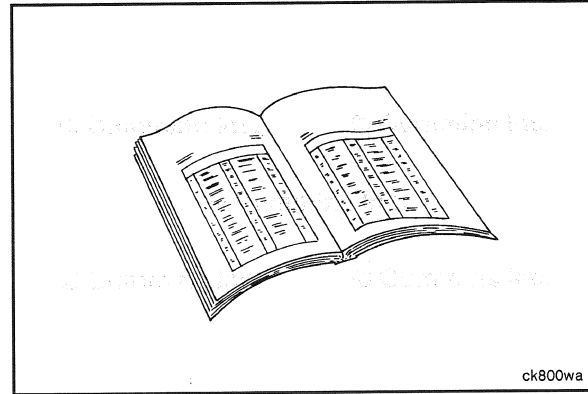


### General Information

Some original equipment manufacturers (OEMs) constrain the operation of the engine based on the specific needs of the equipment.

By constraining the operation of the engine, it is possible to get a standard torque curve to have a higher torque rise to meet the specific demands for the equipment. All constraining **must** be done such that the standard torque curve is **not** modified. See equipment manufacturer service information for the location and specification of the machine constrained engine operation controller.

**NOTE:** The OEM is to provide a secondary label regarding the machine constrained operations. It **must** be placed inside the engine compartment in a location which is clearly visible. Four items are included on this label: maximum constrained power (hp or Kw), maximum engine speed at which maximum power can be achieved (rpm), statement of compliance to government regulations, and machine manufacturer name.



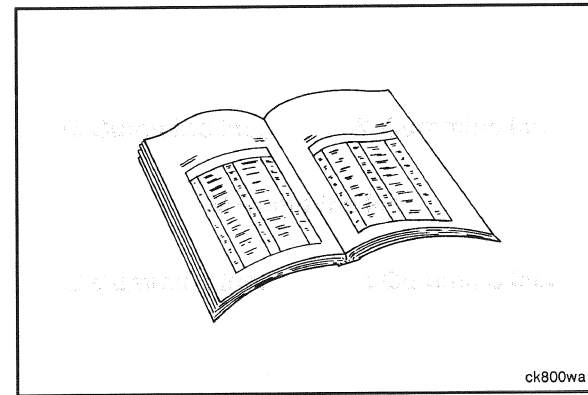
ck800wa

### Inspect for Reuse



The machine constrained engine operation controller uses standard J1939 data link commands. It **must** provide an indication to the engine control module (ECM) which indicates if the controller is in error because of a J1939 data link issue, machine controller software execution issue, or loss of machine controller power.

See equipment manufacturer service information for removal and installation instructions.



ck800wa



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# Section L - Service Literature

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## Additional Service Literature General Information

The following publications can be purchased:

Bulletin	Title of Publication
4367316	QSF3.8 CM2350 F107 Service Manual
4367319	QSF3.8 CM2350 F107 Fault Code Troubleshooting Manual
4367320	QSF3.8 CM2350 F107 Wiring Diagram
4367317	QSF3.8 CM2350 F107 Operation and Maintenance Manual
4367318	QSF3.8 CM2350 F107 Owners Manual
3379000	Air for Your Engine
3379001	Fuel for Cummins® Engines
3379009	Operation - Cold Weather
3666132	Cummins® Coolant Requirements and Maintenance
3810340	Cummins® Engine Oil and Oil Analysis Recommendations
4021566	Diesel Exhaust Fluid Specifications for Cummins® Selective Catalytic Reduction Systems

## **Service Literature Ordering Location Contact Information**

<b>Region</b>	<b>Ordering Location</b>
United States and Canada	Cummins Distributors or Credit Cards at <a href="https://store.cummins.com">https://store.cummins.com</a>
All Other Countries	Cummins Distributors or Dealers

## Cummins Customized Parts Catalog

### General Information

Cummins is pleased to announce the availability of a parts catalog compiled specifically for you. Unlike the generic versions of parts catalogs that support general high volume parts content; Cummins Customized catalogs contain only the new factory parts that were used to build your engine.

The catalog cover, as well as the content, is customized with you in mind. You can use it in your shop, at your worksite, or as a coffee table book in your RV or boat. The cover contains your name, company name, address, and telephone number.

This new catalog was designed to provide you with the exact information you need to order parts for your engine. This will be valuable for customers that do not have easy access to Cummins QuickServe Online.

Additional Features of the Customized Catalog include:

- Engine Configuration Data
- Table of Contents
- Separate Option and Parts Indexes
- Service Kits (when applicable)
- ReCon Part Numbers (when applicable)

### Ordering the Customized Parts Catalog

#### Ordering by Telephone

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

#### Ordering On-Line

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

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

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

Required information needed for your Customized Parts Catalog Order.

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

Unfortunately not all Cummins Engines can be supported by Customized Parts Catalogs. Engines older than 1984 or newer than 3 months may not have the necessary parts information to compile a catalog. We will contact you if this occurs and explain why we are unable to fill your order.

Customized Parts Catalogs are produced specifically for a single customer. This means they are not returnable for a refund. If we make an error and your catalog is not useable, we will correct that error by sending you a new catalog.





# Section V - Specifications

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Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
<b>Engine Assembly - Group 00 - Specifications</b>			
Connecting Rod and Crankshaft Side Clearance		0.125 mm	MIN 0.005 in
		0.275 mm	MAX 0.011 in
Piston Protrusion		0.25 mm	MIN 0.010 in
		0.52 mm	MAX 0.020 in
Starting Motor Spacing		49.28 mm	MIN 1.94 in
		52.32 mm	MAX 2.06 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
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### Engine Assembly - Group 00 - Torque Values

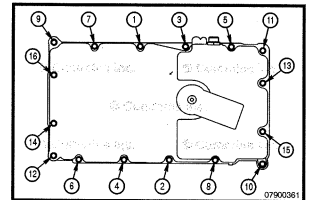
- 15 N•m [ 133 in-lb ]
- 77 N•m [ 57 ft-lb ]
- 47 N•m [ 35 ft-lb ]
- 24 N•m [ 212 in-lb ]
- 24 N•m [ 212 in-lb ]
- 15 N•m [ 133 in-lb ]
- 43 N•m [ 32 ft-lb ]

**Lubricating Oil Pan (007-025)**

Four-Cylinder, Standard Capscrew

24 N•m

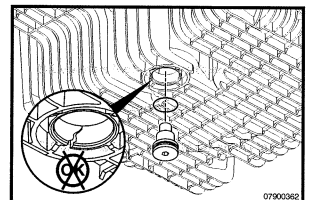
[ 212 in-lb ]



Lubricating Oil Pan Drain Plug

24 N•m

[ 212 in-lb ]



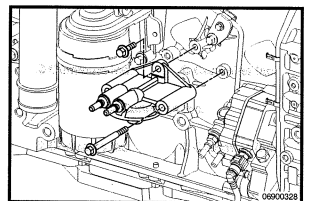
- 24 N•m [ 212 in-lb ]
- 77 N•m [ 57 ft-lb ]
- 24 N•m [ 212 in-lb ]

**Fuel Filter Head (006-017)**

Rear Gear Train Fuel Filter Head Mounting Capscrews

24 N•m

[ 212 in-lb ]

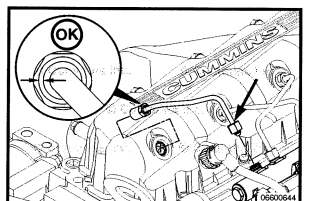


- 40 N•m [ 30 ft-lb ]
- 1.5 N•m [ 13 in-lb ]
- 24 N•m [ 212 in-lb ]

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

35 N•m  
35 N•m

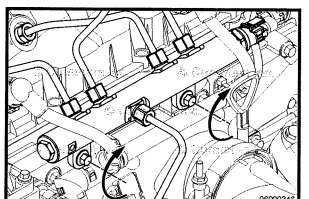
[ 26 ft-lb ]  
[ 26 ft-lb ]



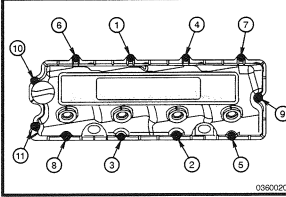
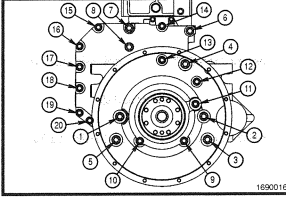
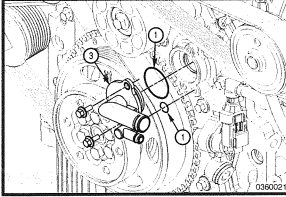
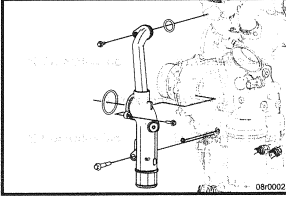
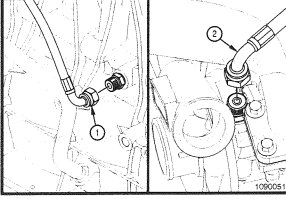
Fuel Line Isolators Capscrews

24 N•m

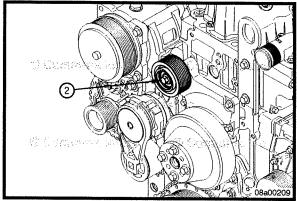
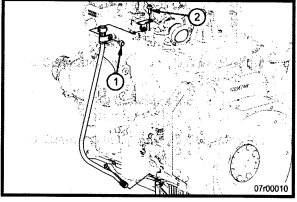
[ 212 in-lb ]



- 8.5 N•m [ 75 in-lb ]
- 24 N•m [ 212 in-lb ]
- 36 N•m [ 27 ft-lb ]
- 24 N•m [ 212 in-lb ]

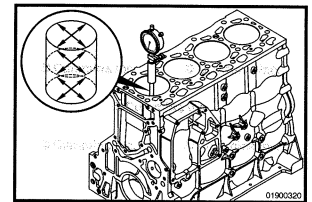
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
<b>Rocker Lever Cover (003-011)</b> Capscrew Mounted Rocker Lever Cover Capscrews.		9 N•m	[ 80 in-lb ]	
		28 N•m	[ 248 in-lb ]	
		20 N•m	[ 180 in-lb ]	
<b>Flywheel Housing (016-006)</b>		49 N•m 85 N•m	[ 36 ft-lb ] [ 63 ft-lb ]	
		18 N•m	[ 159 in-lb ]	
<b>Crankcase Breather Adapter (003-031)</b>		7.5 N•m	[ 66 in-lb ]	
		27 N•m	[ 239 in-lb ]	
<b>Water Inlet Connection (008-082)</b>		9 N•m 13 N•m	[ 80 in-lb ] [ 115 in-lb ]	
		53 N•m	[ 39 ft-lb ]	
		23 N•m	[ 204 in-lb ]	
		24 N•m	[ 212 in-lb ]	
		10 N•m	[ 89 in-lb ]	
<b>Turbocharger Oil Supply Line (010-046)</b> Turbocharger Oil Supply Line		35 N•m 16 N•m	[ 26 ft-lb ] [ 142 in-lb ]	
		30 N•m	[ 22 ft-lb ]	
		43 N•m	[ 32 ft-lb ]	
		4 N•m	[ 35 in-lb ]	
		21 N•m	[ 186 in-lb ]	
		45 N•m	[ 33 ft-lb ]	
		40 N•m	[ 30 ft-lb ]	
		24 N•m	[ 212 in-lb ]	
		36 N•m	[ 27 ft-lb ]	
		64 N•m	[ 47 ft-lb ]	
		40 N•m	[ 30 ft-lb ]	



Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
		24 N•m	[ 212 in-lb ]	
		32 N•m	[ 24 ft-lb ]	
<b>Pulley, Fan Idler (008-111)</b>				
Idler Pulley Support Bracket Capscrews		43 N•m	[ 32 in-lb ]	
		5 N•m	[ 44 in-lb ]	
<b>Lubricating Oil Dipstick Tube (007-011)</b>		24 N•m	[ 212 in-lb ]	
		5 N•m	[ 44 in-lb ]	
		Capscrew 24 212	Capscrew 18 159	
		77 N•m	[ 57 ft-lb ]	
		80 N•m	[ 60 ft-lb ]	
		125 N•m	[ 95 ft-lb ]	
		80 N•m	[ 60 ft-lb ]	
		115 N•m	[ 85 ft-lb ]	
		125 N•m	[ 95 ft-lb ]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
<b>Cylinder Block - Group 01 - Specifications</b>			
Crankshaft End Play		0.11 mm	MIN 0.004 in
		0.39 mm	MAX 0.017 in
Main Bearing Underhead Capscrew Length		120.00 mm	MAX 4.724 in
Crankshaft End Play		0.11 mm	MIN 0.004 in
		0.39 mm	MAX 0.017 in
Journal Diameter		53.095 mm	MIN 2.0903 in
		53.995 mm	MAX 2.1257 in
Camshaft Thrust Plate Thickness		5.2 mm	MIN 0.204 in
		5.4 mm	MAX 0.212 in
Camshaft Bore (Bushing Installed)		54.083 mm	MIN 2.1293 in
		54.147 mm	MAX 2.1318 in
Camshaft End Play		0.070 mm	MIN 0.003 in
		0.330 mm	MAX 0.013 in
Camshaft Backlash		0.076 mm	MIN 0.003 in
		0.280 mm	MAX 0.011 in
Connecting Rod Piston Pin Bushing Diameter		40.019 mm	MIN 1.5756 in
		40.042 mm	MAX 1.5765 in
Connecting Rod Crankshaft Bore Diameter Bearings Removed		72.99 mm	MIN 2.873 in
		73.01 mm	MAX 2.875 in
Connecting Rod to Crankshaft Bearing Clearance		0.04 mm	MIN 0.002 in
		0.12 mm	MAX 0.005 in
Connecting Rod to Crankshaft Bearing Clearance		0.04 mm	MIN 0.002 in
		0.12 mm	MAX 0.005 in
Main Bearing Bore to Crankshaft Bearing Clearance		0.04 mm	MIN 0.002 in
		0.12 mm	MAX 0.005 in
Thrust Distance		0.065 mm	MIN 0.003 in
		0.432 mm	MAX 0.017 in
Crankshaft End Play		0.102 mm	MIN 0.004 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
		0.432 mm	MAX 0.017 in
Tappet Bore Diameter		16.000 mm	MIN 0.630 in
		16.055 mm	MAX 0.632 in
Main Bearing Bore Diameter with Bearings Removed		87.983 mm	MIN 3.4639 in
		88.019 mm	MAX 3.4653 in
<b>Cylinder Block (001-026)</b>			
Cylinder Bore Diameter (New Cylinder Block)		102.010 mm	MIN 4.0161 in
		102.030 mm	MAX 4.0169 in
Cylinder Bore Diameter (Used Cylinder Block)		102.010 mm	MIN 4.0161 in
		102.050 mm	MAX 4.0177 in
Out-of-Roundness		0.038 mm	MAX 0.0015 in
Taper		0.076 mm	MAX 0.003 in
Standard Piston Skirt Diameter		101.871 mm	MIN 4.0107 in
		101.889 mm	MAX 4.0114 in
Piston Pin Bore		40.012 mm	MIN 1.5753 in
		40.019 mm	MAX 1.5756 in
Piston Pin Diameter		39.997 mm	MIN 1.5747 in
		40.003 mm	MAX 1.5749 in
Connecting Rod and Crankshaft Side Clearance		0.125 mm	MIN 0.005 in
		0.275 mm	MAX 0.011 in
Piston Protrusion		0.25 mm	MIN 0.010 in
		0.52 mm	MAX 0.020 in
Crankshaft Speed/Position Sensor Air Gap		0.8 mm	MIN 0.032 in
		1.5 mm	MAX 0.060 in



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Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
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### Cylinder Block - Group 01 - Torque Values

50 N•m	[ 37 ft-lb ]
24 N•m	[ 212 in-lb ]
36 N•m	[ 27 ft-lb ]
28 N•m	[ 20 ft-lb ]
15 N•m	[ 133 in-lb ]
176 N•m	[ 130 ft-lb ]
176 N•m	[ 130 ft-lb ]
24 N•m	[ 212 in-lb ]
77 N•m	[ 57 ft-lb ]
47 N•m	[ 35 ft-lb ]
24 N•m	[ 212 in-lb ]
24 N•m	[ 212 in-lb ]
15 N•m	[ 133 in-lb ]
20 N•m	[ 180 in-lb ]
43 N•m	[ 32 ft-lb ]

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
<b>Cylinder Head - Group 02 - Specifications</b>			
Injector Protrusion		1.94 mm	MIN 0.076 in
		2.47 mm	MAX 0.097 in
Intake Valve Depth (Installed)		0.584 mm	MIN 0.023 in
		1.092 mm	MAX 0.043 in
Exhaust Valve Depth (Installed)		0.965 mm	MIN 0.038 in
		1.473 mm	MAX 0.058 in
Cylinder Head Insert Bore Inside Diameter (I.D.)		34.837 mm	MIN 1.3715 in
		34.863 mm	MAX 1.3726 in
Valve Guide Bore Diameter		7.027 mm	MIN 0.2767 in
		7.077 mm	MAX 0.2786 in
Valve Stem Diameter		6.96 mm	MIN 0.2740 in
		7.01 mm	MAX 0.2760 in
Capscrew Free Length		152.1 mm	MAX 5.99 in
Valve Rim Thickness Limit		0.79 mm	MIN 0.031 in
Injector Protrusion		1.94 mm	MIN 0.076 in
		2.47 mm	MAX 0.097 in
Intake Valve Depth (Installed)		0.584 mm	MIN 0.023 in
		1.092 mm	MAX 0.043 in
Exhaust Valve Depth (Installed)		0.965 mm	MIN 0.038 in
		1.473 mm	MAX 0.058 in

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Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
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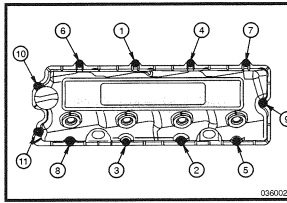
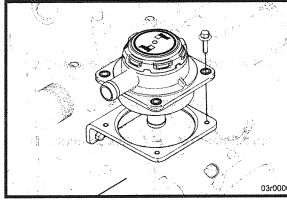
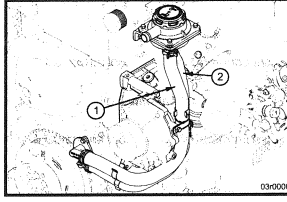
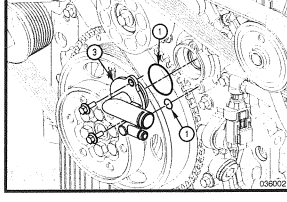
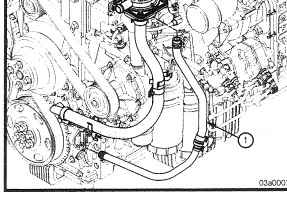
### Cylinder Head - Group 02 - Torque Values

5 N•m	[ 44 in-lb ]
80 N•m	[ 59 ft-lb ]
5 N•m	[ 44 in-lb ]
5 N•m	[ 44 in-lb ]
5 N•m	[ 44 in-lb ]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
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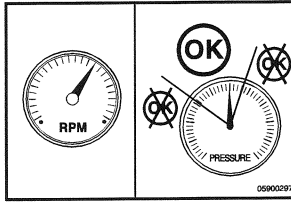
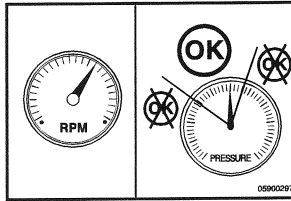
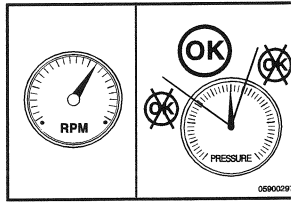
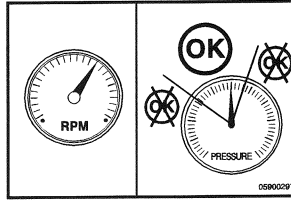
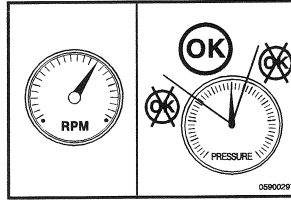
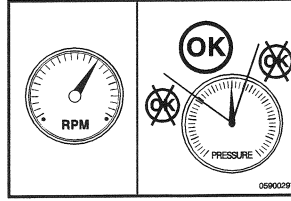
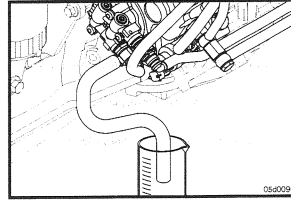
**Rocker Levers - Group 03 - Specifications**

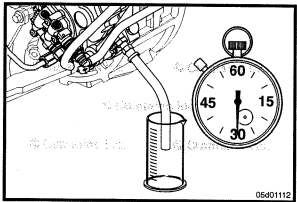
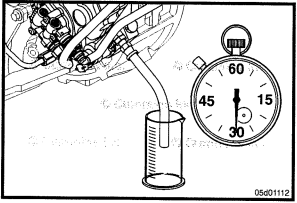
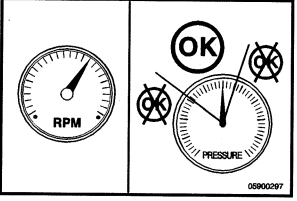
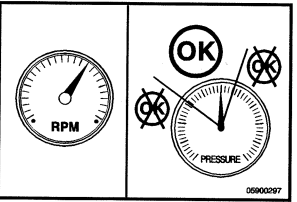
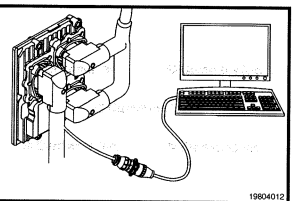
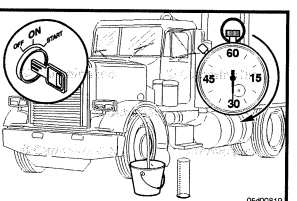
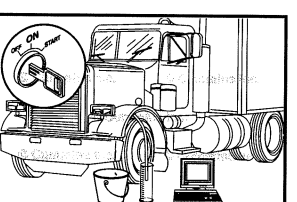


Rocker Lever Bore		22.027 mm	MAX 0.867 in
Rocker Lever Shaft		21.965 mm	MIN 0.865 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
<b>Rocker Levers - Group 03 - Torque Values</b>			
28 N•m		[ 248 in-lb ]	
24 N•m		[ 212 in-lb ]	
9 N•m		[ 80 in-lb ]	
22 N•m		[ 195 in-lb ]	
36 N•m		[ 27 ft-lb ]	
<b>Rocker Lever Cover (003-011)</b> Capscrew Mounted Rocker Lever Cover Capscrews.		9 N•m	[ 80 in-lb ]
			
18 N•m		[ 159 in-lb ]	
<b>Open Crankcase Ventilation Valve (003-025)</b>		7.4 N•m	[ 65 in-lb ]
			
		7.4 N•m	[ 65 in-lb ]
			
7.4 N•m		[ 65 in-lb ]	
7.4 N•m		[ 65 in-lb ]	
<b>Crankcase Breather Adapter (003-031)</b>		7.5 N•m	[ 66 in-lb ]
			
<b>Crankcase Breather Oil Drain Line (003-037)</b>		7.5 N•m	[ 66 in-lb ]
			

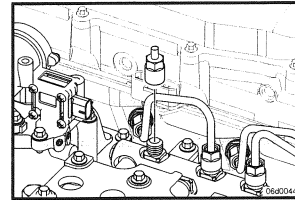
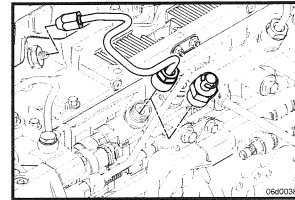
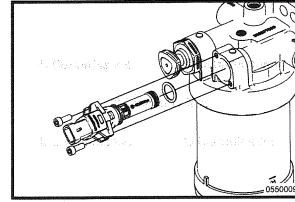


Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
<b>Cam Followers/Tappets - Group 04 - Specifications</b>			
Valve Tappet Stem Diameter		15.936 mm	MIN 0.627 in
		15.977 mm	MAX 0.629 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
<b>Fuel System - Group 05 - Specifications</b>				
Fuel Inlet Restriction at High Idle (2300 rpm)		760 mm Hg	MAX 30 in Hg	
<b>Fuel System Diagnostics (005-236)</b> Drain Line Restriction at High Idle (2300 rpm)		20 kPa	MAX 2.90 psi	
Gear Pump Pressure at High Idle (2300 rpm)		450 kPa 750 kPa	MIN 65.3 psi MAX 108.8 psi	
Pressure Drop Across Fuel Filter at High Idle (2300 rpm)		81 kPa	MAX 11.7 psi	
Drain Line Restriction at Engine Cranking (150 rpm minimum)		20 kPa	MAX 2.90 psi	
Gear Pump Pressure at Engine Cranking (150 rpm minimum)		450 kPa 750 kPa	MIN 65.3 psi MAX 108.8 psi	
Pressure Drop Across Fuel Filter at Engine Cranking (150 rpm minimum)		81 kPa	MAX 11.7 psi	
Minimum High-Pressure Fuel Pump Supply Flow with Engine Cranking (150 rpm minimum) in 30 Seconds		75 ml	MIN 2.5 fl-oz	

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.		
Maximum High-Pressure Fuel Pump Return Flow with Engine Cranking (150 rpm minimum) in 30 Seconds		317 ml	MAX	11 fl-oz	
Maximum High-Pressure Fuel Pump Return Flow at Standard Idle Conditions in 30 Seconds		317 ml	MAX	11 fl-oz	
Fuel Pressure Range at Fuel Filter with Engine Cranking (150 rpm minimum)		207 kPa	MIN	30 psi	
		750 kPa	MAX	108 psi	
Maximum Allowable Pressure Drop Across Fuel Filter while Cranking (150 rpm minimum)		81 kPa	MAX	11.7 psi	
Fuel Pressure Range at Fuel Filter with Engine at High Idle (2300 rpm)		207 kPa	MIN	30 psi	
		750 kPa	MAX	108 psi	
Maximum Allowable Pressure Drop Across Fuel Filter while Engine Running at High Idle (2300 rpm)		81 kPa	MAX	11.7 psi	
High-Pressure Fuel Rail Return Flow at Standard Idle Conditions using INSITE™ electronic service tool "Fuel System Leakage Test" in 30 Seconds		8 ml	MAX	0.27 fl-oz	
Injector Return Flow at Engine Cranking (150 rpm minimum) for 30 Seconds		90 ml	MAX	4 fl-oz	
Injector Return Flow at Standard Engine Idle Conditions using INSITE™ electronic service tool "Fuel System Leakage Test" in 30 Seconds		120 ml	MAX	4.1 fl-oz	

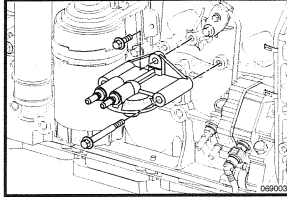
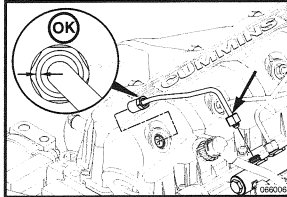
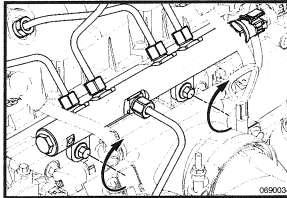
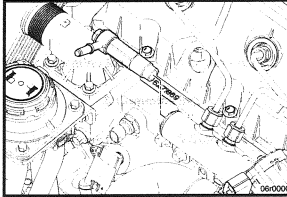
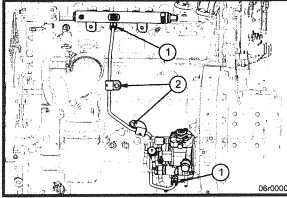
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
<b>Fuel System - Group 05 - Torque Values</b>			
<b>Engine Fuel Heater, Electric (005-008)</b>			
Fuel Heater Bolts		9 N•m	[ 80 in-lb ]
		67 N•m [ 49 ft-lb ]	
		24 N•m [ 212 in-lb ]	
<b>Fuel System Diagnostics (005-236)</b>		40 N•m	[ 30 ft-lb ]
Injector Isolation Tool, Part Number 4918298		40 N•m	[ 30 ft-lb ]



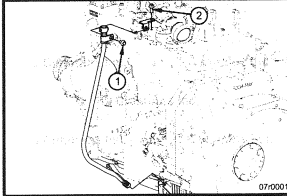
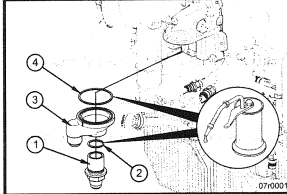
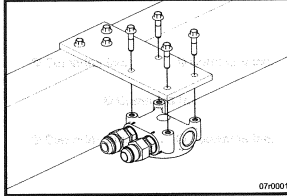
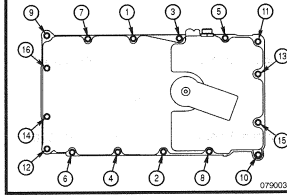
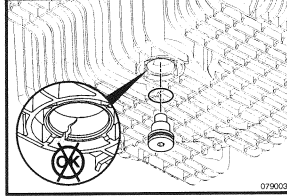
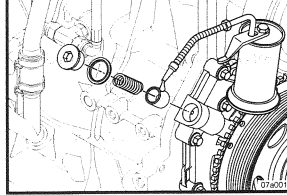
<b>Component or Assembly (Procedure)</b>	<b>Ref.No./ Steps</b>	<b>Metric</b>	<b>U.S.</b>
<b>Injectors and Fuel Lines - Group 06 - Specifications</b>			
Maximum Drain Line Restriction		20.0 kPa	MAX 2.9 psi
Maximum Fuel Inlet Restriction Vacuum at High Idle		41 kPa	MAX 12.0 in Hg

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
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### Injectors and Fuel Lines - Group 06 - Torque Values

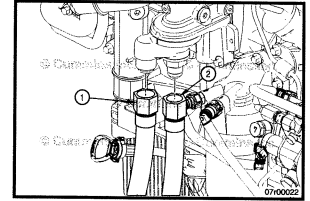
<b>Fuel Filter Head (006-017)</b> Rear Gear Train Fuel Filter Head Mounting Capscrews		24 N•m	[ 212 in-lb ]	
		40 N•m [ 30 ft-lb ] 1.5 N•m [ 13 in-lb ]		
<b>Injector Supply Lines (High Pressure) (006-051)</b>		35 N•m 35 N•m	[ 26 ft-lb ] [ 26 ft-lb ]	
Fuel Line Isolators Capscrews		24 N•m	[ 212 in-lb ]	
Fuel Pressure Relief Valve (006-061)		24 N•m	[ 212 in-lb ]	
<b>Torque Value:</b>				
Step 1		30 N•m	[ 22 ft-lb ]	
Step 2		Turn an additional 24 degrees		
<b>Fuel Rail Supply Line (High Pressure) (006-071)</b> Fuel Rail Supply Line Bracket Fastener		35 N•m 24 N•m	[ 26 ft-lb ] [ 212 in-lb ]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
<b>Lubricating Oil System - Group 07 - Specifications</b>			
Air Pressure Test		449 kPa	MIN 65 psi
		518 kPa	MAX 75 psi
Oil Pressure at Low Idle		69 kPa	MIN 10 psi
Oil Pressure at Rated Engine Speed		207 kPa	MIN 30 psi

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
<b>Lubricating Oil System - Group 07 - Torque Values</b>				
		24 N•m	[ 212 in-lb ]	
		15 N•m	[ 133 in-lb ]	
		27 N•m	[ 239 in-lb ]	
		5 N•m	[ 44 in-lb ]	
		24 N•m	[ 212 in-lb ]	
<b>Lubricating Oil Dipstick Tube (007-011)</b>				
		5 N•m	[ 44 in-lb ]	
		Capscrew 24 212	Capscrew 18 159	
<b>Lubricating Oil Filter Head (Remote-Mounted) (007-017)</b>				
Lubricating Oil Filter Head Assembly		100 N•m	[ 74 ft-lb ]	
Lubricating Oil Filter Fitting Nut		18 N•m	[ 159 in-lb ]	
<b>Lubricating Oil Pan (007-025)</b>				
Four-Cylinder, Standard Capscrew		24 N•m	[ 212 in-lb ]	
Lubricating Oil Pan Drain Plug		24 N•m	[ 212 in-lb ]	
<b>Lubricating Oil Pressure Regulator (Main Rifle) (007-029)</b>				
Pressure Regulator Valve Plug		80 N•m	[ 59 ft-lb ]	
		8.5 N•m	[ 75 in-lb ]	
		20 N•m	[ 177 in-lb ]	



Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
<b>Lubricating Oil Lines (007-092)</b> Lubricating Oil Lines		76 N•m	[ 56 ft-lb ]
		76 N•m	[ 56 ft-lb ]



Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
<b>Cooling System - Group 08 - Specifications</b>			
Fan Hub End Clearance		0.15 mm	MAX 0.006 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
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### Cooling System - Group 08 - Torque Values

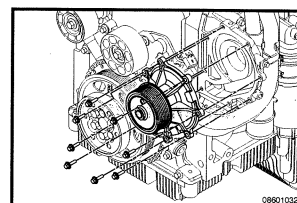
24 N•m [ 212 in-lb ]  
 55 N•m [ 41 ft-lb ]  
 7 N•m [ 62 in-lb ]  
 32 N•m [ 24 ft-lb ]

**Water Pump (008-062)**

Water Pump Mounting Capscrews

8 N•m

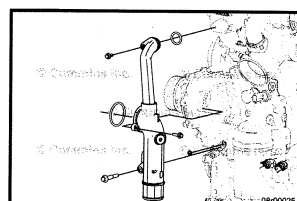
[ 71 in-lb ]



**Water Inlet Connection (008-082)**

9 N•m  
13 N•m

[ 80 in-lb ]  
[ 115 in-lb ]



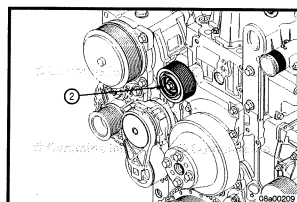
43 N•m [ 32 ft-lb ]

**Pulley, Fan Idler (008-111)**

Idler Pulley Support Bracket Capscrews

43 N•m

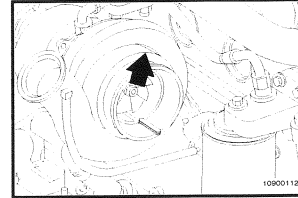
[ 32 in-lb ]



Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
<b>Drive Units - Group 09 - Specifications</b>			
Accessory Drive Gear Bore Inside Diameter (Accessory Drive Adapter)		38.920 mm	MIN 1.5323 in
		38.945 mm	MAX 1.5333 in
Accessory Drive Shaft Outside Diameter (Accessory Drive Adapter)		39.008 mm	MIN 1.5357 in
		39.020 mm	MAX 1.5362 in
Bearing Bore Inside Diameter (Accessory Drive Adapter)		67.759 mm	MIN 2.6755 in
		67.983 mm	MAX 2.6765 in
Accessory Drive Gear End Play		0.5 mm	MIN 0.020 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
<b>Drive Units - Group 09 - Torque Values</b>			
		77 N•m	[ 57 ft-lb ]
		62 N•m	[ 46 ft-lb ]
		46 N•m	[ 33 ft-lb ]

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
<b>Air Intake System - Group 10 - Specifications</b>			
Air Intake Restriction		635 mm H <sub>2</sub> O	MAX 25 in H <sub>2</sub> O
Axial Specifications		0.01 mm 0.076 mm	MIN 0.0004 in MAX 0.003 in
<b>Turbocharger (010-033)</b>			
Radial Specifications		0.394 mm 0.602 mm	MIN 0.016 in MAX 0.024 in



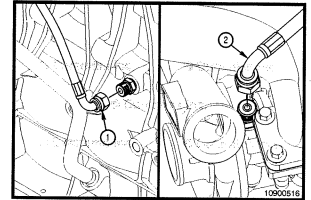
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
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**Air Intake System - Group 10 - Torque Values**

24 N•m	[ 212 in-lb ]
10 N•m	[ 89 in-lb ]
10 N•m	[ 89 in-lb ]
8 N•m	[ 71 in-lb ]
8 N•m	[ 71 in-lb ]
10 N•m	[ 89 in-lb ]
24 N•m	[ 212 in-lb ]
10 N•m	[ 89 in-lb ]

**Turbocharger Oil Supply Line (010-046)**  
 Turbocharger Oil Supply Line

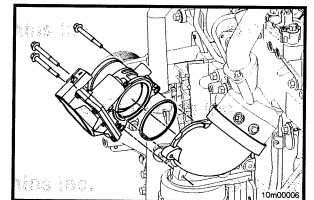
35 N•m	[ 26 ft-lb ]
16 N•m	[ 142 in-lb ]



8 N•m	[ 71 in-lb ]
8 N•m	[ 71 in-lb ]
10 N•m	[ 89 in-lb ]

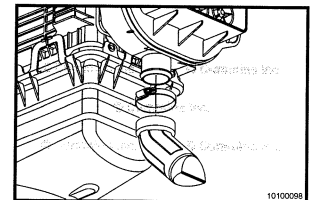
**Air Intake Connection (010-080)**

7 N•m	[ 62 in-lb ]
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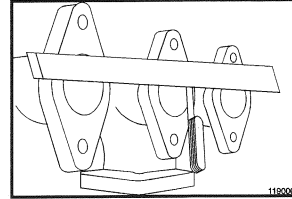


**Dust Ejection Valve (010-146)**  
 Dust Ejection Valve Hose Clamp

10 N•m	[ 89 in-lb ]
5 N•m	[ 44 in-lb ]



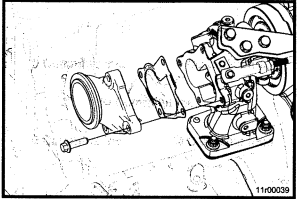
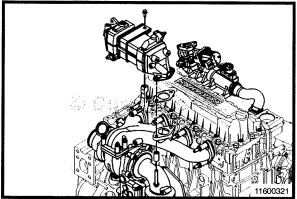
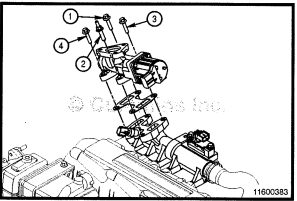
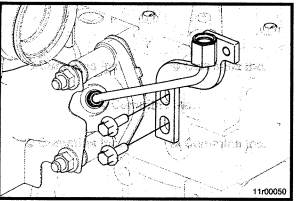
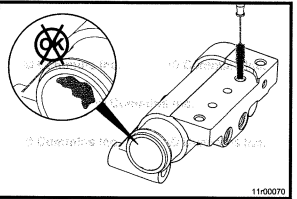
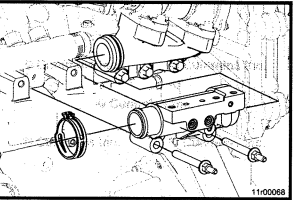
Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
<b>Exhaust System - Group 11 - Specifications</b>			
<b>Exhaust Manifold, Dry (011-007)</b>			
Exhaust Manifold Flatness		0.20 mm MAX	0.008 in
Diesel Exhaust Fluid Injection Volume		106 ml MIN	3.6 fl-oz
		144 ml MAX	4.9 fl-oz
Aftertreatment DEF Dosing Valve Volume Specifications		85 ml MIN	2.9 fl-oz
		115 ml MAX	3.9 fl-oz

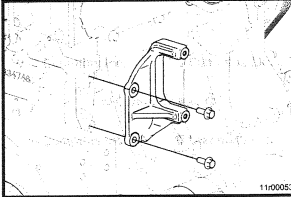
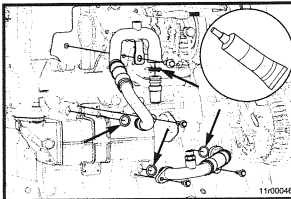
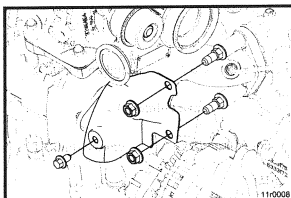
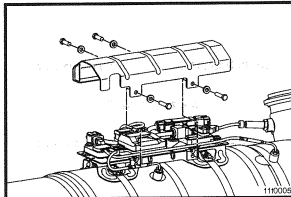
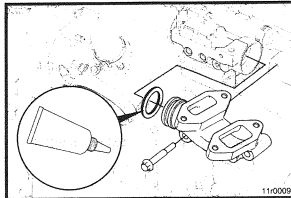
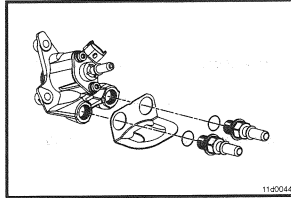


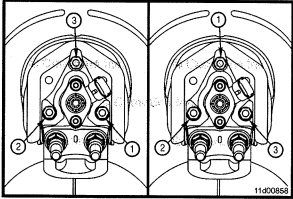
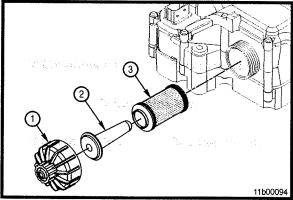
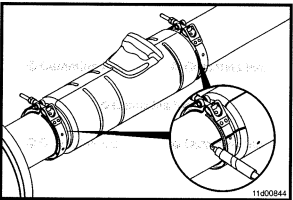
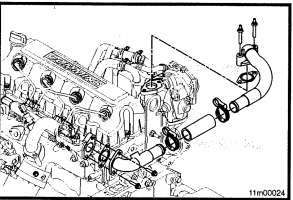
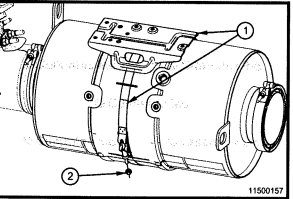


Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
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### Exhaust System - Group 11 - Torque Values

53 N•m [ 39 ft-lb ] 23 N•m [ 204 in-lb ] <b>Exhaust Outlet Connection (011-017)</b>		24 N•m	[ 212 in-lb ]	
<b>EGR Cooler (011-019)</b> Egr Cooler Inlet And Exhaust Capscrews		43 N•m 24 N•m	[ 32 ft-lb ] [ 212 in-lb ]	
2.5 N•m [ 22 in-lb ] <b>EGR Valve (011-022)</b> Egr Valve Mounting Capscrews		18 N•m	[ 159 in-lb ]	
11 N•m [ 97 in-lb ] <b>Exhaust Gas Pressure Sensor Tube (011-027)</b> Exhaust Gas Pressure Sensor Tube Mounting Fastener		24 N•m	[ 212 in-lb ]	
<b>EGR Differential Pressure Sensor Adapter (011-028)</b>		10 N•m	[ 89 in-lb ]	
Pressure Differential Presure Sensor Adapter Capscrews		18 N•m	[ 159 in-lb ]	

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
<b>EGR Cooler Mounting Bracket (011-029)</b>		43 N•m	[ 32 ft-lb ]	
<b>EGR Cooler Coolant Lines (011-031)</b>		9.5 N•m 24 N•m 9.5 N•m	[ 84 in-lb ] [ 212 in-lb ] [ 84 in-lb ]	
<b>Heat Shield (011-032)</b>		33 N•m 24 N•m	[ 24 ft-lb ] [ 212 in-lb ]	
<b>Scr Sensor Table Heat Shield Mounting Capscrew</b>		14 N•m	[ 124 in-lb ]	
<b>EGR Valve Mounting Bracket (011-044)</b>		14 N•m 55 N•m	[ 124 in-lb ] [ 41 ft-lb ]	
<b>Aftertreatment Diesel Exhaust Fluid Dosing Valve (011-059)</b>		18 N•m	[ 159 in-lb ]	

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
		9 N•m	[ 80 in-lb ]	
<b>Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter (011-060)</b> Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter Equalizing Element Cap		20 N•m	[ 177 in-lb ]	
<b>Aftertreatment Decomposition Tube (011-062)</b> V-Band Clamps		14 N•m	[ 124 in-lb ]	
<b>EGR Crossover Tube (011-070)</b>		18 N•m 43 N•m	[ 159 in-lb ] [ 32 ft-lb ]	
<b>Aftertreatment SCR Catalyst Temperature Sensor Interface Module Mounting Bracket (011-076)</b>		7 N•m	[ 62 in-lb ]	
		10 N•m	[ 89 in-lb ]	
		16 N•m	[ 142 in-lb ]	
		10 N•m	[ 89 in-lb ]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
<b>Electrical Equipment - Group 13 - Specifications</b>			
Starting Motor Spacing		49.28 mm	MIN 1.94 in
		52.32 mm	MAX 2.06 in

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
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### Electrical Equipment - Group 13 - Torque Values

40 N•m	[ 30 ft-lb ]
24 N•m	[ 212 in-lb ]
36 N•m	[ 27 ft-lb ]
64 N•m	[ 47 ft-lb ]
40 N•m	[ 30 ft-lb ]
24 N•m	[ 212 in-lb ]
45 N•m	[ 33 ft-lb ]
43 N•m	[ 32 ft-lb ]
4 N•m	[ 35 in-lb ]
21 N•m	[ 186 in-lb ]

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
<b>Engine Testing - Group 14 - Specifications</b>			
Pressure Gauge Capacity		276 kPa	MIN 40 psi
Fuel Filter Restriction Pressure Gauge Capacity		1379 kPa	MIN 200 psi
Lubricating Oil Temperature		90 °C	MIN 194 °F
Fuel Temperature		32 °C	MAX 90 °F



Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
<b>Mounting Adaptations - Group 16 - Specifications</b>			
Flywheel Total Indicator Reading		0.127 mm	MAX 0.0050 in
Flywheel Bore Runout		0.127 mm	MAX 0.005 in



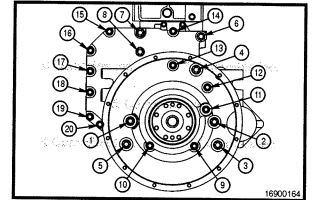
Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.
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**Mounting Adaptations - Group 16 - Torque Values**

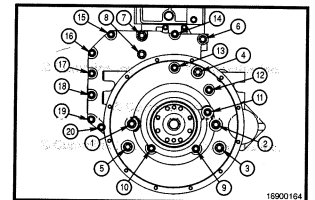
24 N•m	[ 212 in-lb ]
43 N•m	[ 32 ft-lb ]
77 N•m	[ 57 ft-lb ]
80 N•m	[ 60 ft-lb ]
125 N•m	[ 95 ft-lb ]
80 N•m	[ 60 ft-lb ]
115 N•m	[ 85 ft-lb ]
125 N•m	[ 95 ft-lb ]
77 N•m	[ 57 ft-lb ]
30 N•m	[ 22 ft-lb ]
24 N•m	[ 212 in-lb ]

**Flywheel Housing (016-006)**

49 N•m	[ 36 ft-lb ]
85 N•m	[ 63 ft-lb ]



49 N•m	[ 36 ft-lb ]
85 N•m	[ 63 ft-lb ]



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Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
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### Miscellaneous - Group 17 - Torque Values

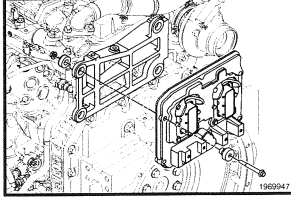
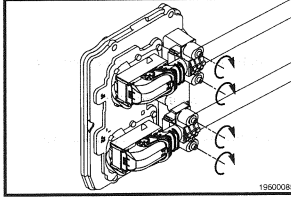
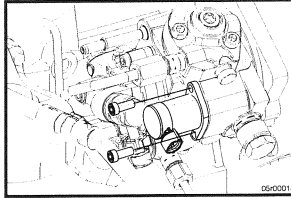
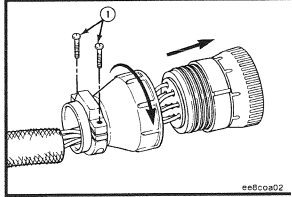
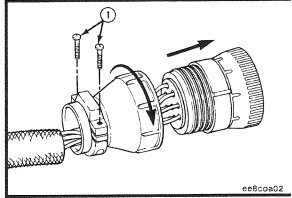
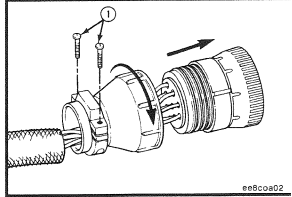
10 N•m	[ 89 in-lb ]
20 N•m	[ 177 in-lb ]
25 N•m	[ 221 in-lb ]
35 N•m	[ 25 ft-lb ]
45 N•m	[ 33 ft-lb ]
18 N•m	[ 160 in-lb ]
25 N•m	[ 221 in-lb ]
30 N•m	[ 22 ft-lb ]
40 N•m	[ 30 ft-lb ]
50 N•m	[ 37 ft-lb ]

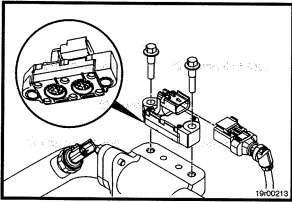
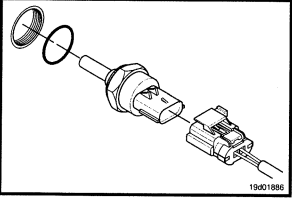
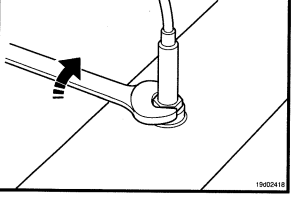
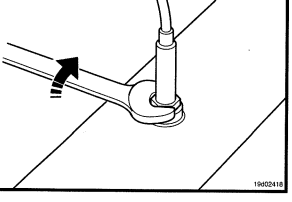
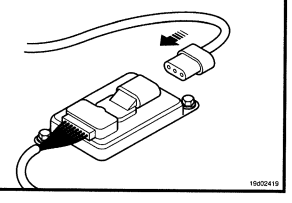
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Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.
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## **Electronic Controls - Group 19 - Specifications**

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
<b>Electronic Controls - Group 19 - Torque Values</b>				
20 N•m [ 177 in-lb ] <b>Engine Control Module (019-031)</b> Engine Control Module (Ecm) Mounting Capscrews And Nuts		18 N•m	[ 159 in-lb ]	
<b>Engine Wiring Harness (019-043)</b> Engine Wiring Harness Hold-Down Clamps		8 N•m	[ 71 in-lb ]	
8 N•m [ 71 in-lb ] 1.5 N•m [ 13 in-lb ] 23 N•m [ 204 in-lb ] 65 N•m [ 48 ft-lb ] 70 N•m [ 52 ft-lb ] <b>Fuel Pump Actuator (019-117)</b> <b>Torque Value:</b> Step 1 4 N•m [ 35 in-lb ] Step 2 9 N•m [ 80 in-lb ]				
3 N•m [ 27 in-lb ] <b>Deutsch HD10 Connector Series (019-207)</b>		1 N•m	[ 9 in-lb ]	
<b>Deutsch HDP20 and HD30 Connector Series (019-208)</b> Clamp Capscrews		1 N•m	[ 9 in-lb ]	
Clamp Capscrews		1 N•m	[ 9 in-lb ]	
8 N•m [ 71 in-lb ]				

Component or Assembly (Procedure)	Ref.No./Steps	Metric	U.S.	
<p>8 N•m [ 71 in-lb ] <b>EGR Differential Pressure Sensor (019-370)</b> Egr Valve Differential Pressure Sensor</p>		18 N•m	[ 159 in-lb ]	
<p>18 N•m [ 159 in-lb ] <b>EGR Temperature Sensor (019-378)</b> Egr Temperature Sensor</p>		20 N•m	[ 177 in-lb ]	
<p>30 N•m [ 22 ft-lb ] <b>Aftertreatment Outlet NOx Sensor (019-451)</b> Nox Sensor Installation Torque</p>		50 N•m	[ 37 ft-lb ]	
<p><b>Aftertreatment Intake NOx Sensor (019-463)</b> Intake Nox Sensor</p>		50 N•m	[ 37 ft-lb ]	
<p>Intake Nox Sensor</p>		14.4 N•m	[ 127 in-lb ]	
<p>7 N•m [ 62 in-lb ] 8 N•m [ 71 in-lb ]</p>				

## General Engine

### Specifications

Listed below are the general specifications for this engine.

Horsepower.....	Refer to engine dataplate
Bore and Stroke.....	102 mm [4.02 in] x 115 mm [4.53 in]
Firing Order.....	1-3-4-2
<b>Engine Weight (with standard accessories):</b>	
Dry Weight for 3.8 liter engine [231 C.I.D.].....	348 kg [767 lb]
Crankshaft Rotation (viewed from the front of the engine).....	<b>Clockwise</b>
<b>Valve Clearance:</b>	
Intake.....	0.330 mm [0.013 in]
Exhaust.....	0.584 mm [0.023 in]
Maximum Overspeed Capability (15 seconds maximum).....	3750 rpm
Minimum Ambient Air Temperature for Unaided Cold Start.....	- 12.2°C [10°F]
Minimum Engine Cranking Speed.....	120 rpm
Engine Idle Speed.....	700 rpm
<b>Altitude Maximum Before Derate Occurs</b>	
3.8 liter engine.....	1676 m [5500 ft]
<b>Oil Carryover:</b>	
Open crankcase ventilation system.....	Less than 2 grams/hour [0.07 oz/hr]
<b>Engine Blowby (with orifice size 5.61 mm [0.221 in]):</b>	
New.....	101.6 mm H <sub>2</sub> O [ 4.0 in H <sub>2</sub> O]
Used.....	431.8 mm H <sub>2</sub> O [ 17.0 in H <sub>2</sub> O]

**NOTE:** The engine features a no-adjust overhead. Adjustment of the valve lash is **not** required for normal service during the first 5000 hours. The valve train operates acceptably within the limits of 0.229 to 0.457 mm [0.009 to 0.018 in] intake valve lash and 0.457 to 0.838 mm [0.018 to 0.033 in] exhaust valve lash. It is recommended that the valve lash be checked at 5000 hours and every 2000 hours thereafter.

## Fuel System

### Specifications

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

Maximum Fuel Inlet Restriction - With gear pump <b>only</b> (at gear pump inlet).....	14 kPa [12 in-Hg]
Rail Pressure.....	250 to 2,000 bar [3,626 to 29,008 psi]
Maximum Fuel Pressure Range at Fuel Filter Outlet (engine cranking) - With gear pump <b>only</b> ....	3.3 kPa [1 in-Hg]
Maximum	
Fuel Pressure Range at Fuel Filter Inlet (engine running) - With gear pump <b>only</b> .....	400 to 810 kPa [58 to 117 psi]
Maximum Fuel Drain Line Restriction.....	20 kPa [5.9 in-Hg]
Maximum Fuel Inlet Temperature.....	70°C [158°F]

## Lubricating Oil System

### Specifications

#### Oil Pressure

Low idle (minimum allowed).....	69 kPa [10 psi]
At rated speed (minimum allowed).....	275 kPa [40 psi]
Oil-regulating valve-opening pressure range.....	525 kPa to 600 kPa [76 psi to 87 psi]
Oil filter differential pressure to open bypass.....	345 kPa [50 psi]
Lubricating oil filter capacity.....	0.85 liters [0.9 qt]

#### Oil Capacity of Standard Engine

##### Low Capacity Rear Sump Oil Pan

Pan <b>only</b> .....	8 liters [8.4 qt]
Total system.....	10.6 liters [11.2 qt]
High to low (on dipstick).....	1.5 liters [1.6 qt]
Maximum Oil Temperature.....	135°C [275°F]

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

- 1 Contact a Cummins® Authorized Repair Location.
- 2 Determine the capacity of the oil pan option for the engine being serviced. Use QuickServe™ Online and the engine serial number.
- 3 Fill the lubricating oil pan to the smallest oil pan capacity listed for the engine being serviced. Then add 0.95 liters [1 qt] of oil at a time until it reaches the high mark on the dipstick. Record the number of quarts added, so that the capacity is known the next time the oil is drained.



## Cooling System

### Specifications

Engine Coolant Capacity.....	7.3 liters [7.7 qt]
Standard Modulating Thermostat - Range.....	82 to 95°C [180 to 203°F]
Maximum Allowed Operating Temperature.....	107°C [225°F]
Minimum Recommended Operating Temperature.....	70°C [158°F]
Minimum Recommended Pressure Cap at Sea Level.....	90 kPa [13 psi]

## Air Intake System

### Specifications

**Maximum Intake Restriction:**

Clean Air Filter Element.....3.71 kPa / 378 mm H<sub>2</sub>O [15 in H<sub>2</sub>O]  
Dirty Air Filter Element.....6.2 kPa / 632 mm H<sub>2</sub>O [25 in H<sub>2</sub>O]

**Charge-Air Cooler Temperature Differential:**

Maximum Differential.....30°C [86°F]

**Charge-Air Cooler Pressure Differential:**

Maximum Charge-Air Cooler Pressure Drop.....13.5 kPa [1.96 psi]  
Recommended Intake Piping Size.....76 mm [3 in]

## Exhaust System

### Specifications

Maximum Back Pressure (imposed by complete exhaust system).....	18 kPa [5.3 Hg]
Exhaust Pipe Size (normally acceptable inside diameter).....	75 mm [3 in]

## Electrical System

### Specifications

#### Recommended Battery Capacity

System Voltage	Ambient Temperature			
	-18°C [0°F]		-29°C [-20°F]	
	Cold Cranking Amperes	Reserve Capacity (minutes) <sup>1</sup>	Cold Cranking Amperes	Reserve Capacity (minutes) <sup>1</sup>
12-VDC	950	180	1200	180
24-VDC <sup>2</sup>	550	130	700	130

<sup>1</sup>The number of plates within a given battery size determines reserve capacity. Reserve capacity is the length of time for which a battery at 27°C [81°F] can supply 25 amperes at 10.5-VDC or greater.

<sup>2</sup>Cold cranking amperes are based on two 12-VDC batteries in series.

#### Batteries (Specific Gravity)

Specific Gravity at 27°C [81°F]	State of Charge
1.260 to 1.280	100%
1.230 to 1.250	75%
1.200 to 1.220	50%
1.170 to 1.190	25%
1.110 to 1.130	Discharged

## 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 <sup>2</sup>	sq. millimeters	mm <sup>2</sup>	645.16	0.001550
			sq. centimeters	cm <sup>2</sup>	6.452	0.155
	sq. foot	ft <sup>2</sup>	sq. meter	m <sup>2</sup>	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 <sub>2</sub> O	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 <sub>2</sub> O	millimeters of water	mm H <sub>2</sub> O	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 × °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 <sup>3</sup>	liter	l	0.01639	61.02545
	cubic inch	in <sup>3</sup>	cubic centimeter	cm <sup>3</sup>	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

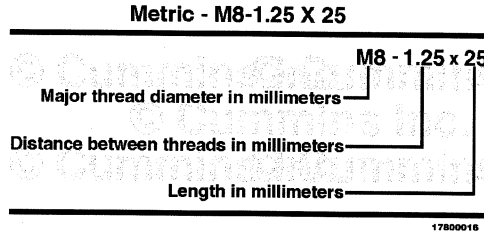
### General Information



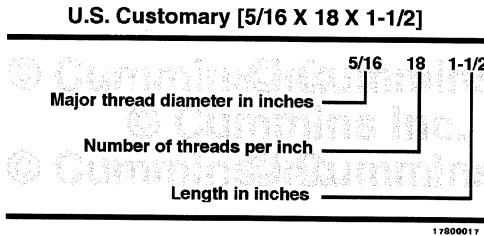
When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using the wrong capscrews can result in engine damage.

Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts. U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

The following examples indicate how capscrews are identified:



- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.



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### Capscrew Markings and Torque Values - Metric

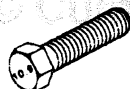
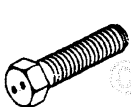
**Commercial Steel Class**

**8.8**

**10.9**

**12.9**

**Capscrew Head Markings**


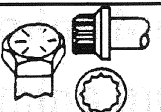




17800014

Body Size	Torque				Torque				Torque			
	Cast Iron		Aluminium		Cast Iron		Aluminium		Cast Iron		Aluminium	
	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
6	9	5	7	4	13	10	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7

Body Size	Torque				Torque				Torque			
	Cast Iron		Aluminium		Cast Iron		Aluminium		Cast Iron		Aluminium	
Diameter	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
8	23	17	18	14	33	25	18	14	40	29	18	14
10	45	33	30	25	65	50	30	25	70	50	30	25
12	80	60	55	40	115	85	55	40	125	95	55	40
14	125	90	90	65	180	133	90	65	195	145	90	65
16	195	140	140	100	280	200	140	100	290	210	140	100
18	280	200	180	135	390	285	180	135	400	290	180	135
20	400	290	—	—	550	400	—	—	—	—	—	—

**Capscrew Markings and Torque Values - U.S. Customary**

<b>SAE Grade Number</b>	5	8	
<b>Capscrew Head Markings</b>			17800015
These are all SAE Grade 5 (3 line)			
			
<b>Capscrew Torque - Grade 5 Capscrew</b>		<b>Capscrew Torque - Grade 8 Capscrew</b>	

Capscrew Body Size	Cast Iron		Aluminium		Cast Iron		Aluminium	
	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1/4 - 20	9	7	8	6	15	11	8	6
1/4 - 28	12	9	9	7	18	13	9	7
5/16 - 18	20	15	16	12	30	22	16	12
5/16 - 24	23	17	19	14	33	24	19	14
3/8 - 16	40	30	25	20	55	40	25	20
3/8 - 24	40	30	35	25	60	45	35	25
7/16 - 14	60	45	45	35	90	65	45	35
7/16 - 20	65	50	55	40	95	70	55	40
1/2 - 13	95	70	75	55	130	95	75	55
1/2 - 20	100	75	80	60	150	110	80	60
9/16 - 12	135	100	110	80	190	140	110	80
9/16 - 18	150	110	115	85	210	155	115	85
5/8 - 11	180	135	150	110	255	190	150	110
5/8 - 18	210	155	160	120	290	215	160	120
3/4 - 10	325	240	255	190	460	340	255	190
3/4 - 16	365	270	285	210	515	380	285	210
7/8 - 9	490	360	380	280	745	550	380	280
7/8 - 14	530	390	420	310	825	610	420	310
1 - 8	720	530	570	420	1100	820	570	420
1 - 14	800	590	650	480	1200	890	650	480

## 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 Size	Tap Size		Drill Size	Tap Size		Drill Size	Tap Size		Drill Size
60%	75%		60%	75%		60%	75%		60%	75%	
		48			4.40mm						
		1.95mm			16						
		5/64			4.50mm						
	3-48	47			15						
	M2.5x.45	2.00mm			4.60mm						
		2.05mm			14						
		46			13						
3-48	3056	45			4.70mm						
		2.10mm			4.75mm						
M2.5x.45	M2.6x.45	2.15mm			3/16						
3-56	4-36	44			12						
		2.20mm			4.80mm						
M2.6x.45		2.25mm			11						
4-36	4-40	43			4.90mm						
		2.30mm			10						
		2.35mm			9						
4-40	4-48	42			5.00mm						
		3/32			8						
	M3x.6	2.40mm			5.10mm						
		41			7						
		2.45mm			13/64						
		40			6						
M3x.6	M3x.5	2.50mm			5.20mm						
		39			5						
		38			5.25mm						
M3x.5	5-40	2.60mm			5.30mm						
5-40	5-44	37			4						
		2.70mm			5.40mm						
	6-32	36			3						
5-44		2.75mm			5.50mm						
		7/64			7/32						
		35			5.60mm						
		2.80mm			2						
		34			5.70mm						
	6-40	33			5.75mm						
	M3.5x6	2.90mm			1						
6-40		32			5.80mm						
		3.00mm			5.90mm						
		31			A						
		3.10mm			15/64						
		1/8			6.00mm						
		3.20mm			B						
	M4x.75	3.25mm			6.10mm						
		30			C						
	M4x.7	3.30mm			6.20mm						
M4x.75		3.40mm			D						
M4x.7	8-32	29			6.25mm						
		3.50mm			6.30mm						
	8-36	28			E						
8-32		9/64			1/4						
8-36		3.60mm			6.40mm						
		27			6.50mm						
		3.70mm			F						
		26			6.60mm						
	M4.5x.75	3.75mm			G						
	10-24	25			6.70mm						
		3.80mm			17/64						
		24			6.75mm						
M4.5x.75		3.90mm			H						
		23			6.80mm						
		5/32			6.90mm						
		22			I						
	M5x1	4.00mm			7.00mm						
	10-32	21			J						
		20			7.10mm						
		4.10mm			K						
M5x1	M5x.9	4.20mm			9/32						
10-32	M5x.8	19			7.20mm						
M5x.9		4.25mm			7.25mm						
M5x.8		4.30mm			7.30mm						
		18			L						
		11/64			7.40mm						
		17			M						
					12-24						
					16						
					4.50mm						
					15						
					4.60mm						
					14						
					13						
					4.70mm						
					4.75mm						
					3/16						
					12						
					4.80mm						
					11						
					4.90mm						
					10						
					9						
					5.00mm						
					8						
					5.10mm						
					7						
					13/64						
					6						
					5.20mm						
					5						
					5.25mm						
					5.30mm						
					4						
					5.40mm						
					3						
					5.50mm						
					7/32						
					5.60mm						
					2						
					5.70mm						
					5.75mm						
					1						
					5.80mm						
					5.90mm						
					A						
					15/64						
					6.00mm						
					B						
					6.10mm						
					C						
					6.20mm						
					D						
					6.25mm						
					6.30mm						
					E						
					1/4						
					6.40mm						
					6.50mm						
					F						
					6.60mm						
					G						
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					17/64						
					6.75mm						
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					J						
					7.10mm						
					K						
					9/32						
					7.20mm						
					7.25mm						
					7.30mm						
					L						
					7.40mm						
					M						
					4.40mm						
					16						
					4.50mm						
					15						
					4.60mm						
					14						
					13						
					4.70mm						
					4.75mm						
					3/16						
					12						
					4.80mm						

## 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

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