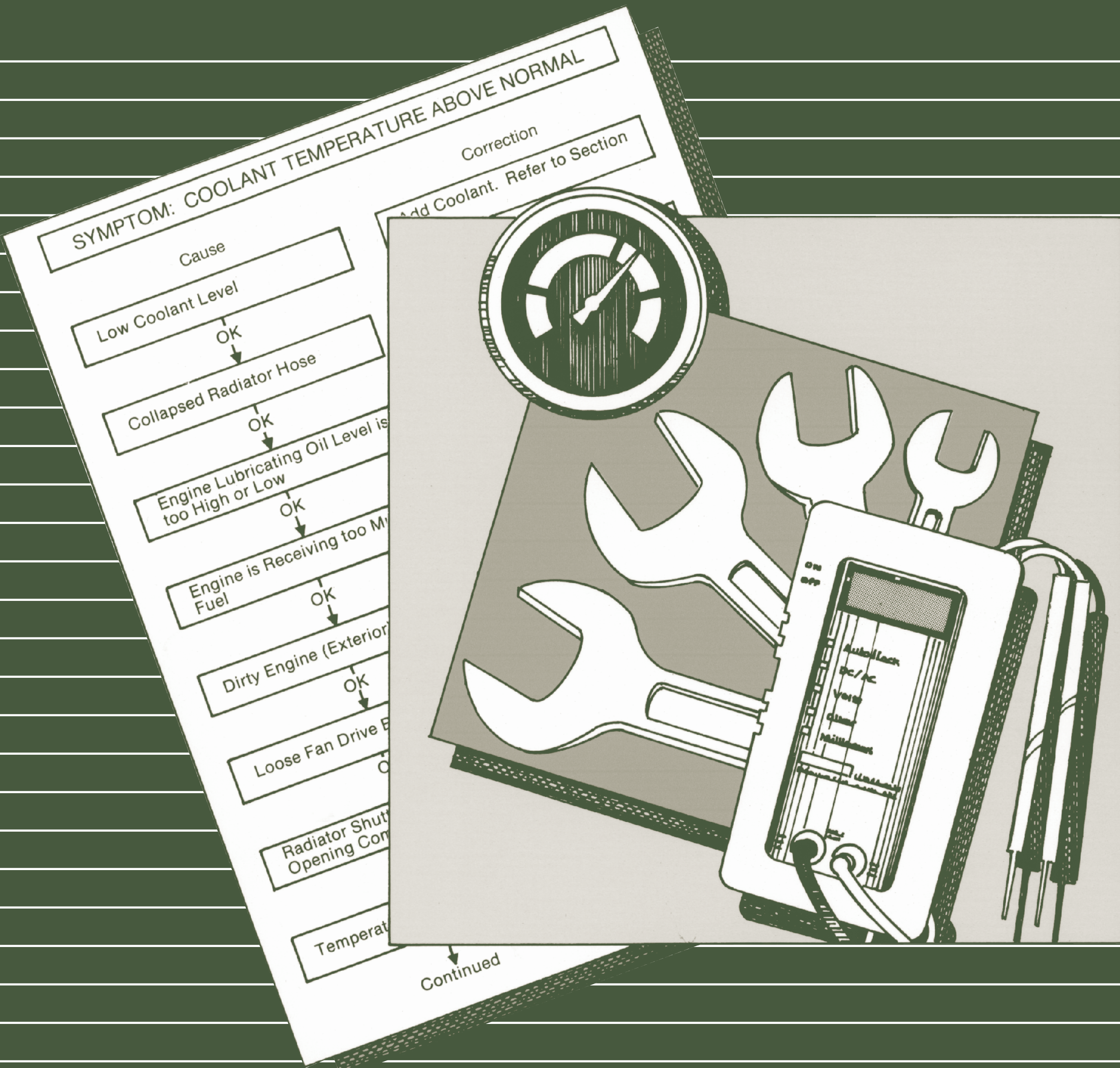
Troubleshooting and Repair Manual ISB, ISBe2, ISBe3, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, ISLe3, ISLe4, and QSL9, CM850 Electronic Control System Volume 4



Troubleshooting and Repair Manual
ISB, ISBe2, ISBe3, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, ISLe3, ISLe4, and QSL9, CM850 Electronic Control System
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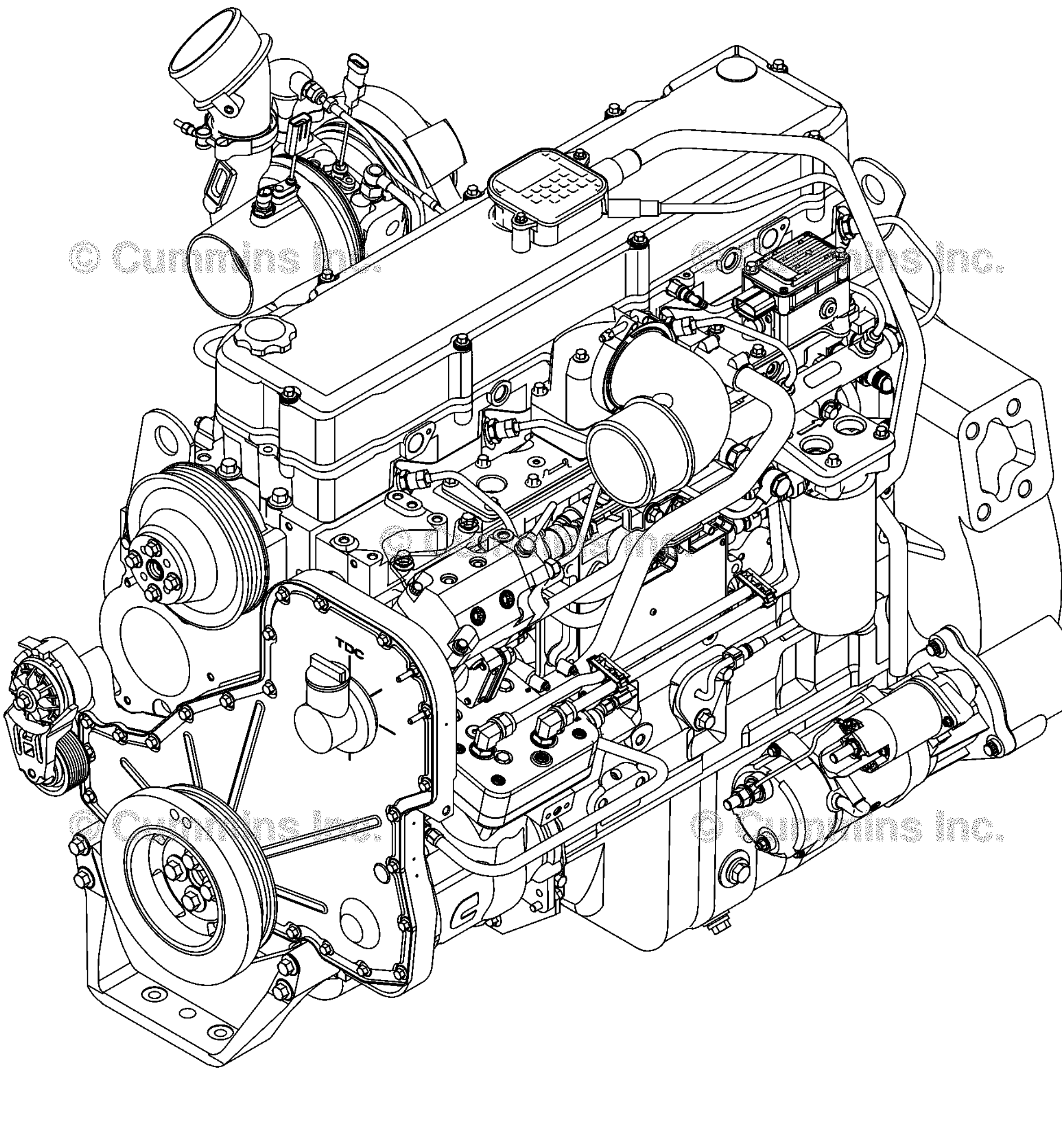

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Foreword

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

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

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

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

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

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

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

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

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Section i - Introduction

Section Contents

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About the Manual

General Information

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

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

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

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

How to Use the Manual

General Information

This manual is organized to provide an easy flow from problem identification to problem correction.

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

1 Locate the symptom on the Section Contents pages of Section TS.
   - Reference to the page number where the Troubleshooting Symptom Tree is found is made to the right of the symptom tree title.

2 The left column of boxes in the Troubleshooting Symptom Charts indicates a probable cause of the problem, starting at the top with the simplest and easiest to repair, and continuing downward to the most difficult.
   - The right column of boxes provides a brief description of the corrective action with a reference number to the correct procedure used to make the repair.

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

4 The Troubleshooting Symptom Charts are based on the following assumptions:
   - The components have been installed according to the manufacturer's specifications.
   - The easiest repairs are done first.
   - All generic solutions are designed for the most common applications and Original Equipment Manufacturer (OEM).

Refer to the Original Equipment Manufacturer's service manual for their specifications.

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.

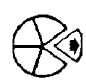
WARNING

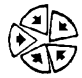
Serious personal injury or extensive property damage can result if the warning instructions are not followed.

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.

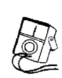
PERFORM a mechanical or time **MEASUREMENT**.

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.

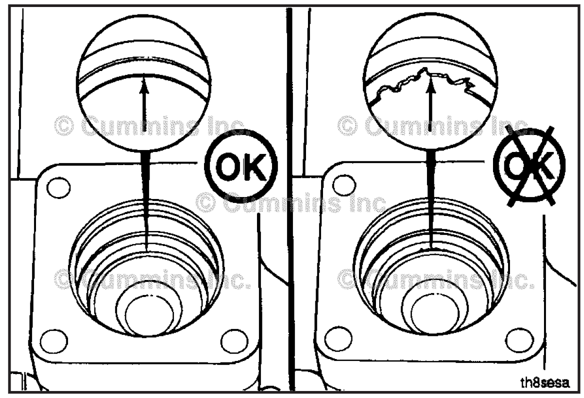
To reduce the risk of high voltage shock, always follow all warnings and service instructions. Always assume the vehicle and its high voltage system are energized, even if the engine is not running.

Approved high voltage insulated gloves are required for this procedure.

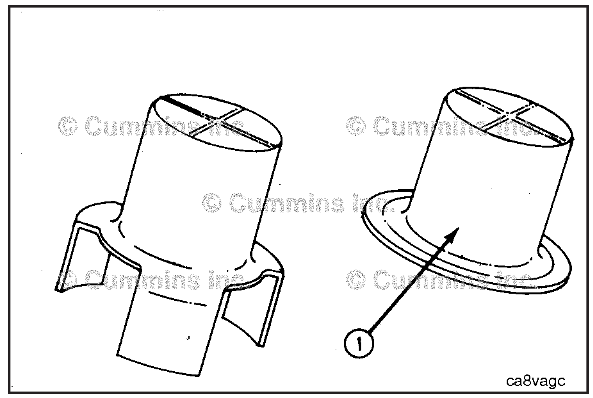
Illustrations

General Information

Some of the illustrations throughout this manual are generic and will **not** look exactly like the engine or parts used in your application. The illustrations can contain symbols to indicate an action required and an acceptable or **not** acceptable condition.



The illustrations are intended to show repair or replacement procedures. The procedure will be the same for all applications, although the illustration can differ.



General Safety Instructions

Important Safety Notice

WARNING

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

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

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

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

General Repair Instructions

General Information

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

WARNING

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

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

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

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

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

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

Welding on a Vehicle with an Electronic Controlled Fuel System

⚠CAUTION⚠

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

General Cleaning Instructions

Definition of Clean

Parts **must** be free of debris that can contaminate any engine system. This does **not** necessarily mean they have to appear as new.

Sanding gasket surfaces until the factory machining marks are disturbed adds no value and is often harmful to forming a seal. It is important to maintain surface finish and flatness tolerances to form a quality sealing surface. Gaskets are designed to fill small voids in the specified surface finish.

Sanding gasket surfaces where edge-molded gaskets are used is most often unnecessary. Edge-molded gaskets are those metal carriers with sealing material bonded to the edges of the gasket to seal while the metal portion forms a metal to metal joint for stability. Any of the small amounts of sealing material that can stick to the parts are better removed with a blunt-edged scraper on the spots rather than spending time polishing the whole surface with an air sander or disc.

For those gaskets that do **not** have the edge molding, nearly all have a material that contains release agents to prevent sticking. Certainly this is **not** to say that some gaskets are **not** difficult to remove because the gasket has been in place a long time, has been overheated or the purpose of the release agent has been defeated by the application of some sealant. The object however is just to remove the gasket without damaging the surfaces of the mating parts without contaminating the engine (don't let the little bits fall where they can not be removed).

Bead blasting piston crowns until the dark stain is removed is unnecessary. All that is required is to remove the carbon build-up above the top ring and in the ring grooves. There is more information on bead blasting and piston cleaning later in this document.

Cummins Inc. does **not** recommend sanding or grinding the carbon ring at the top of cylinder liners until clean metal is visible. The liner will be ruined and any signs of a problem at the top ring reversal point (like a dust-out) will be destroyed. It is necessary to remove the carbon ring to provide for easier removal of the piston assembly. A medium bristle, high quality, steel wire wheel that is rated above the rpm of the power tool being used will be just as quick and there will be less damage. Yes, one **must** look carefully for broken wires after the piston is removed but the wires are more visible and can be attracted by a magnet.

Oil on parts that have been removed from the engine will attract dirt in the air. The dirt will adhere to the oil. If possible, leave the old oil on the part until it is ready to be cleaned, inspected and installed, and then clean it off along with any attracted dirt. If the part is cleaned then left exposed it can have to be cleaned again before installation. Make sure parts are lubricated with clean oil before installation. They do **not** need to be oiled all over but do need oil between moving parts (or a good lube system priming process conducted before cranking the engine).

Bead blasting parts to remove exterior paint is also usually unnecessary. The part will most likely be painted again so all that needs happen is remove any loose paint.

Abrasive Pads and Abrasive Paper

The keyword here is "abrasive". There is no part of an engine designed to withstand abrasion. That is they are all supposed to lock together or slide across each other. Abrasives and dirt particles will degrade both functions.

⚠WARNING⚠

Abrasive material must be kept out of or removed from oil passages and parts wear points. Abrasive material in oil passages can cause bearing and bushing failures that can progress to major component damage beyond reuse. This is particularly true of main and rod bearings.

Cummins Inc. does **not** recommend the use of emery cloth or sand paper on any part of an **assembled** engine or component including but **not** limited to removing the carbon ridge from cylinder liners or to clean block decks or counterbores.

Great care **must** be taken when using abrasive products to clean engine parts, particularly on partially assembled engines. Abrasive cleaning products come in many forms and sizes. All of them contain aluminum oxide particles, silicon carbide, or sand or some other similar hard material. These particles are harder than most of the parts in the engine. Since they are harder, if they are pressed against softer material they will either damage the material or become embedded in it. These materials fall off the holding media as the product is used. If the products are used with power equipment the particles are thrown about the engine. If the particles fall between two moving parts, damage to the moving parts is likely.

If particles that are smaller than the clearance between the parts while they are at rest (engine stopped), but larger than the running clearance then damage will occur when the parts move relative to each other (engine started). While the engine is running and there is oil pressure, particles that are smaller than the bearing clearance are likely to pass between the parts without damage and be trapped in the oil filter. However, particles larger than the bearing clearance will remove material from one part and can become embedded in one of the parts. Once embedded in one part it will abrade the other part until contact is no longer being made between the two parts. If the damage sufficiently degrades the oil film, the two parts will come into contact resulting in early wear-out or failure from lack of effective lubrication.

Abrasive particles can fly about during cleaning it is **very** important to block these particles from entering the engine as much as possible. This is particularly true of lubricating oil ports and oil drilling holes, especially those located downstream of the lubricating oil filters. Plug the holes instead of trying to blow the abrasive particles and debris with compressed air because the debris is often simply blown further into the oil drilling.

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

WARNING

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

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

Gasket Surfaces

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

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

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

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

Solvent and Acid Cleaning

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

WARNING

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

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

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

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

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

Remove all the gasket material, o-rings, and the deposits of sludge, carbon, etc., with a wire brush or scraper before putting the parts in a cleaning tank. Be careful to **not** damage any gasket surfaces. When possible use hot high pressure water or steam clean the parts before putting them in the cleaning tank. Removing the heaviest dirt before placing in the tank will allow the cleaner to work more effectively and the cleaning agent will last longer.

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

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

Steam Cleaning

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

WARNING

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

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

- Electrical Components
- Wiring Harnesses
- Belts and Hoses
- Bearings (ball or taper roller)
- Electronic Control Module (ECM)
- ECM Connectors
- Capacitive Coil Driver Module (CCD)
- Ignition Coils and Leads
- NOx Sensor
- Fuel Control Valve
- Throttle Driver and Actuator.

Plastic Bead Cleaning

Cummins Inc. does **not** recommend the use of glass bead blast or walnut shell media on **any** engine part. Cummins Inc. recommends using **only** plastic bead media, Part Number 3822735 or equivalent on any engine part. **Never** use sand as a blast media to clean engine parts. Glass and walnut shell media when **not** used to the media manufacturer's recommendations can cause excess dust and can embed in engine parts that can result in premature failure of components through abrasive wear.

Plastic bead cleaning can be used on many engine components to remove carbon deposits. The cleaning process is controlled by the use of plastic beads, the operating pressure and cleaning time.

CAUTION

Do not use bead blasting cleaning methods on aluminum pistons skirts or the pin bores in any piston, piston skirt or piston crown. Small particles of the media will embed in the aluminum or other soft metal and result in premature wear of the cylinder liner, piston rings, pins and pin bores. Valves, turbocharger shafts, etc., can also be damaged. Follow the cleaning directions listed in the procedures.

CAUTION

Do not contaminate wash tanks and tank type solvent cleaners with the foreign material and plastic beads. Remove the foreign material and plastic beads with compressed air, hot high pressure water or steam before placing them in tanks or cleaners. The foreign material and plastic beads can contaminate the tank and any other engine parts cleaned in the tank. Contaminated parts may cause failures from abrasive wear.

Plastic bead blasting media, Part Number 3822735, can be used to clean all piston ring grooves. Do **not** sure any bead blasting media on piston pin bores or aluminum skirts.

Follow the equipment manufacturer's cleaning instructions. Make sure to adjust the air pressure in the blasting machine to the bead manufacturer's recommendations. Turning up the pressure can move material on the part and cause the plastic bead media to wear out more quickly. The following guidelines can be used to adapt to manufacturer's instructions:

1 Bead size: U.S. size Number 16 — 20 for piston cleaning with plastic bead media, Part Number 3822735

2 Operating Pressure — 270 kPa (40 psi) for piston cleaning. Pressure should not cause beads to break.

3 Steam clean or wash the parts with solvent to remove all of the foreign material and plastic beads after cleaning. Rinse with hot water. Dry with compressed air.

CAUTION

The bead blasting operation must not disturb the metal surface. If the metal surface is disturbed the engine can be damaged due to increased parts clearance or inadequate surface finish on parts that move against other parts.

When cleaning pistons, it is **not** necessary to remove all the dark stain from the piston. All that is necessary is to remove the carbon on the rim and in the ring grooves. This is best done by directing the blast across the part as opposed to straight at the part. If the machining marks are disturbed by the blasting process, then the pressure is too high or the blast is being held on one spot too long. The blast operation **must not** disturb the metal surface.

Walnut shell bead blast material is sometimes used to clean ferrous metals (iron and steel). Walnut shell blasting produces a great amount of dust particularly when the pressure if the air pressure on the blasting machine is increased above media manufacturer's recommendation. Cummins Inc. recommends **not** using walnut shell media to clean engine parts due to the risk media embedment and subsequent contamination of the engine.

Cummins Inc. now recommends glass bead media **NOT** used to clean any engine parts. Glass media is too easily embedded into the material particularly in soft materials and when air pressures greater than media manufacturer's recommend are used. The glass is an abrasive so when it is in a moving part, that part is abrading all the parts in contact with it. When higher pressures are used the media is broken and forms a dust of a very small size that floats easily in the air. This dust is very hard to control in the shop, particularly if **only** compressed air (and not hot water) is used to blow the media after it is removed from the blasting cabinet (blowing the part off inside the cabinet may remove large accumulations but never removes all the media).

Bead blasting is best used on stubborn dirt/carbon build-up that has **not** been removed by first steam/higher pressure washing then washing in a heated wash tank. This is particularly true of pistons. Steam and soak the pistons first then use the plastic bead method to safely remove the carbon remaining in the grooves (instead of running the risk of damaging the surface finish of the groove with a wire wheel or end of a broken piston ring. Make sure the parts are dry and oil free before bead blasting to prevent clogging the return on the blasting machine.

Always direct the bead blaster nozzle "across" rather than directly at the part. This allows the bead to get under the unwanted material. Keep the nozzle moving rather than hold on one place. Keeping the nozzle directed at one-place too long causes the metal to heat up and be moved around. Remember that the spray is **not** just hitting the dirt or carbon. If the machining marks on the piston groove or rim have been disturbed then there has **not** been enough movement of the nozzle and/or the air pressure is too high.

Never bead blast valve stems. Tape or use a sleeve to protect the stems during bead blasting. Direct the nozzle across the seat surface and radius rather than straight at them. The object is to remove any carbon build up and continuing to blast to remove the stain is a waste of time.

Fuel System

When servicing any fuel system components, which can be exposed to potential contaminants, prior to disassembly, clean the fittings, mounting hardware, and the area around the component to be removed. If the surrounding areas are **not** cleaned, dirt or contaminants can be introduced into the fuel system.

The internal drillings of some injectors are extremely small and susceptible to plugging from contamination. Some fuel injection systems can operate at very high pressures. High pressure fuel can convert simple particles of dirt and rust into a highly abrasive contaminant that can damage the high pressure pumping components and fuel injectors.

Electrical contact cleaner can be used if steam cleaning tools are **not** available. Use electrical contact cleaner rather than compressed air, to wash dirt and debris away from fuel system fittings. Diesel fuel on exposed fuel system parts attracts airborne contaminants.

Choose lint free towels for fuel system work.

Cap and plug fuel lines, fittings, and ports whenever the fuel system is opened. Rust, dirt, and paint can enter the fuel system whenever a fuel line or other component is loosened or removed from the engine. In many instances, a good practice is to loosen a line or fitting to break the rust and paint loose, and then clean off the loosened material.

When removing fuel lines or fittings from a new or newly-painted engine, make sure to remove loose paint flakes/chips that can be created when a wrench contacts painted line nuts or fittings, or when quick disconnect fittings are removed.

Fuel filters are rated in microns. The word micron is the abbreviation for a micrometer, or one millionth of a meter. The micron rating is the size of the smallest particles that will be captured by the filter media. As a reference, a human hair is 76 microns [0.003 in] in diameter. One micron measures 0.001 mm [0.00004 in.]. The contaminants being filtered out are smaller than can be seen with the human eye, a magnifying glass, or a low powered microscope.

The tools used for fuel system troubleshooting and repair are to be cleaned regularly to avoid contamination. Like fuel system parts, tools that are coated with oil or fuel attract airborne contaminants. Remember the following points regarding your fuel system tools:

- Fuel system tools are to be kept as clean as possible.
- Clean and dry the tools before returning them to the tool box.
- If possible, store fuel system tools in sealed containers.
- Make sure fuel system tools are clean before use.

Acronyms and Abbreviations

General Information

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

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society of Testing and Materials
ATDC	After Top Dead Center
BTU	British Thermal Unit
BTDC	Before Top Dead Center
°C	Celsius
CAN	Controller Area Network
CO	Carbon Monoxide
CCA	Cold Cranking Amperes
CARB	California Air Resources Board
C.I.B.	Customer Interface Box
C.I.D.	Cubic Inch Displacement
CNG	Compressed Natural Gas
CPL	Control Parts List
cSt	Centistokes
DEF	Diesel Exhaust Fluid
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
ECM	Engine Control Module
EFC	Electronic Fuel Control
EGR	Exhaust Gas Recirculation
EPA	Environmental Protection Agency
°F	Fahrenheit
ft-lb	Foot-Pound Force
FMI	Failure Mode Indentifier
GVW	Gross Vehicle Weight
Hg	Mercury
hp	Horsepower
H_2O	Water
inHg	Inches of Mercury
in H_20	Inches of Water
ICM	Ignition Control Module
IEC	International Electrotechnical Commission
km/l	Kilometers per Liter
kPa	Kilopascal
LNG	Liquid Natural Gas
LPG	Liquified Petroleum Gas
LTA	Low Temperature Aftercooling
MCRS	Modular Common Rail System
MIL	Malfunction Indicator Lamp
MPa	Megapascal
mph	Miles Per Hour
mpq	Miles Per Quart
N•m	Newton-meter

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

Section TF - Troubleshooting Fault Codes

Section Contents

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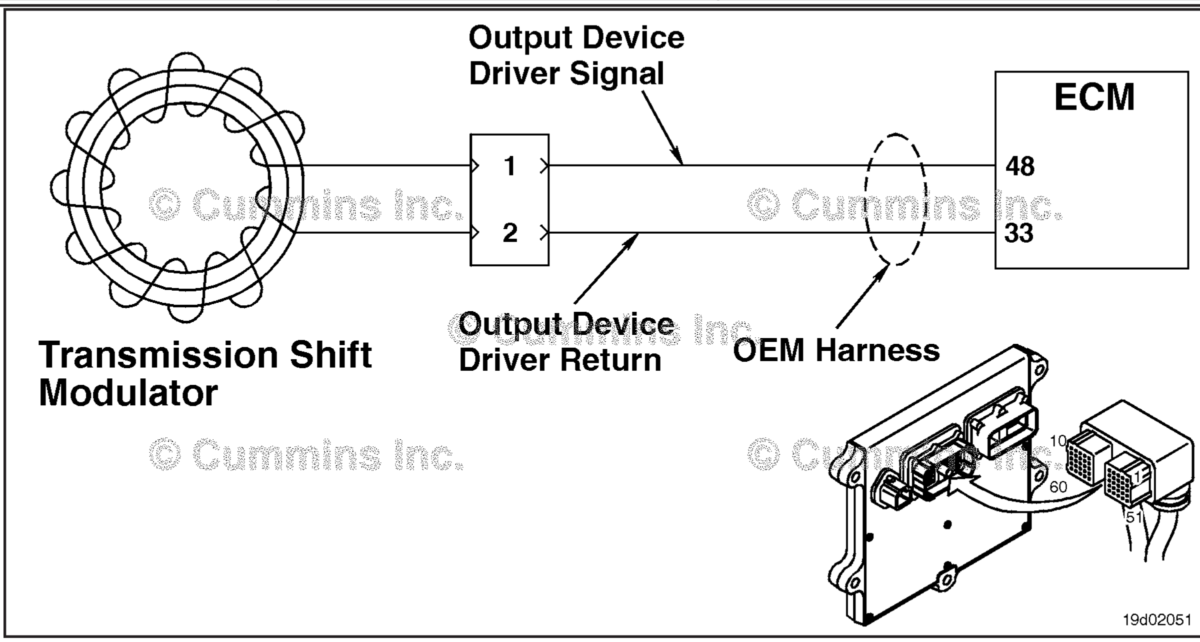
Fault Code 2557

Auxiliary PWM Driver #1 - Voltage Above Normal or Shorted to High Source

CODES	REASON	EFFECT
Fault Code: 2557 PID(P), SID(S): S057 SPN: 697 FMI: 3 Lamp: Amber SRT:	Auxiliary PWM Driver #1 - Voltage Above Normal or Shorted to High Source. High signal voltage detected at the analog torque circuit.	Can **not** control transmission.



Auxiliary PWM Driver #1 Circuit

Circuit Description:

The transmission shift modulator uses this signal from the ECM to determine when to shift the transmission. The return circuit is dependent on OEM wiring. It may be wired back to the ECM on some vehicles or wired to chassis or block ground on others. Consult the OEM wiring diagram for return circuit details.

Component Location:

Refer to the OEM diagram for the location of the transmission shift modulator.

Shop Talk:

The default setting for Transmission PWM output Type in INSITE™ electronic service tool is 80/65. The PWM output only has meaning with non-electronic Allison Transmission™ AT545. Older software and ECMs had no diagnostics on this output and having the default set at 86/50 was of no consequence. Newer software and ECMs do have a diagnostic if this output is selected but no hardware is connected. FC 2557 will be logged. Setting Transmission PWM Output Type in INSITE™ electronic service tool to NONE may clear the fault code.

This fault can be caused by the following:

- A faulty transmission shift modulator
- An open circuit in the output device driver return line
- A short pin to pin in the output device driver line.

Refer to Troubleshooting Fault Code t05-2557

FAULT CODE 2557 - Auxiliary PWM Driver #1 - Voltage Above Normal or Shorted to High Source

TROUBLESHOOTING SUMMARY

CAUTION

To reduce the possibility of damaging a new ECM, all other active fault codes must be investigated prior to replacing the ECM.

CAUTION

To reduce the possibility of pin and harness damage, use the following test leads when taking a measurement: Part Number 3822758 - male Deutsch™/AMP™/Metri-Pack™ test lead and Part Number 3822917 - female Deutsch™/AMP™/Metri-Pack™ test lead.

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the fault codes.**		
STEP 1A:	Check for an inactive fault code.	Fault Code 2557 inactive?	
STEP 2:	**Check the transmission shift modulator and circuit.**		
STEP 2A:	Inspect the transmission shift modulator and connector pins.	Dirty or damaged pins?	
STEP 2B:	Check the resistance of the transmission shift modulator.	Less than 2.2k ohms?	
STEP 2C:	Check the transmission shift modulator diagnostic supply voltage, supply line and return circuit.	Greater than 5-VDC?	
STEP 2D:	Check for an open circuit in the output device driver return circuit.	Less than 10 ohms?	
STEP 3:	**Check the ECM and OEM harness.**		
STEP 3A:	Inspect the ECM and OEM harness connector pins.	Dirty or damaged pins?	
STEP 3B:	Check for an open circuit in the OEM harness.	Less than 10 ohms?	
STEP 3C:	Check for a pin to pin short circuit in the OEM harness.	Greater than 100k ohms?	
STEP 3D:	Check for an inactive fault code.	Fault Code 2557 inactive?	
STEP 4:	**Clear the fault code.**		
STEP 4A:	Disable the fault code.	Fault Code 2557 inactive?	
STEP 4B:	Clear the inactive fault codes.	All fault codes cleared?	

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for an inactive fault code.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for an inactive fault code. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 2557 inactive? **YES**	Use the following procedure for an inactive or intermittent fault code. Refer to Procedure 019-362 in Section 19.
	Fault Code 2557 inactive? **NO**	2A

STEP 2: Check the transmission shift modulator and circuit.

STEP 2A: Inspect the transmission shift modulator and connector pins.

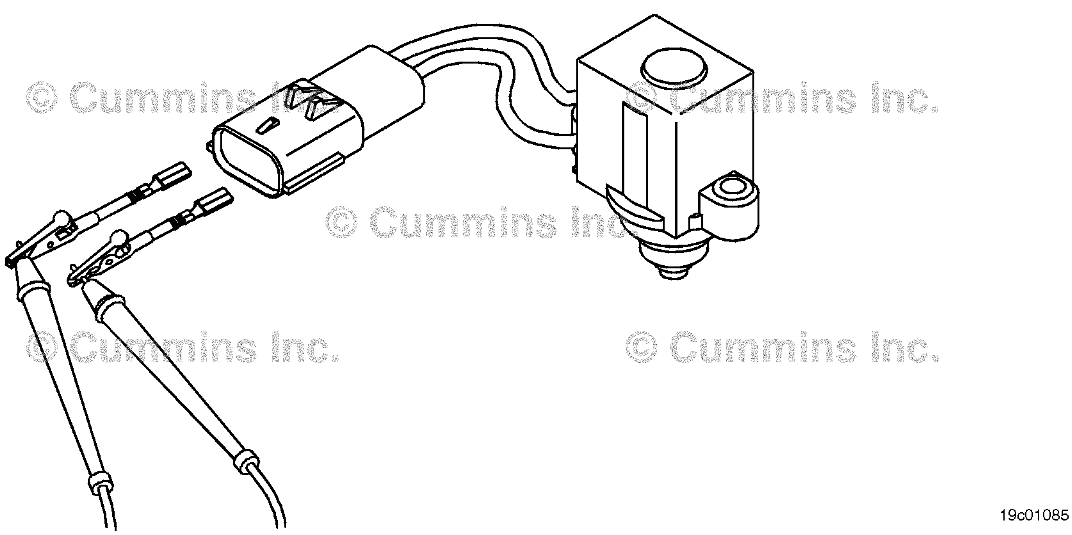
Condition:
- Turn keyswitch OFF.
- Disconnect the transmission shift modulator from the OEM harness.

Action	Specification/Repair	Next Step
Inspect the OEM harness and transmission shift modulator 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the sensor or harness connector. Clean the connector and pins. Repair the damaged harness, connector, or pins if possible. Refer to Procedure 019-071 in Section 19.	4A
	Dirty or damaged pins? **NO**	2B

STEP 2B: Check the resistance of the transmission shift modulator.

Condition:
- Turn keyswitch OFF.
- Disconnect the transmission shift modulator from the OEM harness.

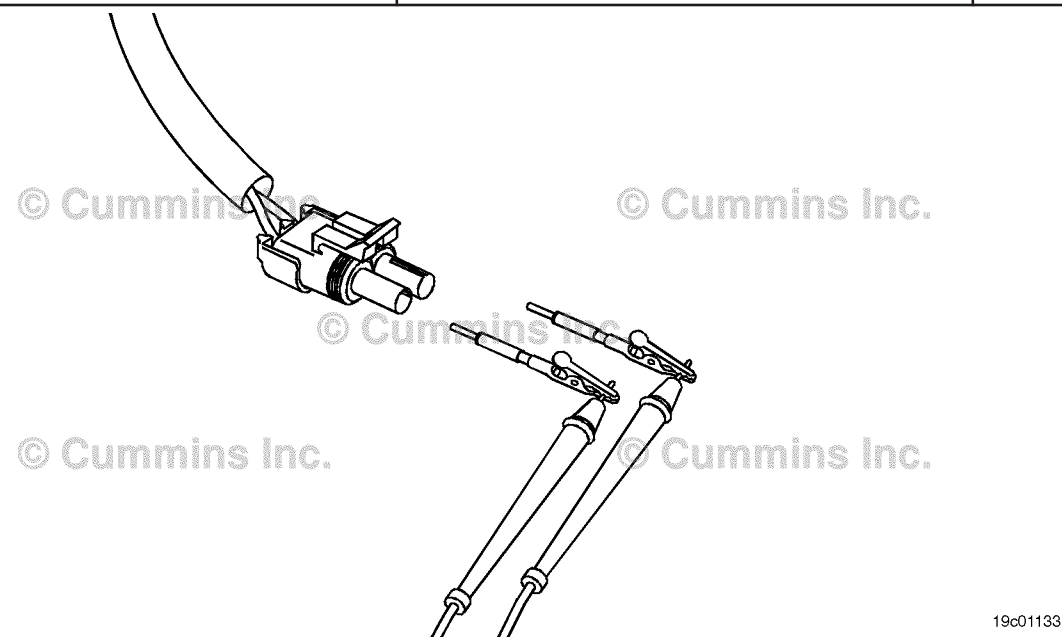
Action	Specification/Repair	Next Step
Check the transmission shift modulator resistance. • Measure the resistance between the output device driver SIGNAL pin and the output device driver RETURN pin at the transmission shift modulator connector. Refer to the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Less than 2.2k ohms? **YES**	2C
	Less than 2.2k ohms? **NO** **Repair:** Replace the transmission shift modulator. Refer to the OEM service manual.	4A



STEP 2C: Check the transmission shift modulator diagnostic supply voltage, supply line and return circuit.

Condition:
- Turn keyswitch OFF.
- Disconnect the transmission shift modulator from the OEM harness.
- Turn keyswitch ON.

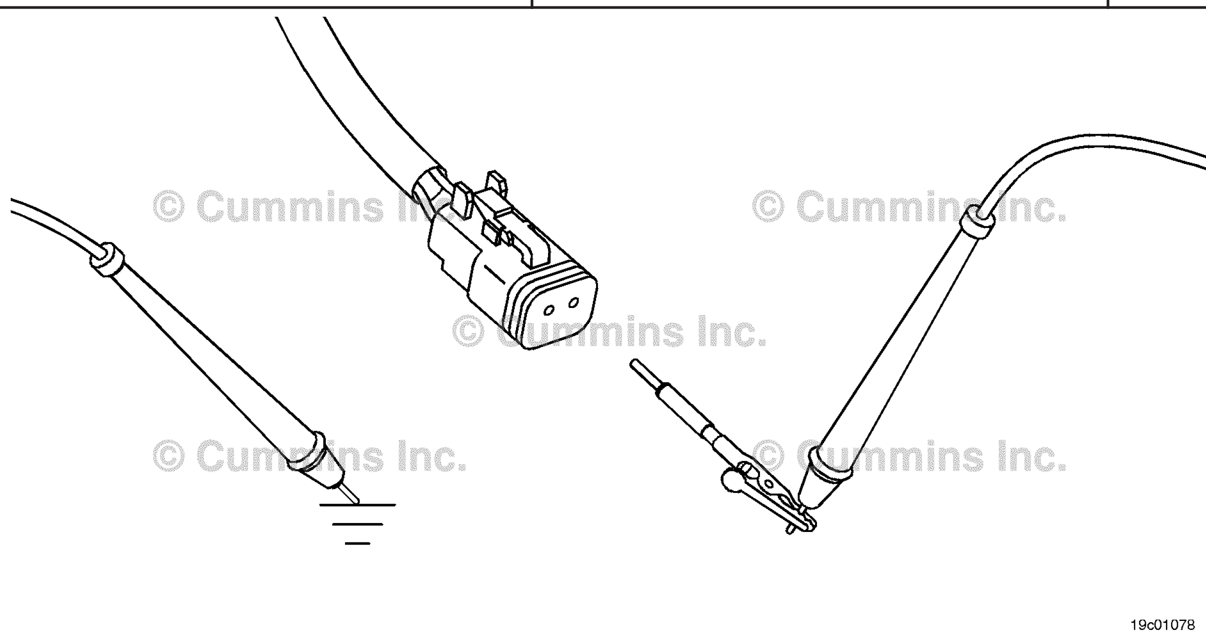
Action	Specification/Repair	Next Step
Check the transmission shift modulator diagnostic supply voltage and return circuit. • Measure the voltage between the output device driver SIGNAL pin and the output device driver RETURN pin at the transmission shift modulator connector of the OEM harness.	Greater than 5-VDC? **YES**	3C
	Greater than 5-VDC? **NO**	2D



STEP 2D: Check for an open circuit in the output device driver return circuit.

Condition:
- Turn keyswitch OFF.
- Disconnect the transmission shift modulator from the OEM harness.
- Disconnect the OEM harness from the ECM.

Action	Specification/Repair	Next Step
Check for an open circuit. • Measure the resistance between the output device driver RETURN pin at the transmission shift modulator connector to ground. Refer to the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Less than 10 ohms? **YES**	3A
	Less than 10 ohms? **NO** **Repair:** An open circuit on the RETURN wire has been detected. Refer to the OEM wiring diagram for RETURN wire configuration. If the RETURN is wired to the ECM, repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19. If the RETURN wire is grounded to the chassis or engine block ground, repair the source of the damaged connection. Clean and repair, or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	4A



STEP 3: Check the ECM and OEM harness.

STEP 3A: Inspect the ECM and OEM harness connector pins.

Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM.

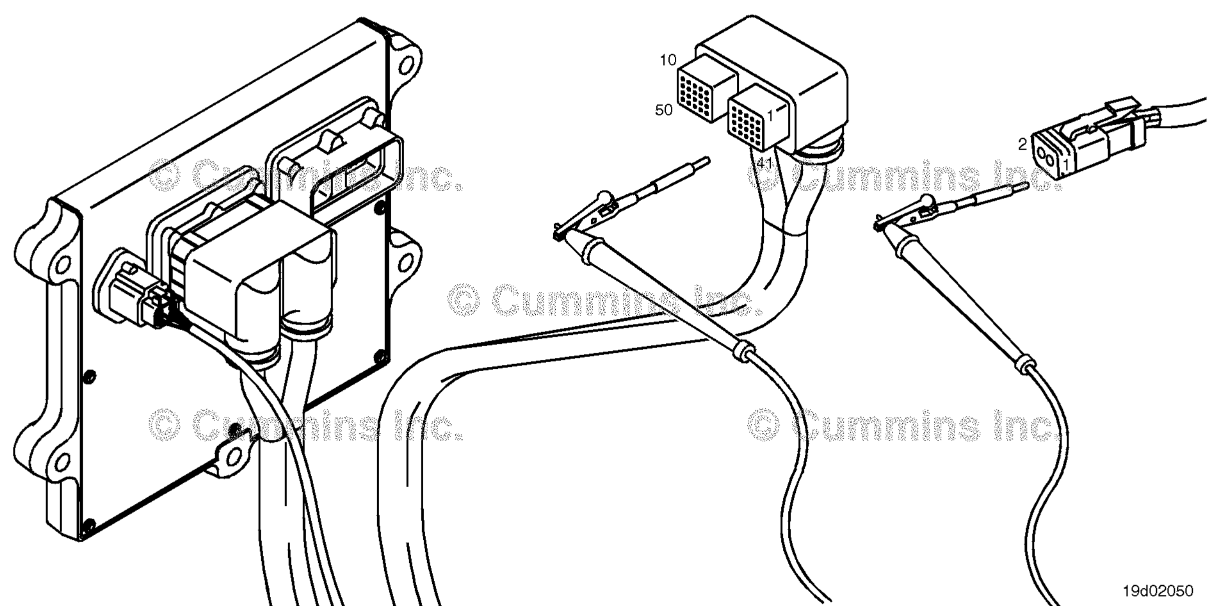
Action	Specification/Repair	Next Step
Inspect the OEM harness and ECM connector pins for the following: • Loose connector • Corroded pins • Bent or broken pins • Pushed back or expanded pins • Moisture in or on the connector • Missing or damaged connector seals • Dirt or debris in or on the connector 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the ECM or OEM harness connector. Clean the connector and pins. Repair the damaged harness, connector, or pins if possible. Refer to Procedure 019-071 in Section 19.	4A
	Dirty or damaged pins? **NO**	3B

STEP 3B: Check for an open circuit in the OEM harness.

Condition:

- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM.
- Disconnect the transmission shift modulator from the OEM harness.

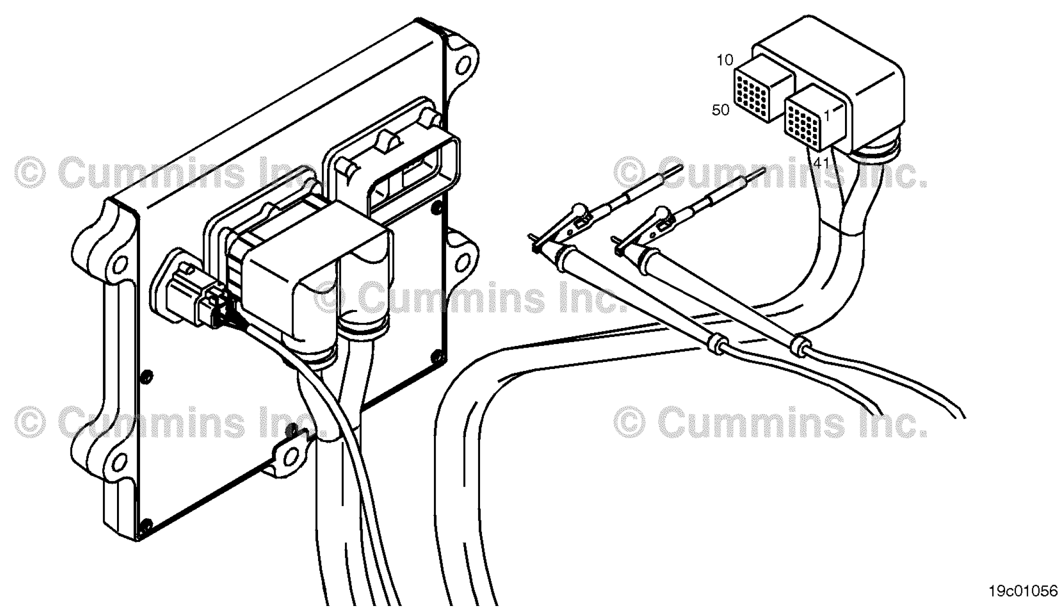
Action	Specification/Repair	Next Step
Check for a pin-to-ground short. • Measure the resistance between the output device driver SIGNAL pin at the transmission shift modulator connector and the output device driver SIGNAL pin at the OEM harness ECM connector. Refer to the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Less than 10 ohms? **YES**	3C
	Less than 10 ohms? **NO** **Repair:** An open circuit on the output device driver SIGNAL line has been detected in the OEM harness. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	4A



STEP 3C: Check for a pin-to-pin short circuit in the OEM harness.

Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM.
- Disconnect the transmission shift modulator from the OEM harness.

Action	Specification/Repair	Next Step
Check for a pin-to-pin short. • Measure the resistance between the output device driver SIGNAL pin in the OEM ECM connector and all other pins in the OEM connector. Refer to the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Greater than 100k ohms? **YES**	3D
	Greater than 100k ohms? **NO** **Repair:** A pin-to-pin short circuit on the output device driver SIGNAL line has been detected in the OEM harness. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	4A



STEP 3D: Check for an inactive fault code.

Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for the appropriate circuit response after 30 seconds. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 2557 inactive? **YES** **Repair:** None. The removal and installation of the connector corrected the fault.	4A
	Fault Code 2557 inactive? **NO** **Repair:** Replace the ECM. Refer to Procedure 019-031 in Section 19.	4A

STEP 4: Clear the fault code.

STEP 4A: Disable the fault code.

Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable the fault code. • Start the engine and let it idle for 1 minute. • Use INSITE™ electronic service tool to verify the fault code is inactive.	Fault Code 2557 inactive? **YES**	4B
	Fault Code 2557 inactive? **NO** **Repair:** Return to the appropriate steps or contact a Cummins® Authorized Repair Location if all steps have been completed and checked again.	1A

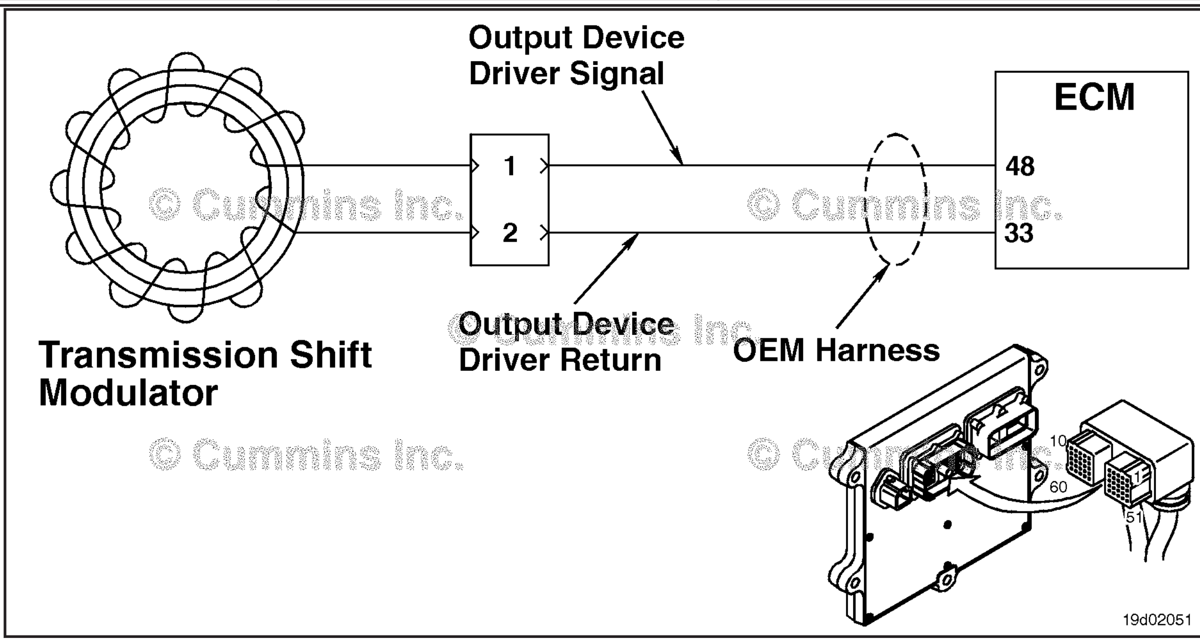
STEP 4B: Clear the inactive fault codes.

<table>
<tr><td colspan="3">Condition:
• Connect all components.
• Turn keyswitch ON.
• Connect INSITE™ electronic service tool.</td></tr>
<tr><th>Action</th><th>Specification/Repair</th><th>Next Step</th></tr>
<tr><td rowspan="2">Clear the inactive fault codes.
• Use INSITE™ electronic service tool to clear the inactive fault codes.</td><td>All fault codes cleared?
YES</td><td>Repair complete</td></tr>
<tr><td>All fault codes cleared?
NO
Repair:
Troubleshoot any remaining active fault codes.</td><td>Appropriate troubleshooting steps</td></tr>
</table>

Fault Code 2558

Auxiliary PWM Driver #1 - Voltage Below Normal or Shorted to Low Source

CODES	REASON	EFFECT
Fault Code: 2558 PID(P), SID(S): S057 SPN: 697 FMI: 4 Lamp: Amber SRT:	Auxiliary PWM Driver #1 - Voltage Below Normal or Shorted to Low Source. Low signal voltage detected at the analog torque circuit.	Can **not** control transmission.



Auxiliary PWM Driver #1 Circuit

Circuit Description:

The transmission shift modulator uses this signal from the ECM to determine when to shift the transmission. The return circuit is dependent on OEM wiring. It may be wired back to the ECM on some vehicles or wired to chassis or block ground on others. Consult the OEM wiring diagram for return circuit details.

Component Location:

Refer to the OEM diagram for the location of the transmission shift modulator.

Shop Talk:

This fault can be caused by the following:

- A faulty transmission shift modulator
- An short circuit to ground on the output device driver line
- A short pin to pin in the output device driver line.

Refer to Troubleshooting Fault Code t05-2558

FAULT CODE 2558 - Auxiliary PWM Driver #1 - Voltage Below Normal or Shorted to Low Source

TROUBLESHOOTING SUMMARY

CAUTION

To reduce the possibility of damaging a new ECM, all other active fault codes must be investigated prior to replacing the ECM.

CAUTION

To reduce the possibility of pin and harness damage, use the following test leads when taking a measurement: Part Number 3822758 - male Deutsch™/AMP™/Metri-Pack™ test lead and Part Number 3822917 - female Deutsch™/AMP™/Metri-Pack™ test lead.

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	Check the fault codes.		
STEP 1A:	Check for an inactive fault code.	Fault Code 2558 is inactive?	
STEP 2:	Check the transmission shift modulator and circuit.		
STEP 2A:	Inspect the transmission shift modulator and connector pins.	Dirty or damaged pins?	
STEP 2B:	Check the resistance of the transmission shift modulator.	Less than 2.2k ohms?	
STEP 2B-1:	Check for a short to ground in the transmission shift modulator.	Greater than 100k ohms?	
STEP 2C:	Check the transmission shift modulator diagnostic supply voltage, supply line and return circuit.	Greater than 5-VDC?	
STEP 3:	Check the ECM and OEM harness.		
STEP 3A:	Inspect the ECM and OEM harness connector pins.	Dirty or damaged pins?	
STEP 3B:	Check for a pin short circuit to ground.	Greater than 100k ohms?	
STEP 3C:	Check for a pin-to-pin short circuit in the OEM harness.	Greater than 100k ohms?	
STEP 3D:	Check for an inactive fault code.	Fault Code 2558 inactive?	
STEP 4:	Clear the fault code.		
STEP 4A:	Disable the fault code.	Fault Code 2558 inactive?	
STEP 4B:	Clear the inactive fault codes.	All fault codes cleared?	

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for an inactive fault code.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for an inactive fault code. • Using INSITE™, read the fault codes.	Fault Code 2558 is inactive? **YES**	Use the following procedure for an inactive or intermittent fault code. Refer to Procedure 019-362 in Section 19.
	Fault Code 2558 is inactive? **NO**	2A

STEP 2: Check the transmission shift modulator and circuit.

STEP 2A: Inspect the transmission shift modulator and connector pins.

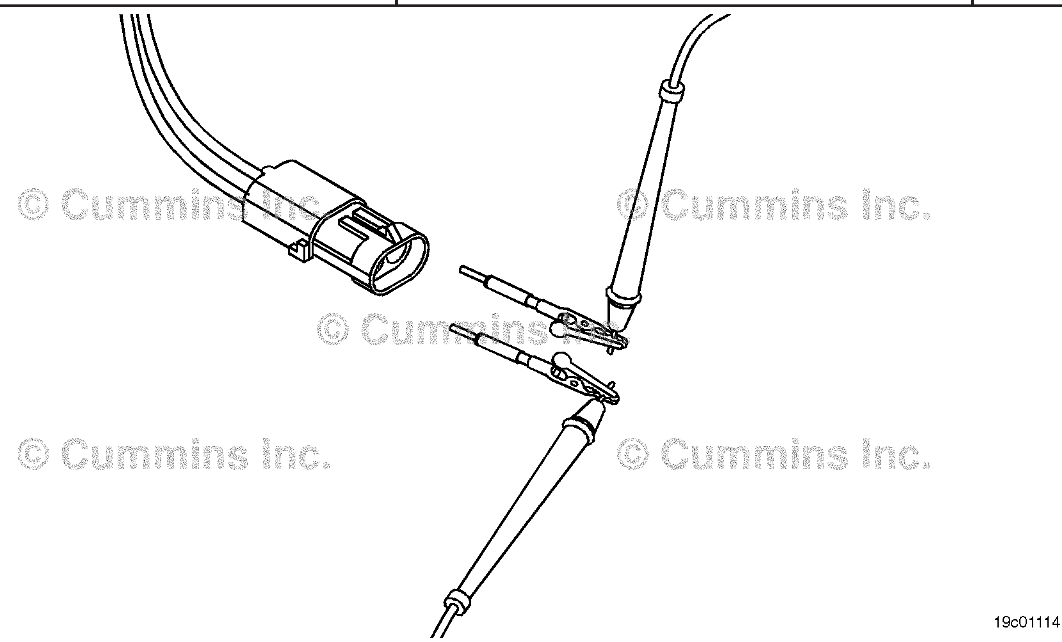
Condition:
- Turn keyswitch OFF.
- Disconnect the transmission shift modulator from the OEM harness.

Action	Specification/Repair	Next Step
Inspect the OEM harness and transmission shift modulator 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the sensor or harness connector. Clean the connector and pins. Repair the damaged harness, connector, or pins if possible. Refer to Procedure 019-071 in Section 19.	4A
	Dirty or damaged pins? **NO**	2B

STEP 2B: Check the resistance of the transmission shift modulator.

Condition:
- Turn keyswitch OFF.
- Disconnect the transmission shift modulator from the OEM harness.

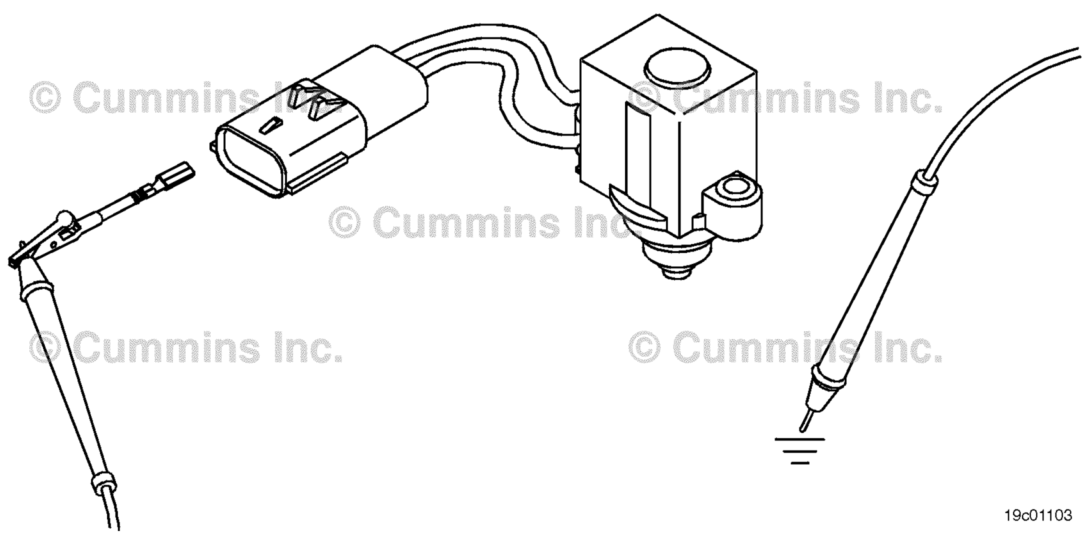
Action	Specification/Repair	Next Step
Check the transmission shift modulator resistance. • Measure the resistance between the output device driver SIGNAL pin and the output device driver RETURN pin at the transmission shift modulator connector. Refer to the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Less than 2.2k ohms? **YES**	2B-1
	Less than 2.2k ohms? **NO** **Repair:** Replace the transmission shift modulator. Refer to the OEM service manual.	4A



STEP 2B-1: Check for a short to ground in the transmission shift modulator.

Condition:
- Turn keyswitch OFF.
- Disconnect the transmission shift modulator from the OEM harness.

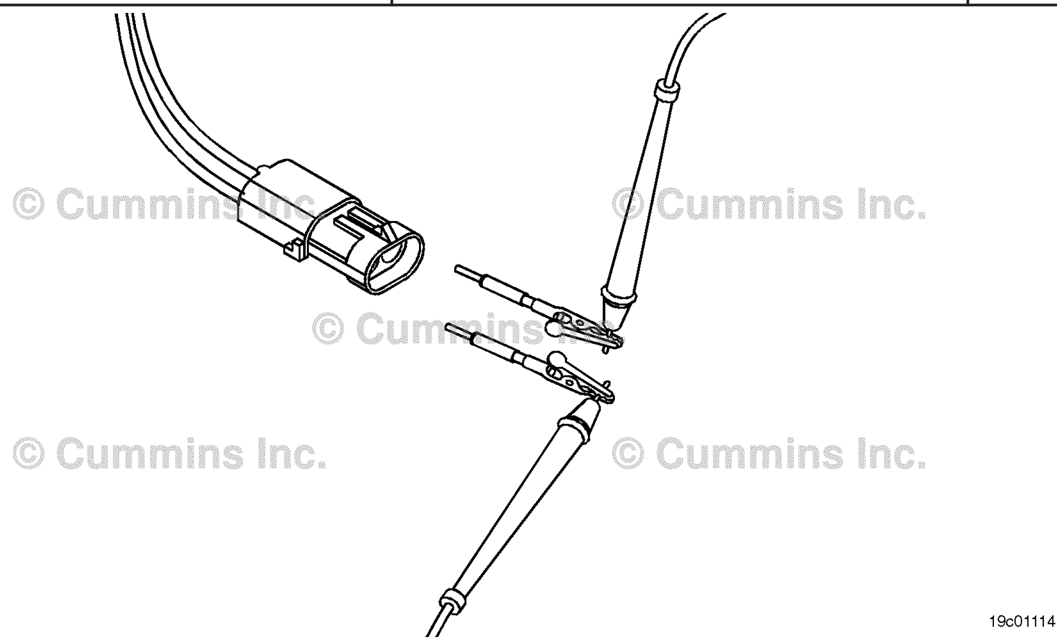
Action	Specification/Repair	Next Step
Check for a transmission shift modulator output short to ground. • Measure the resistance between the output device driver SIGNAL pin and ground at the transmission shift modulator connector. Refer to the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Greater than 100k ohms? **YES**	2C
	Greater than 100k ohms? **NO** **Repair:** Replace the transmission shift modulator. Refer to the OEM service manual.	4A



STEP 2C: Check the transmission shift modulator diagnostic supply voltage, supply line and return circuit.

Condition:
- Turn keyswitch OFF.
- Disconnect the transmission shift modulator from the OEM harness.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check the transmission shift modulator diagnostic supply voltage and return circuit. • Measure the voltage between the output device driver SIGNAL pin and output device driver RETURN pin at the transmission shift modulator connector of the OEM harness.	Greater than 5-VDC? **YES**	3C
	Greater than 5-VDC? **NO**	3A



STEP 3: Check the ECM and OEM harness.

STEP 3A: Inspect the ECM and OEM harness connector pins.

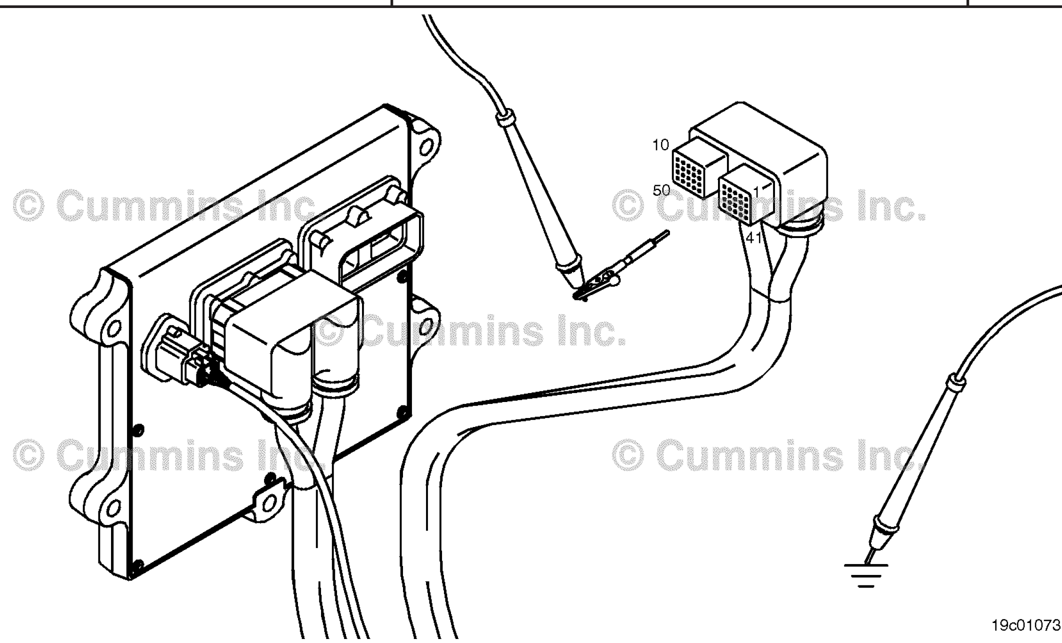
Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM.

Action	Specification/Repair	Next Step
Inspect the OEM harness and ECM 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the sensor or harness connector. Clean the connector and pins. Repair the damaged harness, connector, or pins if possible. Refer to Procedure 019-071 in Section 19.	4A
	Dirty or damaged pins? **NO**	3B

STEP 3B: Check for a pin short circuit to ground.

Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM.
- Disconnect the transmission shift modulator from the OEM harness.

Action	Specification/Repair	Next Step
Check for a pin-to-ground short. • Measure the resistance between the output device driver SIGNAL pin in the OEM harness ECM connector and ground. Refer to the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Greater than 100k ohms? **YES**	3C
	Greater than 100k ohms? **NO** **Repair:** A pin-to-ground short circuit on the output device driver SIGNAL line has been detected in the OEM harness. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	4A

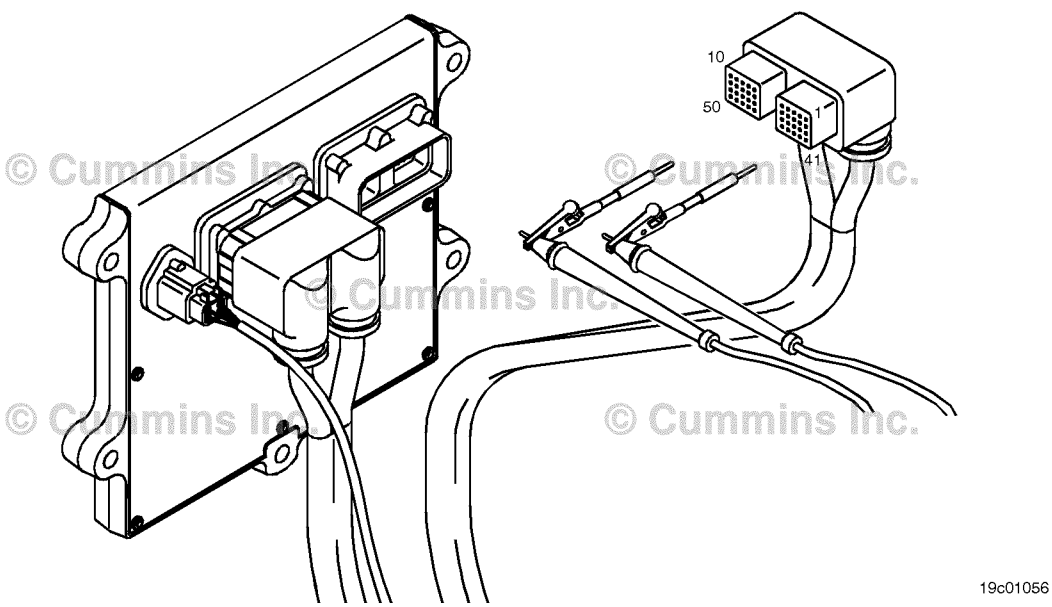


STEP 3C: Check for a pin-to-pin short circuit in the OEM harness.

Condition:

- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM.
- Disconnect the transmission shift modulator from the OEM harness.

Action	Specification/Repair	Next Step
Check for a pin-to-pin short. • Measure the resistance between the output device driver SIGNAL pin in the OEM ECM connector and all other pins in the OEM connector. Refer to the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Greater than 100k ohms? **YES**	3D
	Greater than 100k ohms? **NO** **Repair:** A pin-to-pin short circuit on the output device driver SIGNAL line has been detected in the OEM harness. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	4A



STEP 3D: Check for an inactive fault code.

Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for the appropriate circuit response after 30 seconds. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 2558 inactive? **YES** **Repair:** None. The removal and installation of the connector corrected the fault.	4A
	Fault Code 2558 inactive? **NO** **Repair:** Replace the ECM. Refer to Procedure 019-031 in Section 19.	4A

STEP 4: Clear the fault code.

STEP 4A: Disable the fault code.

Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable the fault code. • Start the engine and let it idle for 1 minute. • Use INSITE™ electronic service tool to verify that the fault code is inactive.	Fault Code 2558 inactive? **YES**	4B
	Fault Code 2558 inactive? **NO**	1A

STEP 4B: Clear the inactive fault codes.

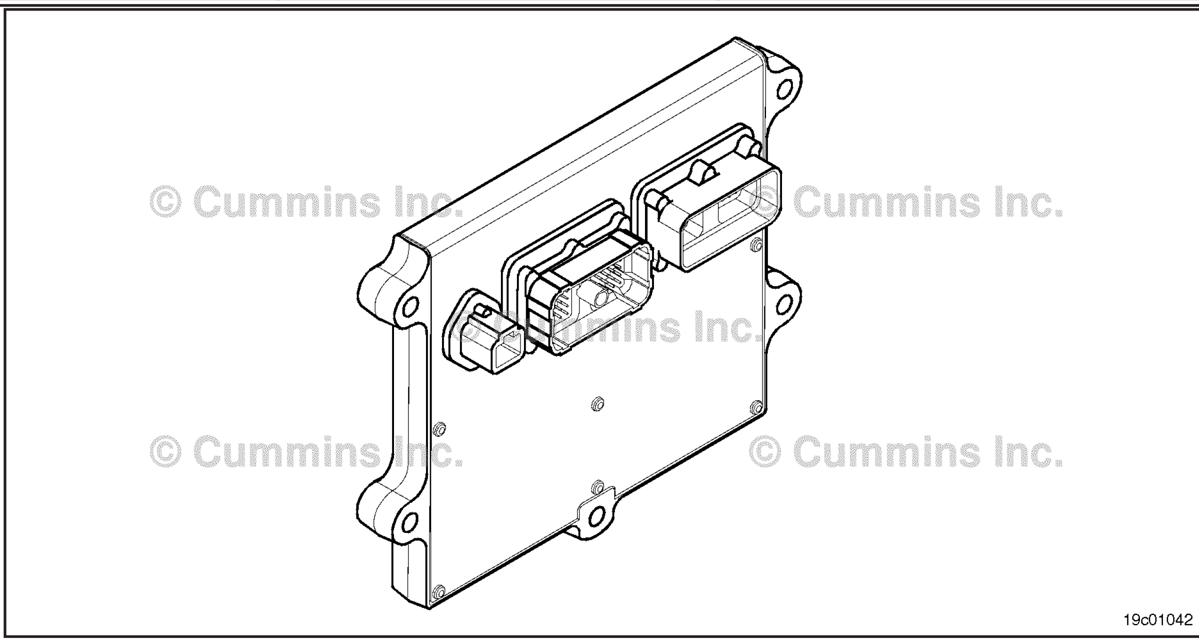
Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Clear the inactive fault codes. • Use INSITE™ electronic service tool to erase the inactive fault codes.	All fault codes cleared? **YES**	Repair complete
	All fault codes cleared? **NO**	Appropriate troubleshooting steps

Fault Code 2559

Transmission ECU to ECM Communication - Abnormal Update Rate

CODES	REASON	EFFECT
Fault Code: 2559 PID(P), SID(S): SPN: 1845 FMI: 4 Lamp: Amber SRT:	Transmission ECU to ECM Communication Lost - Abnormal Update Rate. No communication or an invalid data transfer rate has been detected between the ECM and the transmission ECU.	None on performance.



Circuit Description:

Normally, switches, accelerators, and other components are connected to the engine control module (ECM) directly through individual wires. Multiplexing allows those same components to be hard wired to an original equipment manufacturer (OEM) vehicle electronic control unit (VECU) or transmission electronic control unit (ECU) in the cab. Component values and states from components such as sensors, accelerators, and switches can then be transmitted from the OEM VECU to the Cummins® ECM over the data link.

Messages sent from OEM VECUs or transmission ECUs are received by the Cummins® ECM and used for controlling the engine. The Cummins® ECM and OEM VECU(s) **must** be configured properly so that proper operation of the multiplexed components will occur.

Component Location:

The data link wiring and the devices vary by OEM options.

Conditions for Running the Diagnostics:

This diagnostic runs continuously when the keyswitch is in the ON position or when the engine is running.

Conditions for Setting the Fault Codes:

The ECM did **not** receive a message from the multiplexed device.

Action Taken When the Fault Code is Active:

The ECM illuminates the amber CHECK ENGINE lamp and/or malfunction indicator lamp (MIL) immediately when the diagnostic runs and fails.

Conditions for Clearing the Fault Code:

- To validate the repair, start the engine and let it idle for 1 minute.
- The fault code status displayed by INSITE™ electronic service tool will change to INACTIVE immediately after the diagnostic runs and passes.
- The ECM will turn off the amber CHECK ENGINE lamp after the diagnostic runs and passes.
- The “Reset All Faults” command in INSITE™ electronic service tool can be used to clear active and inactive faults.

Shop Talk:

When this fault code is active, some multiplexed devices may **not** function as desired.

This fault can occur for the following reasons:

- When the ECM is set up properly (components enabled and OEM VECU source addressed correctly) to receive information from an OEM VECU, but the OEM VECU is actually transmitting a message that says that component is **not** available for multiplexing. This can be caused when a multiplexed component is enabled in the Cummins® ECM, but the OEM VECU source address of the VECU transmitting the component message is incorrect in the Cummins® ECM, or the OEM VECU is **not** set up to transmit the multiplexed component message.
- This fault can also be caused by a malfunctioning data link connection between the OEM VECU and Cummins® ECM, a malfunctioning connection between the component and the OEM VECU, a malfunctioning OEM VECU, or a malfunctioning Cummins® ECM. It may be necessary to contact the OEM for the proper multiplexing configuration.

It is possible to use INSITE™ electronic service tool to monitor multiplexed components.

Refer to Troubleshooting Fault Code t05-2559.

FAULT CODE 2559 - Transmission ECU to ECM Communication - Abnormal Update Rate

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check for engine control module (ECM) communication with INSITE™ electronic service tool.**		
STEP 1A:	Check for ECM communication with INSITE™ electronic service tool.	Communication between INSITE™ electronic service tool and the ECM possible?	
STEP 2:	**Check the fault codes.**		
STEP 2A:	Check for an active fault code.	Fault Code 2559 active?	
STEP 3:	**Check the original equipment manufacturer (OEM) vehicle electronic control unit (VECU) and ECM for proper multiplexing configuration.**		
STEP 3A:	Determine which VECU multiplexed components (switches, accelerators, or sensors) are enabled for multiplexing over the data link to the engine ECM and compare to the engine ECM configuration.	ECM multiplexing configuration matches the OEM VECU multiplexing configuration?	
STEP 4:	**Check the service data link harness.**		
STEP 4A:	Inspect the service data link harness and connector pins.	Dirty or damaged pins?	
STEP 4B:	Check for an open or short circuit in the service data link harness.	50 to 70 ohms?	
STEP 5:	**Check the OEM harness.**		
STEP 5A:	Check the ECM and OEM harness connector pins.	Dirty or damaged pins?	
STEP 5B:	Check for an open or short circuit in the ECM data link harness.	50 to 70 ohms?	
STEP 5C:	Check for a short circuit in the ECM data link harness.	Greater than 100k ohms?	
STEP 5D:	Check for an inactive fault code.	Fault Code 2559 inactive?	
STEP 6:	**Check ECM calibration and clear fault codes.**		
STEP 6A:	Check if an ECM calibration update is available.	If a calibration update for this fault code is available, does the ECM contain that revision or higher?	
STEP 6B:	Disable the fault code.	Fault code inactive?	

TROUBLESHOOTING STEP

STEP 1: Check for ECM communication with INSITE™ electronic service tool.

STEP 1A: Check for ECM communication with the INSITE™ electronic service tool.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Verify INSITE™ electronic service tool communication with the ECM.	Communication between INSITE™ electronic service tool and the ECM possible? **YES**	2A
	Communication between INSITE™ electronic service tool and the ECM possible? **NO**	4A

STEP 2: Check the fault codes.

STEP 2A: Check for an active fault code.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for an active fault code. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 2559 active? **YES**	3A
	Fault Code 2559 active? **NO**	Use the following procedure for inactive or intermittent fault code. Refer to Procedure 019-362 in Section 19.

STEP 3: Check the OEM VECU and ECM for proper multiplexing configuration.

STEP 3A: Determine which VECU multiplexed components (switches, accelerators, or sensors) are enabled for multiplexing over the data link to the engine ECM and compare to the engine ECM configuration.

Condition:

- Determine proper OEM VECU multiplexing configuration component enables and OEM VECU source addresses from the appropriate OEM information, or from a saved job image.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check that the engine ECM multiplexed component enables and source addresses match the OEM VECU multiplexed component enables and source addresses. NOTE: Refer to Multiplexing Troubleshooting, Bulletin 4021378, for OEM specific multiplexing configuration information.	ECM multiplexing configuration matches the OEM VECU multiplexing configuration? **YES** **Repair:** An OEM issue has been detected. Contact the OEM for further repair instructions. It is still possible that there is a VECU, VECU setup, or VECU to data link connection issue.	6A
	ECM multiplexing configuration matches the OEM VECU multiplexing configuration? **NO** **Repair:** An incorrect setup has been detected in the Cummins® ECM. Enable the proper components for multiplexing on the applicable OEM application and make sure the OEM VECU source addresses for each component are correct.	6A

STEP 4: Check the service data link harness.

STEP 4A: Inspect the service data link harness and connector pins.

Condition:
- Turn keyswitch OFF.
- Disconnect the data link adapter from the service data link connector.

Action	Specification/Repair	Next Step
Inspect the service data link 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the service data link cable. Clean the connector and pins. Repair the damaged harness, connector, or pins, if possible.	6A
	Dirty or damaged pins? **NO**	4B

STEP 4B: Check for an open or short circuit in the service data link harness.

Condition:
- Turn keyswitch OFF.
- Disconnect the data link adapter from the service data link connector.

Action	Specification/Repair	Next Step
Check for an open or short circuit. • Measure the resistance between the data link (+) wire and the data link (-) wire on the service data link connector. Use a wiring diagram for pin identification and use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	50 ohms to 70 ohms? **YES**	5A
	50 ohms to 70 ohms? **NO** **Repair:** An open or short has been detected on the service data link connector or harness connection to the data link backbone. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	6A

STEP 5: Check the OEM harness

STEP 5A: Check the ECM and OEM harness connector pins.

Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM connector.

Action	Specification/Repair	Next Step
Inspect the ECM data link harness 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection to the Cummins® ECM has been detected in the data link connector or harness. Clean the connector and pins. Repair the damaged harness, connector, or pins, if possible.	6A
	Dirty or damaged pins? **NO**	5B

STEP 5B: Check for an open or short circuit in the ECM data link harness.

Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM connector.

Action	Specification/Repair	Next Step
Check for an open or short circuit. • Measure the resistance between the data link (+) wire and the data link (-) wire on the appropriate Cummins® ECM OEM connection to the data link harness connector. Use a wiring diagram for pin identification and use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	50 ohms to 70 ohms? **YES**	5C
	50 ohms to 70 ohms? **NO** **Repair:** An open or short circuit has been detected in the OEM harness. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	6A

STEP 5C: Check for a short circuit in the ECM data link harness.

<table>
<tr><td colspan="3">Condition:
• Turn keyswitch OFF.
• Disconnect the OEM harness from the ECM connector.</td></tr>
<tr><th>Action</th><th>Specification/Repair</th><th>Next Step</th></tr>
<tr><td rowspan="2">Check for a pin-to-pin short circuit.
• Measure the resistance and check for a short circuit between the data link (+) wire and the data link (-) wire on the Cummins® ECM OEM connection to all other pins in the OEM connector.
NOTE: Disregard any resistance between 50 and 70 ohms between the data link (+) and the data link (-) pins.
Refer to the circuit diagram or wiring diagram for connector pin identification.
Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.</td><td>Greater than 100k ohms?
YES</td><td>5D</td></tr>
<tr><td>Greater than 100k ohms?
NO
Repair:
A short has been detected in the OEM harness.
Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.</td><td>6A</td></tr>
</table>

STEP 5D: Check for an inactive fault code.

<table>
<tr><td colspan="3">Condition:
• Connect all components.
• Turn keyswitch ON.
• Connect INSITE™ electronic service tool.</td></tr>
<tr><th>Action</th><th>Specification/Repair</th><th>Next Step</th></tr>
<tr><td rowspan="2">Check for the appropriate circuit response after 30 seconds.
• Use INSITE™ electronic service tool to read the fault codes.</td><td>Fault Code 2559 inactive?
YES
Repair:
None. The removal and installation of the connector corrected the fault.</td><td>6A</td></tr>
<tr><td>Fault Code 2559 inactive?
NO
Repair:
A communication issue between the ECM and the data link, or a damaged ECM or calibration is causing the fault code.</td><td>The appropriate ECM No Communication symptom tree</td></tr>
</table>

STEP 6: Check ECM calibration and clear fault codes.

STEP 6A: Check if an ECM calibration update is available.

Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Compare the ECM code and revision number in the ECM to the calibration revisions listed in the ECM Calibration Revision History for applicable changes related to this fault code. • Use INSITE™ electronic service tool to find the present ECM code and revision number in the ECM. The ECM code and revision number are found in the Calibration Information section of System ID and Dataplate in Features and Parameters.	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **YES**	6B
	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **NO** **Repair:** If necessary, calibrate the ECM. Refer to Procedure 019-032 in Section 19.	6B

STEP 6B: Disable the fault code.

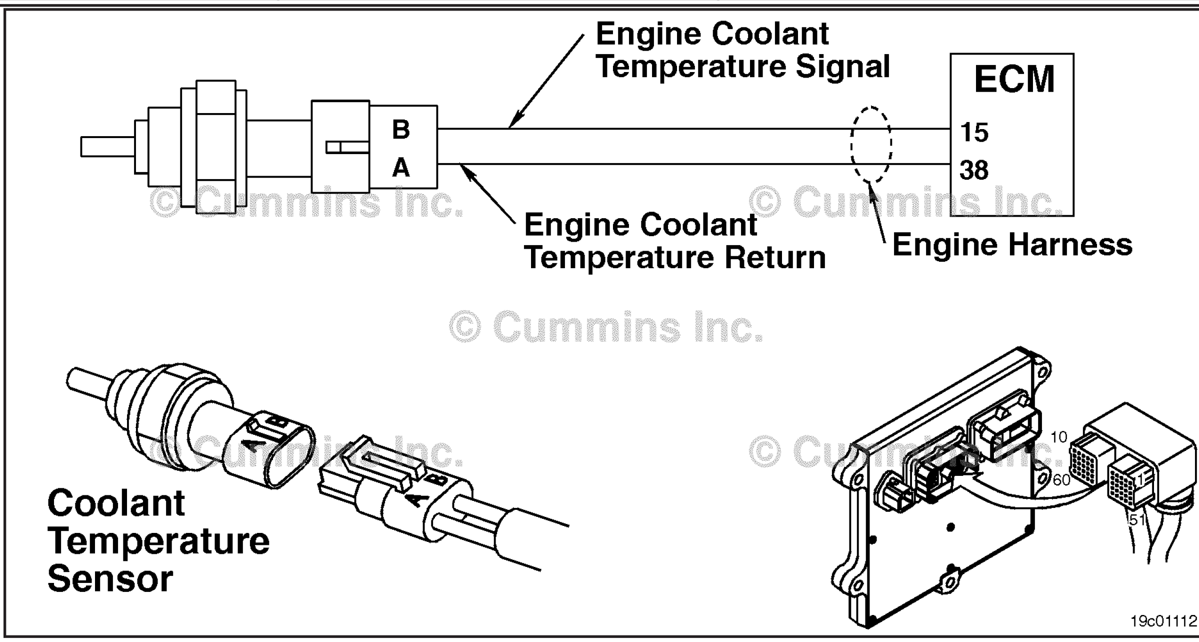
Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable and clear the fault code. • Operate the engine within the "Conditions for Clearing the Fault Code" found in the Overview section of this troubleshooting procedure.	Fault code inactive? **YES**	Repair complete
	Fault code inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair Location if all steps have been completed and checked again.	1A

Fault Code 2659

Engine Coolant Temperature - Condition Exists

CODES	REASON	EFFECT
Fault Code: 2659 PID(P), SID(S): P110 SPN: 110 FMI: Lamp: None SRT:	Engine Coolant Temperature - Condition Exists. Engine coolant signal indicates coolant temperature is above the engine coolant temperature engine protection warning limit.	Progressive power derate increasing in severity from time of alert.



Engine Coolant Temperature Sensor Circuit

Circuit Description:

The engine coolant temperature sensor is used by the ECM to monitor the engine coolant temperature. The ECM monitors the voltage on the signal pin and converts this to a temperature value. The engine coolant temperature value is used by the ECM for the engine protection system and engine emissions control. This fault code will result in an Engine Protection power derate.

Component Location:

The engine coolant temperature sensor is located on the exhaust side of the engine, near the thermostat housing. Refer to Procedure 100-002 (Engine Views) in Section E for a detailed component location view.

Shop Talk:

This fault code indicates that coolant temperature has exceeded the engine protection limits for high coolant temperature. Refer to Engine Coolant Temperature Above Normal symptom tree.

Refer to Troubleshooting Fault Code t05-2659

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the fault codes.**		
STEP 1A:	**Check for fault code 2659.**	**Active or inactive counts of Fault Code 2659?**	

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for fault code 2659.

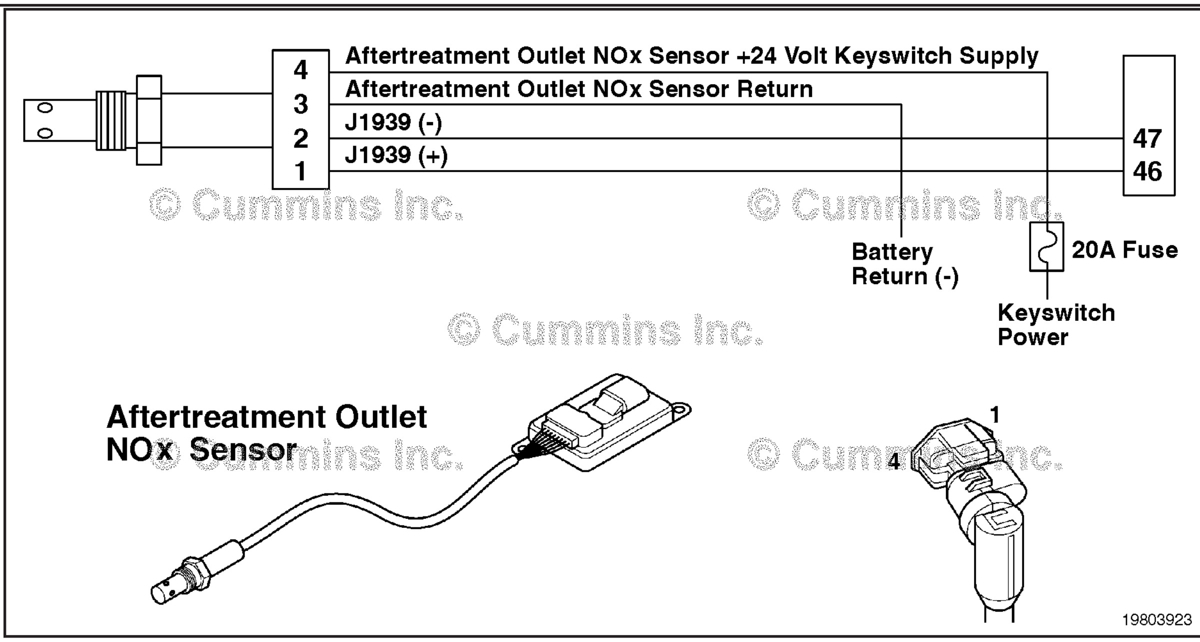
Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for fault code 2659. • Use INSITE™ electronic service tool to read the fault codes.	Active or inactive counts of Fault Code 2659? **YES** **Repair:** Refer to the Coolant Temperature Above Normal symptom tree.	Appropriate symptom tree in the Service Manual, ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines, Bulletin 4021271
	Active or inactive counts of Fault Code 2659? **NO**	Repair complete

Fault Code 2771

Aftertreatment Outlet NOx Sensor - Abnormal Update Rate

CODES	REASON	EFFECT
Fault Code: 2771 PID(P), SID(S): SPN: 3234 FMI: 9 Lamp: Amber SRT:	Aftertreatment Outlet NOx Sensor - Abnormal Update Rate. No communications or valid data transfer rate detected on the J1939 datalink between the ECM and the aftertreatment outlet NOx sensor.	Aftertreatment outlet NOx sensor operation will be disabled. Engine will derate after running 50 hours with the fault active.



Circuit: Aftertreatment Outlet NOx Sensor Circuit

Circuit Description:

The aftertreatment outlet nitrogen oxides (NOx) sensor is a smart device and receives commands from the engine electronic control module (ECM) via the J1939 datalink. The aftertreatment outlet NOx sensor receives power and a ground directly from the battery. The aftertreatment outlet NOx sensor performs its own internal diagnostics and reports malfunctions back to the primary engine ECM using the J1939 datalink. The aftertreatment outlet NOx sensor is permanently attached to the NOx control module. The aftertreatment outlet NOx sensor is used to measure the outlet NOx emissions from the engine.

Component Location:

The aftertreatment outlet NOx sensor location can vary depending on engine application. It is usually located in the exhaust system at the outlet of the aftertreatment catalyst.

Shop Talk:

On-Board Diagnostics (OBD) Information (Euro 4 Stage 1+ Certified Engines):

- The ECM illuminates the malfunction indicator lamp (MIL) when the diagnostic runs and fails.
- An engine torque derate will be activated after 50 hours of engine operation with the fault code active.
- The ECM turns OFF the malfunction indicator lamp (MIL) after 1 ignition cycle that the diagnostic runs and does **not** fail. The MIL lamp can **not** be cleared using the INSITE™ electronic service tool.
- The fault code will be cleared from memory after 400 days or 9600 hours of engine operation.

The NOx sensor is permanently attached to the NOx control module. They are serviced as a single component and can **not** be replaced individually.

Possible causes of this fault code include:

- The aftertreatment outlet NOx sensor is **not** receiving power from the battery supply circuit in the OEM harness. This could be caused by an open circuit in the power supply wire, blown NOx sensor fuse, or low voltage supplied by the battery.
- Open return circuit on the aftertreatment outlet NOx sensor circuit between the battery circuit aftertreatment outlet NOx sensor.
- Open or short circuit on the J1939 datalink circuit between the engine ECM and aftertreatment outlet NOx sensor.
- Intermittent communications between the aftertreatment outlet NOx sensor and the primary engine ECM on the J1939 datalink.
- A damaged engine ECM
- Incorrect engine calibration.

Refer to Troubleshooting Fault Code t05-2771

FAULT CODE 2771 - Aftertreatment Outlet NOx Sensor - Abnormal Update Rate

TROUBLESHOOTING SUMMARY

△CAUTION△

To reduce the possibility of damaging a new engine control module (ECM), all other active fault codes must be investigated prior to replacing the ECM.

△CAUTION△

To reduce the possibility of pin and harness damage, use the following test leads when taking a measurement: Part Number 3822758 - male Deutsch™/AMP™/Metri-Pack™ test lead and Part Number 3822917 - female Deutsch™/AMP™/Metri-Pack™ test lead.

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	Check the fault codes.		
STEP 1A:	Check for inactive fault codes	Fault Code 2771 inactive?	
STEP 2:	Check the aftertreatment outlet Mono-Nitrogen Oxides (NOx) sensor circuit.		
STEP 2A:	Inspect the aftertreatment outlet NOx sensor body and condition of the aftertreatment outlet NOx sensor harness.	Any external damage to the sensor body, head (component installed on the exhaust gas processor) or harness?	
STEP 2B:	Inspect the aftertreatment outlet NOx sensor and connector pins.	Damaged or dirty pins?	
STEP 2C:	Check the voltage to the aftertreatment outlet NOx sensor.	Voltage within 1 - volt of direct current (VDC) of battery voltage?	
STEP 2D:	Check for correct adjustable parameter settings.	Electrical system voltage parameter correct for the engine control parts list (CPL)?	
STEP 2E:	Check for correct aftertreatment outlet NOx sensor.	Aftertreatment outlet NOx sensor the correct sensor for the engine CPL?	
STEP 3:	Check the original equipment manufacturer (OEM) harness battery power circuit.		
STEP 3A:	Check the battery and the power connector.	Connections tight and corrosion-free?	
STEP 3B:	Verify that the OEM fuse is installed correctly.	Is the fuse installed correctly, or has it been replaced?	
STEP 3C:	Check for an open circuit in the battery power circuit.	Voltage is within 1-VDC of battery voltage?	
STEP 4:	Check the OEM harness		
STEP 4A:	Inspect the ECM and OEM harness connector pins.	Damaged or dirty pins?	
STEP 4B:	Check for an open circuit in the J1939 data link harness.	Less than 10 ohms?	
STEP 4C:	Check for a short circuit in the J1939 data link harness.	Voltage is within 1-VDC of battery voltage?	
STEP 4D:	Check for a short circuit to ground in the J1939 data link harness.	Greater than 100k ohms?	

STEP 4E:	Check the J1939 terminating resistance.	50 to 70 ohms?
STEP 4F:	Check the fault codes.	Fault Code 2771 active?

STEP 5: Check ECM calibration and clear fault codes.

STEP 5A:	Check if an ECM calibration update is available.	If a calibration update for this fault code is available, does the ECM contain that revision or higher?
STEP 5B:	Disable the fault code.	Fault code inactive?

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for inactive fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for inactive fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 2771 inactive? **YES**	Refer to Procedure 019-362 in Section 19.
	Fault Code 2771 inactive? **NO**	2A

STEP 2: Check the aftertreatment outlet Mono-Nitrogen Oxides (NOx) sensor circuit.

STEP 2A: Inspect the aftertreatment outlet NOx sensor body and condition of the aftertreatment outlet NOx sensor harness.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the aftertreatment outlet NOx sensor body, and the aftertreatment outlet NOx sensor harness. • Inspect the aftertreatment outlet NOx sensor body and aftertreatment outlet NOx sensor harness for cracks or damage. Use the following procedure for general inspection techniques. Refer to Procedure 019-361 in Section 19.	Any external damage to the sensor body, head (component installed on the exhaust gas processor) or harness? **YES** **Repair:** Replace the NOx sensor. Refer to Procedure 019-451 in the Section 19.	4A
	Any external damage to the sensor body, head (component installed on the exhaust gas processor) or harness? **NO**	2B

STEP 2B: Inspect the aftertreatment outlet NOx sensor and connector pins.

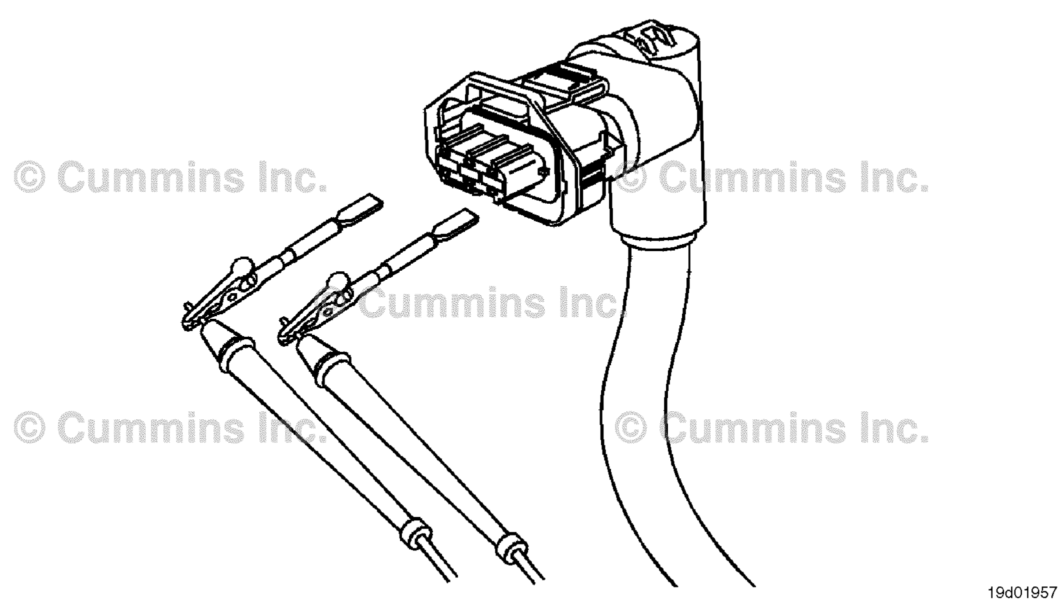
Condition:
- Turn keyswitch OFF
- Disconnect the aftertreatment outlet NOx sensor from the OEM harness.

Action	Specification/Repair	Next Step
Inspect the OEM harness and aftertreatment outlet NOx 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connector has been detected in the sensor or harness connector. Clean the connector and pins. Repair the damaged harness, connector, or pins, if possible. Refer to Procedure 019-071 in Section 19.	4A
	Dirty or damaged pins? **NO**	2C

STEP 2C: Check the voltage to the aftertreatment outlet NOx sensor.

Condition:
- Turn keyswitch OFF
- Disconnect the aftertreatment outlet NOx sensor from the OEM harness
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check the power supply and return circuit to the aftertreatment outlet NOx sensor. • Measure the voltage between the aftertreatment outlet NOx sensor battery voltage supply circuit and the aftertreatment outlet NOx sensor return circuit at the NOx sensor wiring harness connector. Note: Check the voltage at key-ON, while cranking the engine, and with the engine at idle. Note: 24-VDC NOx sensors will operate between 14 and 32-VDC. 12-VDC NOx sensors will operate between 6 and 16.5-VDC. Refer to the wiring diagram or circuit diagram for connector pin identification. Use the following procedure for instructions on how to use a multimeter. Refer to Procedure 019-359 in Section 19.	Voltage within 1 - volt of direct current (VDC) of battery voltage? **YES**	2D
	Voltage within 1 - volt of direct current (VDC) of battery voltage? **NO**	3A



STEP 2D: Check for corrrect adjustable parameter settings

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for correct adjustable parameter settings. • Make sure the electrical system voltage setting in INSITE™ electronic service tool is correct for the engine CPL.	Electrical system voltage parameter correct for the engine control parts list (CPL)? **YES**	2E
	Electrical system voltage parameter correct for the engine control parts list (CPL)? **NO** **Repair:** To configure the electrical system voltage to match the engine CPL, use INSITE™ electronic service tool.	4A

STEP 2E: Check for correct aftertreatment outlet NOx sensor

Condition:
- Turn keyswitch OFF.
- Remove the aftertreatment outlet NOx sensor.

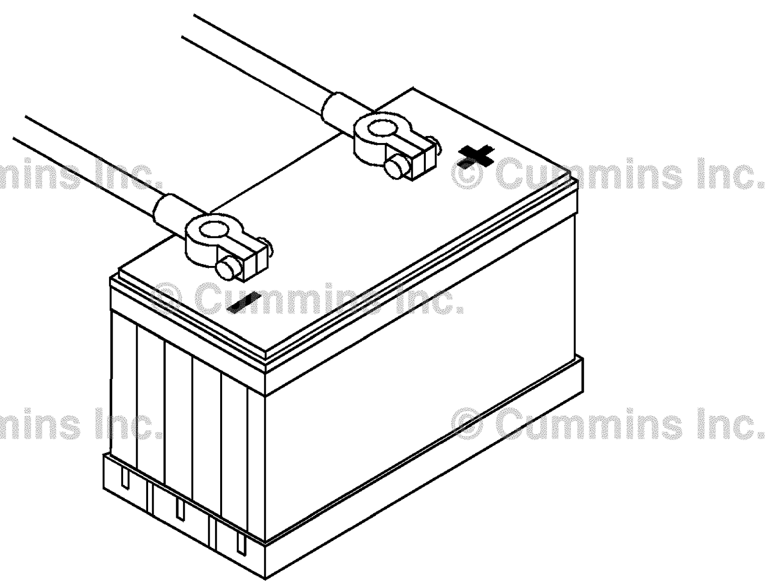
Action	Specification/Repair	Next Step
Verify aftertreatment outlet NOx sensor is the correct sensor for the engine CPL. Note: The aftertreatment outlet NOx sensor is available in 12-VDC or 24-VDC versions.	Aftertreatment outlet NOx sensor the correct sensor for the engine CPL? **YES**	4A
	Aftertreatment outlet NOx sensor the correct sensor for the engine CPL? **NO** **Repair:** Replace the aftertreatment outlet NOx sensor. Refer to Procedure 019-451 in the Section 19.	4A

STEP 3: Check the original equipment manufacturer (OEM) harness battery power circuit.

STEP 3A: Check the battery and the power connector.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the battery connections. • Check the battery terminal connections.	Connections tight and corrosion-free? **YES** **Repair:** A damaged connection has been detected in the ECM connector or the OEM harness connector. Clean the connector and pins. Repair the damaged harness, connector, or pins, if possible. Refer to Procedure 019-043 in the Section 19.	3B
	Connections tight and corrosion-free? **NO** **Repair:** Tighten the connections. Tighten the loose connections, and clean the terminals. Refer to the OEM service manual.	4A

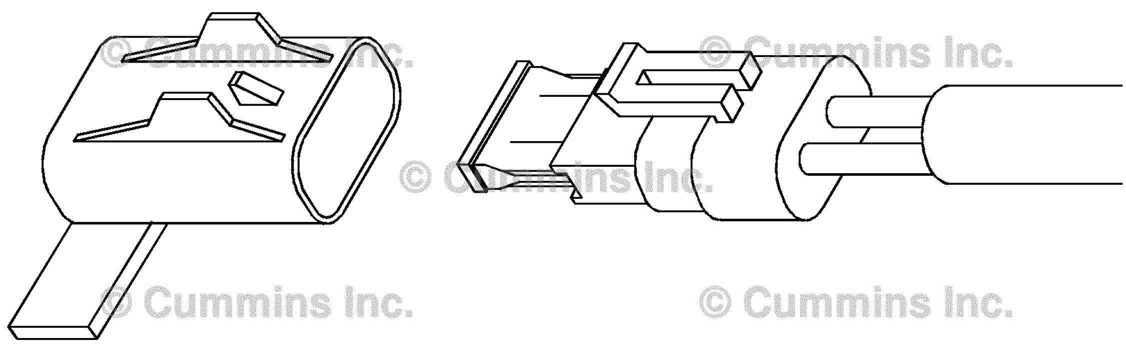


19c00460

STEP 3B: Verify that the OEM fuse is installed correctly.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
The aftertreatment outlet NOx sensor power supply wire contains a 20 amperes fuse. This fuse is located in the OEM harness. • Inspect the OEM fuse for correct installation, or for a blown fuse.	Is the fuse installed correctly, or has it been replaced? **YES**	3C
	Is the fuse installed correctly, or has it been replaced? **NO** **Repair:** Install the fuse correctly. Refer to Procedure 019-198 in Section 19.	4A

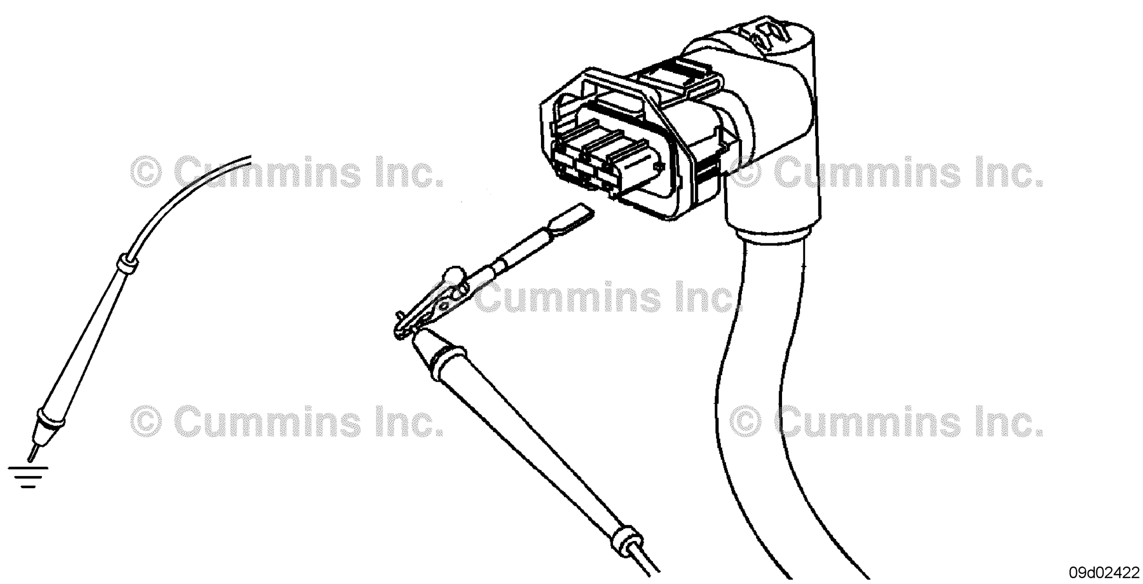


19c00455

STEP 3C: Check for an open circuit in the battery power circuit.

Condition:
- Turn keyswitch OFF.
- Disconnect the aftertreatment outlet NOx sensor from the OEM harness.

Action	Specification/Repair	Next Step
Check for an open circuit in the battery power circuits. • Use a multimeter to measure the voltage from the aftertreatment outlet NOx sensor SUPPLY (+) pin of the OEM harness to engine block ground. Refer to the wiring diagram or the circuit diagram for connector pin identification. Note: 24-VDC NOx sensors will operate between 14 and 32-VDC. 12-VDC NOx sensors will operate between 6 and 16.5-VDC.	Voltage is within 1-VDC of battery voltage? **YES** **Repair:** An open circuit in the OEM battery return circuit from the aftertreatment outlet NOx sensor has been detected. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	4A
	Voltage is within 1-VDC of battery voltage? **NO** **Repair:** An open circuit in the OEM battery supply circuit from the aftertreatment outlet NOx sensor has been detected. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	5A



STEP 4: Check the OEM harness

STEP 4A: Inspect the ECM and OEM harness connector pins.

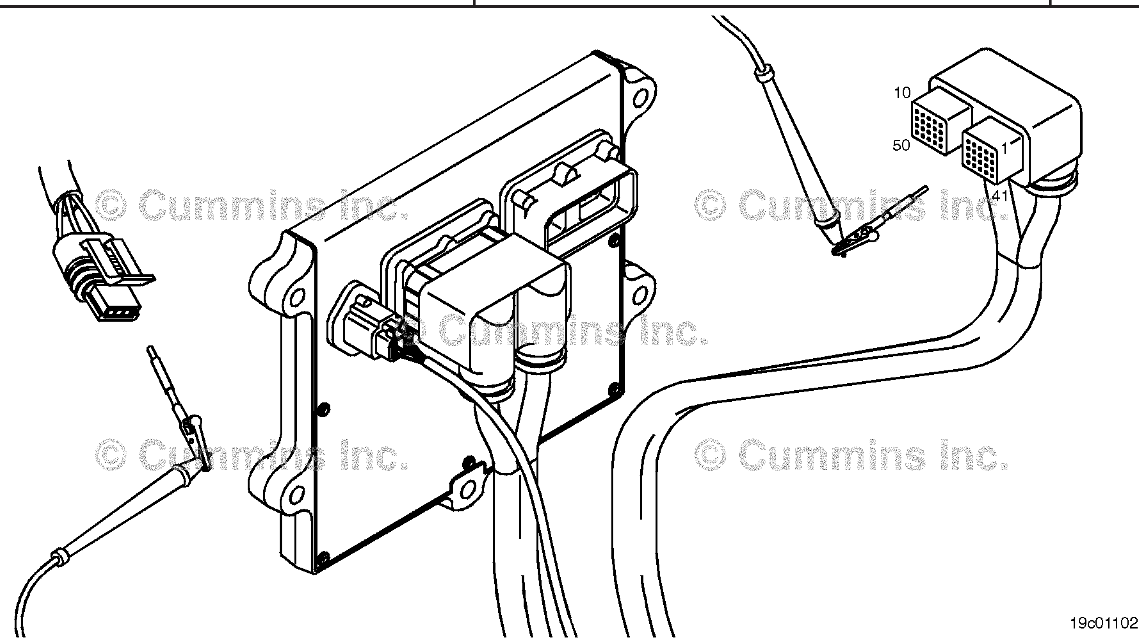
Condition:
- Turn keyswitch OFF
- Disconnect the OEM harness from the ECM connector.

Action	Specification/Repair	Next Step
Inspect the OEM harness and ECM 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the ECM connector or the OEM harness connector. Clean the connector and pins. Repair the damaged harness, connector, or pins, if possible. Refer to Procedure 019-071 in Section 19.	5A
	Dirty or damaged pins? **NO**	4B

STEP 4B: Check for an open circuit in the J1939 data link harness.

Condition:
- Turn keyswitch OFF.
- Disconnect the aftertreatment outlet NOx sensor from the OEM harness.
- Disconnect the OEM harness from the ECM connector.

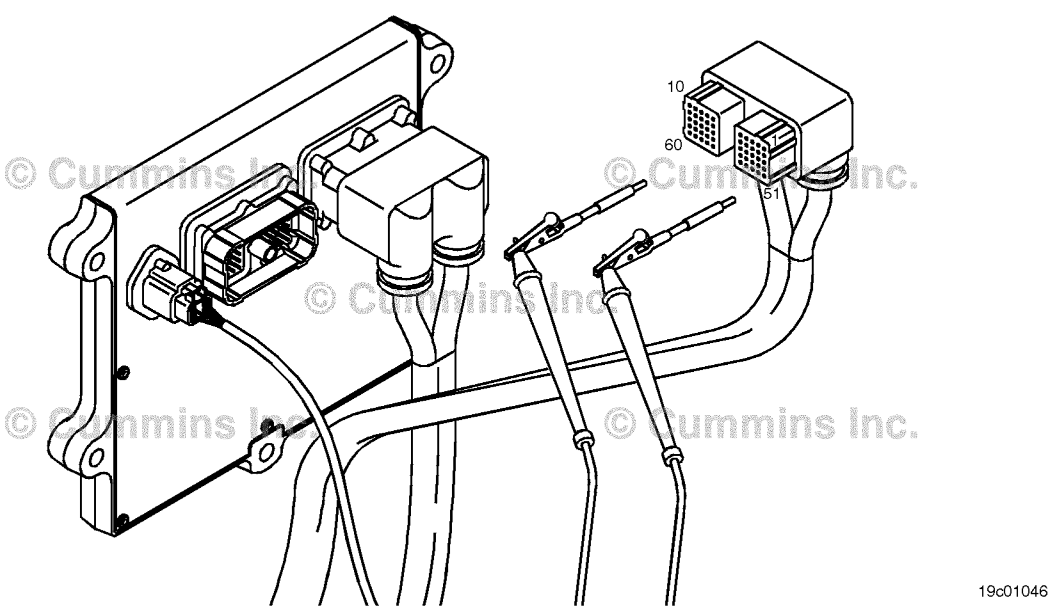
Action	Specification/Repair	Next Step
Check for an open circuit in the J1939 data link harness. • Measure the resistance between the Society of Automotive Engineers (SAE) J1939 data link (+) wire at the aftertreatment outlet NOx sensor OEM harness connector and the SAE J1939 data link (+) wire at the ECM OEM harness connector. • Measure the resistance between the SAE J1939 data link (−) wire at the aftertreatment outlet NOx sensor OEM harness connector and the SAE J1939 data link (−) wire at the ECM OEM harness connector. Refer to the wiring diagram or circuit diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Less than 10 ohms? **YES**	4C
	Less than 10 ohms? **NO** **Repair:** An open circuit has been detected in the J1939 data link harness. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	5A



STEP 4C: Check for a short circuit in the J1939 data link harness.

Condition:
- Turn keyswitch OFF.
- Disconnect the aftertreatment outlet NOx sensor from the OEM harness.
- Disconnect the OEM harness from the ECM.

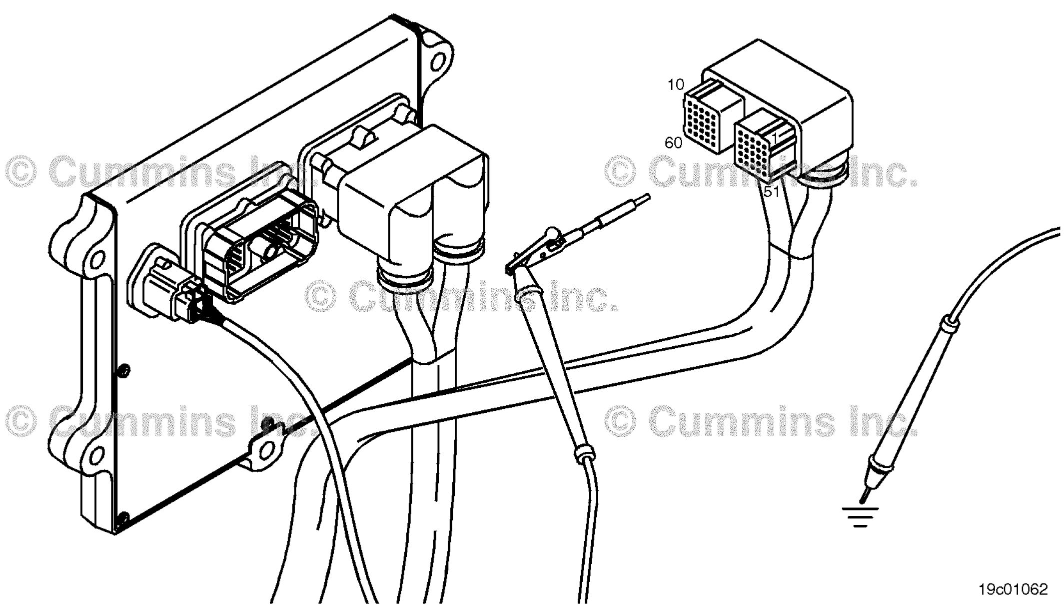
Action	Specification/Repair	Next Step
Check for a short circuit in the J1939 data link harness. • Measure the resistance between the SAE J1939 data link (+) wire at the ECM OEM harness connector and all other pins in the connector. • Measure the resistance between the SAE J1939 data link (−) wire at the ECM OEM harness connector and all other pins in the connector. Note: Disregard any resistance between 50 and 70 ohms between the SAE J1939 data link (+) and the SAE J1939 data link (−) pins. Refer to the wiring diagram or circuit diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Greater than 100k ohms? **YES**	4D
	Greater than 100k ohms? **NO** **Repair:** An short circuit has been detected in the J1939 data link harness. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	5A



STEP 4D: Check for a short circuit to ground in the J1939 data link harness.

Condition:
- Turn keyswitch OFF.
- Disconnect the aftertreatment outlet NOx sensor from the OEM harness.
- Disconnect the OEM harness from the ECM connector.

Action	Specification/Repair	Next Step
Check for a short circuit to ground in the J1939 data link harness. • Measure the resistance between the SAE J1939 data link (+) wire at the ECM OEM harness connector and ground. • Measure the resistance between the SAE J1939 data link (-) wire at the ECM OEM harness connector and ground. Refer to the wiring diagram or circuit diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Greater than 100k ohms? **YES**	4E
	Greater than 100k ohms? **NO** **Repair:** An short circuit to ground has been detected in the J1939 data link harness. Repair or replace the OEM harness. Refer to Procedure 019-071 in Section 19.	5A



STEP 4E: Check the J1939 terminating resistance.

Condition:
- Turn keyswitch OFF.
- Disconnect the aftertreatment outlet NOx sensor from the OEM harness.

Action	Specification/Repair	Next Step
Measure the terminating resistance of the SAE J1939 data link. • Measure the resistance between the SAE J1939 data link (+) wire and the SAE J1939 data link (-) wire at the aftertreatment outlet NOx sensor OEM harness connector.	50 to 70 ohms? **YES**	4F
	50 to 70 ohms? **NO** **Repair:** Incorrect terminating resistance has been detected in the OEM harness. Repair or replace the terminating resistor in the OEM harness. Refer to the OEM service manual.	5A

STEP 4F: Check the fault codes.

Condition:
- Turn keyswitch OFF.
- Connect the OEM harness to the ECM connector.
- Connect the aftertreatment outlet NOx sensor to the OEM harness.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for the appropriate circuit response after 30 seconds. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 2771 active? **YES** **Repair:** Replace the aftertreatment outlet NOx sensor. Refer to Procedure 019-451 in the Section 19.	5A
	Fault Code 2771 active? **NO** **Repair:** None. The removal and installation of the connector corrected the fault.	5A

STEP 5: Check ECM calibration and clear fault codes.

STEP 5A: Check if an ECM calibration update is available.

Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Compare the ECM code and revision number in the ECM to the calibration revisions listed in the ECM Calibration Revision History for applicable changes related to this fault code. • Use INSITE™ electronic service tool to find the present ECM code and revision number in the ECM. The ECM code and revision number are found in the Calibration Information section of System ID and Dataplate in Features and Parameters.	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **YES**	5B
	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **NO** **Repair:** If necessary, calibrate the ECM. Refer to Procedure 019-032 in Section 19.	5B

STEP 5B: Disable the fault code.

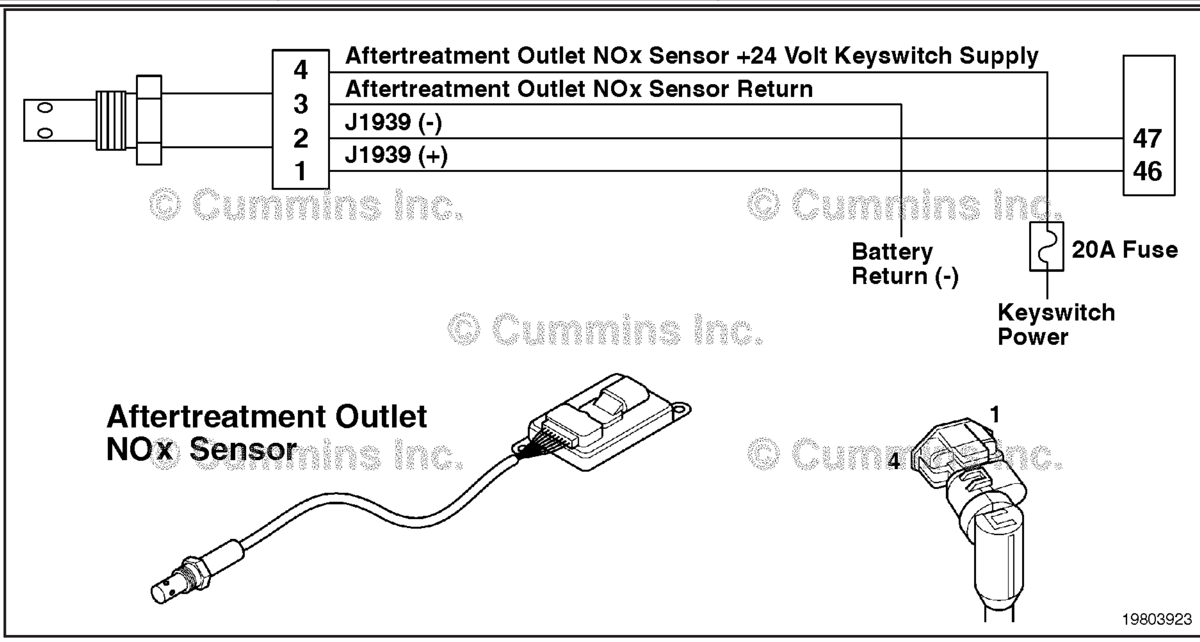
Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable and clear the fault code. • Operate the engine within the "Conditions for Clearing the Fault Code" found in the Overview section of this troubleshooting procedure.	Fault code inactive? **YES**	Repair complete
	Fault code inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair Location if all steps have been completed and checked again.	1A

Fault Code 2772

Aftertreatment Outlet NOx - Data Valid But Above Normal Operational Range - Least Severe Level

CODES	REASON	EFFECT
Fault Code: 2772 PID(P), SID(S): SPN: 3226 FMI: 0/15 Lamp: Amber SRT:	Aftertreatment Outlet NOx - Data Valid But Above Normal Operational Range - Least Severe Level. The engine NOx output is higher than recommended levels.	Aftertreatment Outlet NOx Sensor operation will be disabled.



Circuit: Aftertreatment Outlet NOx Sensor Circuit

Circuit Description:

The aftertreatment outlet nitrogen oxides (NOx) sensor is a smart device that receives commands from the engine control module (ECM) via the J1939 data link. The aftertreatment outlet NOx sensor receives power and a ground directly from the battery. The aftertreatment outlet NOx sensor performs its own internal diagnostics and reports malfunctions back to the primary engine ECM using the J1939 data link. The aftertreatment outlet NOx sensor is permanently attached to the NOx control module. They are serviced as a single component and can **not** be replaced individually. The aftertreatment outlet NOx sensor is used to measure the outlet NOx emissions from the engine.

Component Location:

The aftertreatment outlet NOx sensor location can vary, depending on engine application. It is usually located in the exhaust system, at the outlet of the aftertreatment catalyst.

Shop Talk:

On-Board Diagnostics (OBD) Information (Euro 4 Stage 1+ Certified Engines):

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- The ECM turns OFF the malfunction indicator lamp (MIL) after one ignition cycle that the diagnostic runs and does **not** fail. The MIL lamp and fault code can **not** be cleared using INSITE™ electronic service tool.
- The fault code will be cleared from the memory after 400 days or 9600 hours of engine operation.

The NOx sensor is permanently attached to the NOx control module. They are serviced as a single component and can **not** be replaced individually.

Possible causes of this fault code include:

- Diesel exhaust fluid quality is **not** within specification
- External leaks in the diesel exhaust fluid dosing unit and/or diesel exhaust fluid lines
- Aftertreatment nozzle has malfunctioned
- Aftertreatment diesel exhaust fluid dosing unit has malfunctioned or become damaged
- Sulfur content of the diesel fuel is too high, fouling the selective catalytic reduction (SCR) catalyst and resulting in high NOx output
- Aftertreatment nozzle is partially or completely plugged.

Refer to Troubleshooting Fault Code t05-2772.

FAULT CODE 2772 - Aftertreatment Outlet NOx - Data Valid But Above Normal Operating Range - Least Severe Level

TROUBLESHOOTING SUMMARY

⚠CAUTION⚠

To reduce the possibility of damaging a new engine control module (ECM), all other active fault codes must be investigated prior to replacing the ECM.

⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the following test leads when taking a measurement: Part Number 3822758 - male Deutsch™/AMP™/Metri-Pack™ test lead and Part Number 3822917 - female Deutsch™/AMP™/Metri-Pack™ test lead.

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Perform basic troubleshooting procedures.**		
STEP 1A:	Check for active counts of Fault Code 1694.	Fault Code 1694 active?	
STEP 1B:	Check for inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738.	Recent inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738 present that have not been addressed?	
STEP 2:	**Check the aftertreatment catalyst system.**		
STEP 2A:	Inspect the aftertreatment catalyst system for external leaks.	External leaks detected in the system?	
STEP 2B:	Check the exhaust pressure.	Exhaust back pressure exceeds the limits provided in Procedure 011-009?	
STEP 2C:	Inspect the aftertreatment nozzle.	Plugged or restricted aftertreatment nozzle detected?	
STEP 3:	**Verify the priming cycle of the diesel exhaust fliud dosing unit.**		
STEP 3A:	Check the diesel exhaust fluid dosing unit during priming.	Dosing unit only primes for 3 seconds? (plus the 140 second prime delay if applicable)	
STEP 3B:	Check the sir solenoid operation during priming.	Does the air solenoid click and exhaust air down the aftertreatment nozzle line continously after 30 seconds? (NOTE: will attempt to prime up to 20 times)	
STEP 3C:	Confirm the successful priming of the DEF dosing unit.	Air flow above 25 liters per minute [6.6 gallons per minute]?	
STEP 4:	**Check the diesel exhaust fluid (DEF) dosing unit air supply system.**		
STEP 4A:	Inspect the air supply lines to the diesel exhaust fluid dosing unit.	Original equipment manufacturer (OEM) air supply correctly attached to the DEF dosing unit and supplying adequate air pressure?	
STEP 4B:	Clear the DEF dosing unit air side circuit. Carry out the flushing procedure.	Flushing procedure successful?	
STEP 5:	**Check the DEF lines and fittings for restriction and contamination.**		

STEP 5A:	Check the DEF dosing unit fittings and lines.	DEF fittings and lines pass the inspections?
STEP 5B:	Check the DEF dosing lines for restrictions or leaks.	Restriction line test completed successfully.
STEP 5C:	Inspect the DEF tank and the 35 micron tank filter.	DEF tank contaminated or the urea solution less than 32.5%?

STEP 6: Perform the DEF Doser Pump Override Test.

STEP 6A:	Perform the DEF Doser Pump Override Test with INSITE™ electronic service tool.	Dosing control unit operates correctly during INSITE™ electronic service tool override test? (it is recommended to complete this test 3 times)
STEP 6B:	Inspect the diesel exhaust fluid dosing unit inline screen filter connection.	Contamination present at the screen filter?

STEP 7: Check ECM calibration and clear fault codes.

STEP 7A:	Check if an ECM calibration update is available.	If a calibration update for this fault code is available, does the ECM contain that revision or higher?
STEP 7B:	Disable the fault code.	Fault code inactive?

TROUBLESHOOTING STEP

STEP 1: Inspect the fault codes.

STEP 1A: Check for active counts of Fault Code 1694.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
The following items **must** be checked or verified before continuing: • Check for active Fault Code 1694.	Fault Code 1694 active? **YES** **Repair:** Troubleshoot FC1694 before returning to this troubleshooting tree.	Fault Code 1694 troubleshooting tree.
	Fault Code 1694 active? **NO**	1B

STEP 1B: Check for inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to check for inactive counts of Fault Code 1682, 3548, 3569, 3575 or 3738 in the ECM. • Look specifically for one or more inactive counts of Fault Code 1682, 3548, 3569, 3575 or 3738 within 50 engine hours of this fault code being set.	Recent inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738 present that have **not** been addressed? **YES** **Repair:** Troubleshooting Fault Code 1682, 3548, 3569, 3575, or 3738 before returning to this fault code troubleshooting tree.	Fault Code 1682, 3548, 3569, 3575 or 3738 troubleshooting tree.
	Recent inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738 present that have **not** been addressed? **NO**	2A

STEP 2: Check the aftertreatment catalyst system.

STEP 2A: Inspect the aftertreatment catalyst system for external leaks.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the aftertreatment catalyst system. • Inspect aftertreatment catalyst and all attached exhaust pipework for signs of exhaust gas leakage or damage.	External leaks detected in the system? **YES** **Repair:** Repair the source of the external leak.	7A
	External leaks detected in the system? **NO**	2B

STEP 2B: Check the exhaust back pressure.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Measure the exhaust back pressure. • Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-009 in Section 11.	Exhaust back pressure exceeds the limits provided in Procedure 011-009? **YES** **Repair:** Repair source or replace the aftertreatment SCR catalyst. • Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-036 in Section 11.	7A
	Exhaust back pressure exceeds the limits provided in Procedure 011-009? **NO**	2C

STEP 2C: Inspect the aftertreatment nozzle.

Condition:
- Make sure the nozzle has been warmed in the exhaust prior to removal. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-040 in Section 11.
- Turn keyswitch OFF.
- Remove the aftertreatment nozzle. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-040 in Section 11.

Action	Specification/Repair	Next Step
Inspect the aftertreatment nozzle for blockage or restrictions. • Inspect the aftertreatment nozzle. Inspect the aftertreatment nozzle. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-040 in Section 11. • Soft crystal and ash-like buildup in the spray holes can be dissolved with 40°C [104°F] warm water. • Make sure that the soft buildup in the spray holes clears when the dosing unit begins dosing.	Plugged or restricted aftertreatment nozzle detected? **YES** **Repair:** Clean or replace the aftertreatment nozzle. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-040 in Section 11.	3A
	Plugged or restricted aftertreatment nozzle detected? **NO**	3A

STEP 3: Verify the priming cycle of the diesel exhaust fluid dosing unit.

STEP 3A: Check the diesel exhaust fluid dosing unit during priming.

Condition:
- Disconnect the diesel exhaust fluid line from the aftertreatment nozzle and secure it appropriately.
- Leave the aftertreatment nozzle installed.
- Turn keyswitch ON.
- Start the engine and operate at low idle.
- Connect INSITE™ electronic service tool.

<table>
<tr><th>Action</th><th>Specification/Repair</th><th>Next Step</th></tr>
<tr><td rowspan="2">Check the diesel exhaust fluid dosing unit during priming.
• After key ON with the engine operating, listen for the diesel exhaust fluid dosing pump to start.
• Time the pump operation until the pump automatically switches off (The pump is attempting to prime)
NOTE: While the engine is operating, it may be difficult to hear the pump. If this is the case, listen for the air solenoid to click, indicating that the pump has completed 1 prime attempt.
NOTE: Older calibrations did not incorporate the 140 second delay from key ON to initial prime cycle. During the 140 second delay, the dosing unit will remain on standby before receiving the command to prime. This was introduced to remove any crystallization buildup on the injection tip prior to priming cycle and to avoid any blocked injection lines.
A correct prime cycle is as follows:
1. Key ON
2. 140 second pump start delay
3. Pump starts and operates for 30 seconds. (The system is now priming, this step may be attempted up to 20 times).
4. The diesel exhaust fluid injection line will now exhaust air. Priming is now complete.</td><td>Dosing unit only primes for 3 seconds? (Plus the 140 second prime delay if applicable)
YES
Repair:
Complete line restriction testing procedure then prime again. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-086 in Section 19.</td><td>3A</td></tr>
<tr><td>Dosing unit only primes for 3 seconds? (Plus the 140 second prime delay if applicable)
NO</td><td>3B</td></tr>
</table>

STEP 3B: Check the air solenoid operation during priming.

Condition:
- Disconnect the diesel exhaust fluid line from the aftertreatment nozzle and secure it appropriately.
- Leave the aftertreatment nozzle installed.
- Turn keyswitch ON
- Connect INSITE™ electronic service tool.
- Start the engine and operate at low idle.

Action	Specification/Repair	Next Step
Make sure that the diesel exhaust fluid dosing unit has successfully primed and entered the dosing state. • The diesel exhaust fluid dosing unit enters the dosing state **only** when a successful prime is completed, and the air solenoid has clicked. • At this point, air will be flowing continuously down the aftertreatment nozzle line. • The DEF dosing unit could attempt to prime for up to 12 minutes, at which point, if a prime is successful, the pump will switch off. • Use INSITE™ electronic service tool Data/ Monitor Logger for Aftertreatment DEF Dosing Unit State to confirm the doser status.	Does the air solenoid click and exhaust air down the aftertreatment nozzle line continuously after 30 seconds? (Note: will attempt to prime up to 20 times) **YES**	3C
	Does the air solenoid click and exhaust air down the aftertreatment nozzle line continuously after 30 seconds? (Note: will attempt to prime up to 20 times) **NO** **Repair:** NOTE: The diesel exhaust fluid dosing unit has **not** primed.	5A

STEP 3C: Confirm the successful priming of the DEF dosing unit.

Condition:
- Turn keyswitch OFF for a minimum of 1 minute.
- Disconnect the diesel exhaust fluid line from the aftertreatment nozzle.
- Attach the air flow meter to the diesel exhaust fluid dosing line. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-058 in Section 11.
- Secure the diesel exhaust fluid dosing line and the attached air flow meter.
- Start the engine and operate at low idle.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
The DEF dosing unit should start the priming cycle immediately after the prime delay when the engine is started. After 30 seconds (each prime attempt will take 30 seconds, if **not** successful the doser will attempt to prime up to 20 times) air should continuously flow through the DEF Injection line, and the attached air flow meter. • Record the measured air flow from the diesel exhaust fluid dosing line.	Air flow above 25 liters per minute [6.6 gallons per minute]? **YES** **Repair:** Clean or replace the aftertreatment nozzle.	6A
	Air flow above 25 liters per minute [6.6 gallons per minute]? **NO**	4A

STEP 4: Check the diesel exhaust fluid dosing unit air supply system.

STEP 4A: Inspect the air supply lines to the diesel exhaust fluid dosing unit.

Condition:
- Turn keyswitch ON.
- Start the engine.
- Operate the engine at low idle.

Action	Specification/Repair	Next Step
Inspect the OEM air supply line attached to the diesel exhaust fluid dosing unit. • Check for leaks or loose connections in the air supply line. • Check the diesel exhaust fluid dosing unit air filter for water or excessive oil from the vehicle's compressed air system. • Make sure a clean supply of air, at least 517 kPa [75 psi], pressure is present at the diesel exhaust fluid dosing unit. NOTE: Most vehicles are equipped with an inline air filter in the air line prior to the diesel exhaust fluid dosing unit. A plugged or restricted inline air filter can cause low air pressure to the diesel exhaust fluid dosing unit.	OEM air supply correctly attached to the diesel exhaust fluid dosing unit and supplying adequate air pressure? **YES**	4B
	OEM air supply correctly attached to the diesel exhaust fluid dosing unit and supplying adequate air pressure? **NO** **Repair:** Correct the OEM air supply connection or supply. Refer to the OEM service manual.	3A

STEP 4B: Clear the diesel exhaust fluid dosing unit air side circuit. Carry out the flushing procedure.

Condition:
- Drain or isolate the OEM air supply circuit.
- Remove the OEM air supply hose.

Action	Specification/Repair	Next Step
Carry out the diesel exhaust fluid dosing unit flushing procedure. • Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-082 in Section 11. • Most vehicles are equipped with an inline air filter in the air line prior to the diesel exhaust fluid dosing unit. A plugged or restricted inline air filter can cause low air pressure to the diesel exhaust fluid dosing unit.	Flushing procedure successful? **YES**	5A
	Flushing procedure successful? **NO** **Repair:** Replace the diesel exhaust fluid dosing unit.	7A

STEP 5: Check the diesel exhaust fluid lines and fittings for restriction and contamination.

STEP 5A: Check the diesel exhaust fluid dosing unit fittings and lines.

Condition:
- Clean the front face of the doser before removing any lines.
- Disconnect the diesel exhaust fluid line from the aftertreatment nozzle and secure appropriately.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Start the engine and operate at low idle.

Action	Specification/Repair	Next Step
Inspect the diesel exhaust fluid dosing unit fittings and lines for the following: NOTE: Clean the front face of the aftertreatment dosing unit and lines with warm water or mild detergent before removing any line. This is to prevent any contamination due to service intervention. • Loose diesel exhaust fluid inlet connectors or fittings. • Cracked diesel exhaust fluid lines, resulting in leaks or drawing in air. • Make sure diesel exhaust fluid is returning to the tank during the priming cycle.	Diesel exhaust fluid fittings and lines pass the inspections? **YES**	5B
	Diesel exhaust fluid fittings and lines pass the inspections? **NO** **Repair:** Repair or replace diesel exhaust fluid lines and/or connectors. Refer to the OEM service manual.	3B

STEP 5B: Check the diesel exhaust fluid dosing lines for restrictions or leaks.

Condition:
- Turn keyswitch OFF.
- Do **not** operate engine.

Action	Specification/Repair	Next Step
Complete the line restriction procedure. • Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-086 in Section 11. • Check the diesel exhaust fluid lines for leaks or restrictions. NOTE: Clean the front face of the aftertreatment dosing unit and lines with warm water or mild detergent before removing any lines. This is to prevent any contamination due to service intervention. • Remove and check the supply and return lines. Use the following procedure to identify the different connections on the diesel exhaust fluid dosing unit. Refer to Procedure 019-440 in Section 19.	Restriction line test completed successfully? **YES**	5C
	Restriction line test completed successfully? **NO** **Repair:** Repair or replace the diesel exhaust fluid lines and/or connectors.	3B

STEP 5C: Inspect the diesel exhaust fluid tank and the 35 micron tank filter.

Condition:
- Turn keyswitch OFF.
- Do **not** operate the engine.

Action	Specification/Repair	Next Step
Inspect the diesel exhaust fluid tank and filters for fuel, oil, coolant, dirt, and debris. Refer to the OEM service manual for removal/ installation procedures for the DEF tank and DEF tank level sensor assembly. NOTE: In some cases the DEF tank is bonded to the vehicle chassis leaving no access to DEF tank level sensor assembly. If this is the case then contact the OEM to arrange for the tank to be removed and inspected. • Inspect the contents of the tank. • Inspect the condition of the tank filter. • Check that a 35 micron tank filter is fitted. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-083 in Section 11. • Check and record the urea concentration of the diesel exhaust fluid using a sample from the tank. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 018-026 in Section V.	DEF tank contaminated or the urea solution less than 32.5%? **YES** **Repair:** Locate/remove source, inform OEM. If required replace components and connectors. Drain/refill the diesel exhaust fluid tank. Refer to the OEM service manual.	6A
	DEF tank contaminated or the urea solution less than 32.5%? **NO**	6A

STEP 6: Perform the Diesel Exhaust Fluid Doser Pump Override Test.

STEP 6A: Perform the Diesel Exhaust Fluid Dosing Pump Override Test with INSITE™ electronic service tool.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to perform the Diesel Exhaust Fluid Doser Pump Override Test, under Aftertreatment Diagnostics Tests. • Use the following procedure for instructions and specifications. Refer to Procedure 019-440 in Section 19. • Check to make sure that the diesel exhaust fluid is being injected through the aftertreatment nozzle during the dosing state. NOTE: The aftertreatment nozzle **must** have been warmed in the exhaust before removing and placing it in a measuring container greater than 200 ml [6.8 oz] capacity to perform the Diesel Exhaust Fluid Doser Pump Override Test. The troubleshooting tree **must** be followed completely before completing this test.	Dosing control unit operates correctly during INSITE™ electronic service tool override test? (It is recommended to complete this test 3 times) **YES**	7A
	Dosing control unit operates correctly during INSITE™ electronic service tool override test? (It is recommended to complete this test 3 times) **NO**	6B

STEP 6B: Inspect the diesel exhaust fluid dosing unit inline screen filter connection.

Condition:
- Clean the front face of the doser before removing any lines.
- Disconnect the DEF supply line from the dosing unit and secure appropriately.

Action	Specification/Repair	Next Step
Inspect the diesel exhaust fluid dosing unit inline screen filter connection. • Remove the diesel exhaust fluid dosing unit supply line. • Inspect the inlet screen filter. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-060 in Section 11. NOTE: Clean the front face of the aftertreatment dosing unit and lines with warm water or mild detergent before removing any lines. This is to prevent any contamination due to service intervention. Use the following procedure to identify the different connections on the diesel exhaust fluid dosing unit. Refer to Procedure 019-440 in Section 19.	Contamination present at the screen filter? **YES** **Repair:** Replace the screen filter. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-060 in Section 11.	6A
	Contamination present at the screen filter? **NO** **Repair:** A damaged diesel exhaust fluid dosing unit has been detected. Replace the diesel exhaust fluid dosing unit. • Refer to Procedure 019-440 in Section 19.	7A

STEP 7: Check ECM calibration and clear fault codes.

STEP 7A: Check if an ECM calibration update is available.

Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Compare the ECM code and revision in the ECM to the calibration revisions listed in the ECM Calibration Revision History for applicable changes related to this fault code. • Use INSITE™ electronic service tool to find the present ECM code and revision number in the ECM. The ECM code and revision number are found in the Calibration Information section of System ID and Dataplate in Features and Parameters.	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **YES**	7B
	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **NO** **Repair:** If necessary, calibrate the ECM. Refer to Procedure 019-032 in Section 19.	7B

STEP 7B: Disable the fault code.

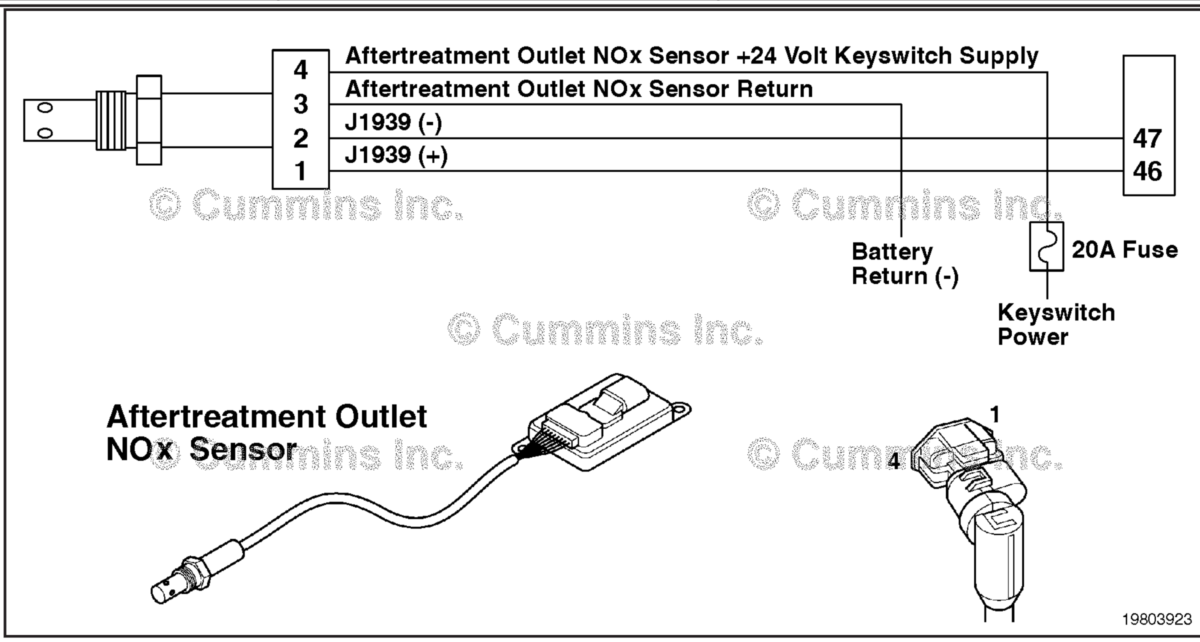
Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable and clear the fault code. • Operate the engine within the "Conditions for Clearing the Fault Code" found in the Overview section of this troubleshooting procedure.	Fault code inactive? **YES**	Repair complete
	Fault code inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair Location if all steps have been completed and checked again.	1A

Fault Code 2773

Aftertreatment Outlet NOx - Data Valid but Above Normal Operational Range - Most Severe Level

CODES	REASON	EFFECT
Fault Code: 2773 PID(P), SID(S): SPN: 3226 FMI: 0 Lamp: Red SRT:	Aftertreatment Outlet NOx - Data Valid but Above Normal Operational Range - Most Severe Level. The engine NOx output is higher than recommended levels.	Aftertreatment outlet NOx sensor operation will be disabled. Engine will derate the next time that the vehicle sees zero vehicle speed.



Circuit: Aftertreatment Outlet NOx Sensor Circuit

Circuit Description:

The aftertreatment outlet nitrogen oxides (NOx) sensor is a smart device and receives commands from the engine electronic control module (ECM) via the J1939 data link. The aftertreatment outlet NOx sensor receives power and a ground directly from the battery. The aftertreatment outlet NOx sensor performs its own internal diagnostics and reports malfunctions back to the primary engine ECM using the J1939 data link. The aftertreatment outlet NOx sensor is permanently attached to the NOx control module. They are serviced as a single component and can **not** be replaced individually. The aftertreatment outlet NOx sensor is used to measure the outlet NOx emissions from the engine.

Component Location:

The aftertreatment outlet NOx sensor location can vary depending on engine application. It is usually located in the exhaust system at the outlet of the aftertreatment catalyst.

Shop Talk:

On-Board Diagnostic (OBD) Information (Euro 4 Stage 1+ Certified Engines):

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- An engine torque derate will be activated immediately after the fault code becomes active.

- The ECM turns OFF the malfunction indicator lamp (MIL) after 1 ignition cycle that the diagnostic runs and does **not** fail. The MIL lamp and fault code **cannot** be cleared using INSITE™ electronic service tool.
- The fault code will be cleared from the memory after 400 days or 9600 hours of engine operation.

The NOx sensor is permanently attached to the NOx control module. They are serviced as a single component and can **not** be replaced individually.

Possible causes of this fault code include:

- Catalyst solution quality is **not** within specification, catalyst solution pump and lines external leaks, catalyst solution injector plugged or restricted, and catalyst solution lines plugged or restricted. Catalyst dosing unit has malfunctioned or become damaged
- Catalyst solution injector nozzle is partially or completely plugged.

Refer to Troubleshooting Fault Code t05-2773

FAULT CODE 2773 - Aftertreatment Outlet NOx - Data Valid But Above Normal Operating Range - Most Severe Level

TROUBLESHOOTING SUMMARY

CAUTION

To reduce the possibility of damaging a new engine control module (ECM), all other active fault codes must be investigated prior to replacing the ECM.

CAUTION

To reduce the possibility of pin and harness damage, use the following test leads when taking a measurement: Part Number 3822758 - male Deutsch™/AMP™/Metri-Pack™ test lead Part Number 3822917 - female Deutsch™/AMP™/Metri-Pack™ test lead.

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Inspect the fault codes.**		
STEP 1A:	Check for active counts of Fault Code 1694.	Fault Code 1694 active?	
STEP 1B:	Check for inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738.	Recent inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738 present that have not been addressed?	
STEP 1C:	Check the remaining active/ inactive fault codes.	Active fault codes or performance complaints present? (With the exception of Fault Code 2772)	
STEP 2:	**Check the aftertreatment catalyst system.**		
STEP 2A:	Inspect the aftertreatment catalyst system for external leaks.	External leaks detected in the system?	
STEP 2B:	Check the exhaust back pressure.	Exhaust back pressure exceeds the limits provided in Procedure 011-009?	
STEP 2C:	Check the aftertreatment selective catalytic reduction (SCR) catalyst.	SCR catalyst present, not damaged, and not found to be broken up?	
STEP 2D:	Inspect the aftertreatment nozzle.	Plugged or restricted aftertreatment nozzle detected?	
STEP 3:	**Verify the priming cycle of the diesel exhaust fluid (DEF) dosing unit.**		
STEP 3A:	Check the DEF dosing unit during priming.	Dosing unit only primes for 3 seconds? (Plus the 140 second prime delay if applicable)	
STEP 3B:	Check the air solenoid operation during priming.	Air solenoid click and exhaust air down the aftertreatment nozzle line continuously after 30 seconds? (Note: will attempt to prime up to 20 times)	
STEP 3C:	Confirm the successful priming of the DEF dosing unit.	Air flow above 25 liters per minute [6.6 gallons per minute]?	
STEP 4:	**Check the DEF dosing unit air supply system.**		
STEP 4A:	Inspect the air supply lines to the DEF dosing unit.	Original equipment manufacturer (OEM) air supply correctly attached to the DEF	

		dosing unit and supplying adequate air pressure?
STEP 4B:	Clear the DEF dosing unit air side circuit. Carry out the flushing procedure.	Flushing procedure successful?

STEP 5: Check the DEF lines and fittings for restriction and contamination.

STEP 5A:	Check the DEF dosing unit fittings and lines.	DEF fittings and lines pass the inspections?
STEP 5B:	Inspect the DEF dosing unit inline screen filter connection.	Contamination present at the screen filter?
STEP 5C:	Inspect the DEF tank and the 35 micron tank filter.	DEF tank contaminated or the urea solution less than 32.5%?

STEP 6: Perform the DEF Doser Pump Override Test.

STEP 6A:	Perform the DEF Dosing Pump Override Test with INSITE™ electronic service tool.	Dosing control unit operates correctly during INSITE™ electronic service tool override test? (It is recommended to complete this test 3 times)

STEP 7: Check ECM calibration and clear fault codes.

STEP 7A:	Check if an ECM calibration update is available.	If a calibration update for this fault code is available, does the ECM contain that revision or higher?
STEP 7B:	Disable the fault code.	Fault code inactive?

TROUBLESHOOTING STEP

STEP 1: Inspect the fault codes.

STEP 1A: Check for active counts of Fault Code 1694.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
The following items **must** be checked or verified before continuing: • Check for active counts of Fault Code 1694.	Fault Code 1694 active? **YES** **Repair:** Troubleshoot Fault Code 1694 before returning to this troubleshooting tree.	Fault Code 1694 troubleshooting tree.
	Fault Code 1694 active? **NO**	1B

STEP 1B: Check for inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to check for inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738 in the ECM. • Look specifically for one or more inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738 within 50 engine hours of this fault code being set.	Recent inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738 present that have **not** been addressed? **YES** **Repair:** Troubleshoot Fault Code 1682, 3548, 3569, 3575, or 3738 before returning to this fault code troubleshooting tree.	Fault Code 1682, 3548, 3569, 3575, or 3738 troubleshooting tree.
	Recent inactive counts of Fault Code 1682, 3548, 3569, 3575, or 3738 present that have **not** been addressed? **NO**	1C

STEP 1C: Check the remaining active/inactive fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for active fault codes. • Use INSITE™ electronic service tool to read the fault codes. • Troubleshoot any other active fault codes first. • All other active fault codes except Fault Code 2772 **must** be resolved before following this troubleshooting tree. • Check for performance complaints • Troubleshoot any performance complaints related to smoke or misfire first. NOTE: Fault Code 2773 is caused by the same symptoms as Fault Code 2772, but at a more severe level. Therefore, if both fault codes are active, Fault Code 2773 should **always** be addressed first.	Active fault codes or performance complaints present? (With the exception of Fault Code 2772) **YES**	Appropriate troubleshooting tree.
	Active fault codes or performance complaints present? (With the exception of Fault Code 2772) **NO**	2A

STEP 2: Check the aftertreatment catalyst system.

STEP 2A: Inspect the aftertreatment catalyst system for external leaks.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the aftertreatment catalyst system. • Inspect the aftertreatment catalyst and all attached exhaust pipe work for signs of exhaust gas leakage or damage.	External leaks detected in the system? **YES** **Repair:** Repair the source of the external leak.	7A
	External leaks detected in the system? **NO**	2B

STEP 2B: Check the exhaust back pressure.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Measure the exhaust back pressure. • Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-009 in Section 11.	Exhaust back pressure exceeds the limits provided in Procedure 011-009? **YES** **Repair:** Repair source or replace the aftertreatment SCR catalyst. • Refer to Procedure 011-036 in Section 11.	7A
	Exhaust back pressure exceeds the limits provided in Procedure 011-009? **NO**	2C

STEP 2C: Check the aftertreatment SCR catalyst.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Make sure that the SCR catalyst is present in the exhaust stream. Remove the aftertreatment SCR catalyst. • Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-036 in Section 11. Inspect the aftertreatment SCR catalyst. If the aftertreatment SCR catalyst has broken up, then a **significant** mass of broken material will move around inside the assembly when the catalyst is tilted or moved.	SCR catalyst present, **not** damaged, and **not** found to be broken up? **YES**	2D
	SCR catalyst present, **not** damaged, and **not** found to be broken up? **NO** **Repair:** Replace the aftertreatment SCR catalyst. • Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-036 in Section 11.	7A

STEP 2D: Inspect the aftertreatment nozzle.

Condition:
- Make sure the nozzle has been warmed in the exhaust prior to removal. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-040 in Section 11.
- Turn keyswitch OFF.
- Remove the aftertreatment nozzle. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-040 in Section 11.

Action	Specification/Repair	Next Step
Inspect the aftertreatment nozzle for blockage or restrictions. • Inspect the aftertreatment nozzle. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-040 in Section 11. • Soft crystal and ash-like buildup in the spray holes can be dissolved with 40°C [104°F] warm water. • Make sure the soft buildup in the spray holes clears when the dosing unit begins dosing.	Plugged or restricted aftertreatment nozzle detected? **YES** **Repair:** Clean or replace the aftertreatment nozzle. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-040 in Section 11.	3A
	Plugged or restricted aftertreatment nozzle detected? **NO**	3A

STEP 3: Verify the priming cycle of the DEF dosing unit.

STEP 3A: Check the diesel exhaust fluid dosing unit during priming.

Condition:
- Disconnect the DEF line from the aftertreatment nozzle and secure it appropriately.
- Leave the aftertreatment nozzle installed.
- Turn keyswitch ON.
- Start the engine and operate at low idle
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
The following items **must** be checked or verified before continuing: • After key ON with the engine operating, listen for the DEF dosing pump to start. • Time the pump operation until the pump automatically switches off (the pump is attempting to prime). NOTE: While the engine is operating it may be difficult to hear the pump. If this is the case, listen for the air solenoid to click, indicating that the pump has completed 1 prime attempt. NOTE: Older calibrations did **not** incorporate the 140 second delay from key on to initial prime cycle. During the 140 second delay the dosing unit will remain on standby before receiving the command to prime. This was introduced to remove any crystallization building up on the injection tip prior to priming cycle and to avoid any blocked injection lines. A correct prime cycle is as follows: 1. Key ON 2. 140 second pump start delay 3. Pump starts and operates for 30 seconds. (The system is now priming, this step may be attempted up to 20 times). 4. The DEF injection line will now exhaust air. Priming is now complete.	Dosing unit **only** primes for 3 seconds? (Plus the 140 second prime delay if applicable) **YES** **Repair:** Complete line restriction testing procedure then prime again. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-086 in Section 11.	3A
	Dosing unit **only** primes for 3 seconds? (Plus the 140 second prime delay if applicable) **NO**	3B

STEP 3B: Check the air solenoid operation during priming.

Condition:
- Disconnect the DEF line from the aftertreatment nozzle and secure it appropriately.
- Leave the aftertreatment nozzle installed.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Start the engine and operate at low idle.

Action	Specification/Repair	Next Step
Make sure the DEF dosing unit has successfully primed and entered the dosing state. • The DEF dosing unit enters the dosing state **only** when a successful prime is has completed, and the air solenoid has clicked. • At this point, air will be flowing continuously down the aftertreatment nozzle line. • The DEF dosing unit could attempt to prime for up to 12 minutes, at which point, if a prime is successful, the pump will switch off. • Use INSITE™ electronic service tool Data/ Monitor Logger for Aftertreatment Diesel Exhaust Fluid Dosing Unit State to confirm the doser status.	Air solenoid click and exhaust air down the aftertreatment nozzle line continuously after 30 seconds? (Note: will attempt to prime up to 20 times) **YES**	3C
	Air solenoid click and exhaust air down the aftertreatment nozzle line continuously after 30 seconds? (Note: will attempt to prime up to 20 times) **NO** **Repair:** NOTE: The DEF dosing unit has **not** primed.	5A

STEP 3C: Confirm the successful priming of the DEF dosing unit.

Condition:
- Turn keyswitch OFF for a minimum of 1 minute.
- Disconnect the DEF line from the aftertreatment nozzle.
- Attach the air flow meter to the DEF dosing line. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-058 in Section 11.
- Secure the DEF dosing line and the attached air flow meter.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Start the engine and operate at low idle.

Action	Specification/Repair	Next Step
The DEF dosing unit should start the priming cycle immediately after the prime delay when the engine is started. After 30 seconds (each prime attempt will take 30 seconds, if **not** successful the doser will attempt to prime up to 20 times) air should continuously flow through the DEF Injection line, and the attached air flow meter. • Record the measured air flow from the DEF dosing line.	Air flow above 25 liters per minute [6.6 gallons per minute]? **YES**	6A
	Air flow above 25 liters per minute [6.6 gallons per minute]? **NO**	4A

STEP 4: Check the DEF dosing unit air supply system.

STEP 4A: Inspect the air supply lines to the DEF dosing unit.

Condition:
- Turn keyswitch ON.
- Start the engine.
- Operate the engine at low idle.

Action	Specification/Repair	Next Step
Inspect the OEM air supply line attached to the DEF dosing unit. • Check for leaks or loose connections in the air supply line. • Check the DEF dosing unit air filter for water or excessive oil from the vehicle's compressed air system. • Make sure a clean supply of air, at least 517 kPa [75 psi], pressure is present at the DEF dosing unit. NOTE: Most vehicles are equipped with an inline air filter in the air line prior to the DEF dosing unit. A plugged or restricted inline air filter can cause low air pressure to the DEF dosing unit.	OEM air supply correctly attached to the DEF dosing unit and supplying adequate air pressure? **YES**	4B
	OEM air supply correctly attached to the DEF dosing unit and supplying adequate air pressure? **NO** **Repair:** Correct the OEM air supply connection or supply. Refer to the OEM service manual.	3A

STEP 4B: Clear the DEF dosing unit air side circuit. Carry out the flushing procedure.

Condition:
- Drain or isolate the OEM air supply circuit.
- Remove the OEM air supply hose.

Action	Specification/Repair	Next Step
Carry out the DEF dosing unit flushing procedure. • Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual. Refer to Procedure 011-082 in Section 11. • Most vehicles are equipped with an inline air filter in the air line prior to the DEF dosing unit. A plugged or restricted inline air filter can cause low air pressure to the DEF dosing unit.	Flushing procedure successful? **YES**	5A
	Flushing procedure successful? **NO** **Repair:** Replace the DEF dosing unit.	7A

STEP 5: Check the DEF lines and fittings for restriction and contamination.

STEP 5A: Check the DEF dosing unit fittings and lines.

Condition:
- Clean the front face of the doser before removing any lines.
- Disconnect the DEF line from the aftertreatment nozzle and secure appropriately.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Start the engine and operate at low idle.

Action	Specification/Repair	Next Step
Inspect the DEF dosing unit fittings and lines for the following: NOTE: Clean the front face of the aftertreatment dosing unit and lines with warm water or mild detergent before removing any line. This is to prevent any contamination due to service intervention. • Loose DEF inlet connectors or fittings • Cracked DEF lines, resulting in leaks or drawing in air • Be sure DEF is returning to the tank during the priming cycle.	DEF fittings and lines pass the inspections? **YES**	5B
	DEF fittings and lines pass the inspections? **NO** **Repair:** Repair or replace DEF lines and/or connectors. Refer to the OEM service manual.	3B

STEP 5B: Inspect the DEF dosing unit inline screen filter connection.

Condition:
- Clean the front face of the doser before removing any lines.
- Disconnect the DEF supply line from the dosing unit and secure appropriately.

Action	Specification/Repair	Next Step
Inspect the DEF dosing unit inline screen filter connection. • Remove the DEF dosing unit supply line. • Inspect the inlet screen filter. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-060 in Section 11. NOTE: Clean the front face of the aftertreatment dosing unit and lines with warm water or mild detergent before removing any lines. This is to prevent any contamination due to service intervention. Use the following procedure to identify the different connections on the DEF dosing unit. Refer to Procedure 019-440 in Section 19.	Contamination present at the screen filter? **YES** **Repair:** Replace the screen filter.	5C
	Contamination present at the screen filter? **NO**	5C

STEP 5C: Inspect the DEF tank and the 35 micron tank filter.

Condition:
- Turn keyswitch OFF.
- Do **not** operate the engine.

Action	Specification/Repair	Next Step
Inspect the DEF tank and filters for fuel, oil, coolant, dirt, and debris. Refer to the OEM service manual for removal / installation procedures for the DEF tank and DEF tank level sensor assembly. NOTE: In some cases the DEF tank is bonded to the vehicle chassis leaving no access to DEF tank level sensor assembly. If this is the case then contact the OEM to arrange for the tank to be removed and inspected. • Inspect the contents of the tank. • Inspect the condition of the tank filter. • Check that a 35 micron tank filter is fitted. Use the following procedure for ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 1 or ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 engines. Refer to Procedure 011-083 in Section 11. • Check and record the urea concentration of the DEF using a sample from the tank. Refer to Procedure 018-026 in Section V.	DEF tank contaminated or the urea solution less than 32.5%? **YES** **Repair:** Locate/remove source, inform OEM. If required, replace components and connectors. Drain/refill the DEF tank. Refer to OEM service manual.	6A
	DEF tank contaminated or the urea solution less than 32.5%? **NO**	6A

STEP 6: Perform the Diesel Exhaust Fluid Doser Pump Override Test.

STEP 6A: Perform the Diesel Exhaust Fluid Dosing Pump Override Test with INSITE™ electronic service tool.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to perform the Diesel Exhaust Fluid Doser Pump Override Test, under Aftertreatment Diagnostics Tests. • Use the following procedure for instructions and specifications. Refer to Procedure 019-440 in Section 19. • Check to make sure that the DEF is being injected through the aftertreatment nozzle during the dosing state. NOTE: The aftertreatment nozzle **must** have been warmed in the exhaust before removing and placing it in a measuring container larger than 200 ml [6.8 oz] capacity to perform the Diesel Exhaust Fluid Doser Pump Override Test. The troubleshooting tree **must** be followed completely before completing this test.	Dosing control unit operates correctly during INSITE™ electronic service tool override test? (It is recommended to complete this test 3 times) **YES**	7A
	Dosing control unit operates correctly during INSITE™ electronic service tool override test? (It is recommended to complete this test 3 times) **NO** **Repair:** A damaged diesel exhaust fluid dosing unit has been detected. Replace the diesel exhaust fluid dosing unit. • Refer to Procedure 019-440 in Section 19.	7A

STEP 7: Check ECM calibration and clear fault codes.

STEP 7A: Check if an ECM calibration update is available.

Condition:
- Connect all components.
- Turn Keyswitch ON.
- Connect INSITE™ electronic service tool

Action	Specification/Repair	Next Step
Compare the ECM code and revision number in the ECM to the calibration revisions listed in the ECM Calibration Revision History for applicable changes related to this fault code. • Use INSITE™ electronic service tool to find the present ECM code and revision number in the ECM. The ECM code and revision number are found in the Calibration Information section of System ID and Data Plate in Features and Parameters.	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **YES**	7B
	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **NO** **Repair:** If necessary, calibrate the ECM. Refer to Procedure 019-032 in Section 19.	7B

STEP 7B: Disable the fault code.

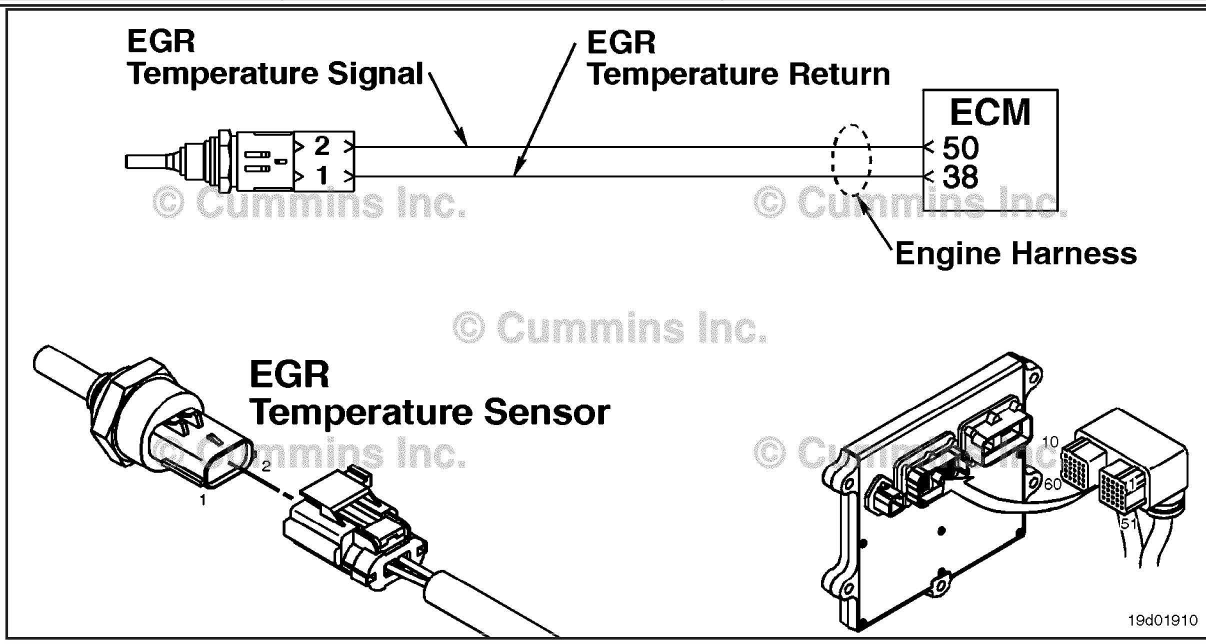
Condition:
- Connect all components
- Connect INSITE™ electronic service tool

Action	Specification/Repair	Next Step
Disable and clear the fault code. • Operate the engine within the "Conditions for Clearing the Fault Code" found in the Overview section of this troubleshooting procedure.	Fault code inactive? **YES**	Repair complete
	Fault code inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair Location if all steps have been completed and checked again.	1A

Fault Code 2961

EGR Temperature - Data Valid But Above Normal Operating Range, Least Severe Level

CODES	REASON	EFFECT
Fault Code: 2961 PID(P), SID(S): P412 SPN: 412 FMI: 0/15 Lamp: None SRT:	Exhaust Gas Recirculation (EGR) temperature - Data Valid but Above Normal Operating Range, Least Severe Level.	Engine power derate until the EGR temperature is under the maximum limit.



EGR Temperature Sensor Circuit

Circuit Description:

The EGR temperature sensor is used to measure the temperature of the exhaust gas that exits the EGR cooler. This temperature is monitored to protect the engine against extremely high temperatures associated with the EGR system.

Component Location:

The EGR temperature sensor is located in the air horn, on the intake side of the engine. Refer to Procedure 100-002 (Engine Diagrams) in Section E for a detailed component location view.

Shop Talk:

This fault code can be caused by:

- A fouled EGR cooler
- High coolant temperature
- Low coolant level
- Malfunctioning EGR valve
- Malfunctioning EGR valve position sensor
- High exhaust temperatures
- Coolant-and-water mix
- Stuck closed variable geometry turbocharger.

NOTE: This fault code will probably **not** be active with no load on the engine in the shop. The engine **must** be loaded to trip this fault code and determine if the malfunction has been found and fixed.

Refer to Troubleshooting Fault Code t05-2961

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the fault codes.**		
STEP 1A:	Check for active fault codes.	Active fault codes present?	
STEP 1B:	Check for inactive fault codes.	Fault Code 151, 235, 245, 595, 2277, 2346, 2348, 2357, 2359 or 2963 inactive?	
STEP 2:	**Check the air intake system for leaks.**		
STEP 2A:	Check the charge air cooler for leaks.	Air leak present?	
STEP 2B:	Check the intake manifold inlet and connections for leaks.	Air leak present?	
STEP 3:	**Check the cooling system.**		
STEP 3A:	Check the engine coolant mixture.	Engine coolant is proper mixture?	
STEP 3B:	Check the engine coolant level.	Coolant level at or above acceptable level?	
STEP 4:	**Check the EGR valve and cooler.**		
STEP 4A:	Perform the INSITE™ electronic service tool EGR valve actuator test.	Does the EGR valve pass the INSITE™ electronic service tool EGR valve actuator test?	
STEP 4B:	Check the EGR cooler for fouling.	Is the EGR cooler efficiency parameter greater than 50 percent after 4 minutes?	
STEP 5:	**Check the turbocharger.**		
STEP 5A:	Perform INSITE™ electronic service tool turbocharger operational test.	Does the Turbocharger Operational Test pass in INSITE™ electronic service tool?	
STEP 6:	**Check the EGR differential pressure sensor.**		
STEP 6A:	Check the EGR differential pressure sensor for proper operation.	Is the EGR differential pressure greater than 6 mm Hg [0.236 in Hg] when the EGR valve is open?	
STEP 7:	**Clear the fault codes.**		
STEP 7A:	Disable the fault code.	Fault Code 2961 inactive?	
STEP 7B:	Clear the inactive fault codes.	All fault codes cleared?	

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for active fault codes.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Active fault codes present? **YES**	Appropriate troubleshooting tree
	Active fault codes present? **NO**	1B

STEP 1B: Check for inactive fault codes.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for inactive fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 151, 235, 245, 595, 2277, 2346, 2348, 2357, 2359 or 2963 inactive? **YES**	7A; Troubleshoot inactive fault codes starting with the fault code containing the highest number of counts
	Fault Code 151, 235, 245, 595, 2277, 2346, 2348, 2357, 2359 or 2963 inactive? **NO**	2A

STEP 2: Check the air intake system for leaks.

STEP 2A: Check the charge air cooler for leaks.

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check the charge air cooler for leaks. • Start the engine and check the charge air cooler and connections for air leaks.	Air leak present? **YES** **Repair:** Repair or replace the leaking component.	7A
	Air leak present? **NO**	2B

STEP 2B: Check the intake manifold inlet and connections for leaks.

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for air leaks in connections and hoses between the turbocharger and intake manifold inlet.	Air leak present? **YES** **Repair:** Repair or replace the leaking component.	7A
	Air leak present? **NO**	3A

STEP 3: Check the cooling system.

STEP 3A: Check engine coolant mixture.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Incorrect coolant mixture will cause high EGR temperatures due to inefficient cooling. • Check the freeze point of the engine coolant to be sure of a proper mixture.	Engine coolant is proper mixture? **YES**	3B
	Engine coolant is proper mixture? **NO** **Repair:** Drain and refill the cooling system with the proper mixture. Refer to Procedure 008-018 (Cooling System) in Section 8 in the Troubleshooting and Repair Manual, ISBe, ISB, and QSB5.9, Bulletin 4021271.	7A

STEP 3B: Check the engine coolant level.

Condition:
- Turn keyswitch OFF.
- Engine coolant temperature should be below 180°F.

Action	Specification/Repair	Next Step
Check the engine coolant level. • Low engine coolant level can cause erratic coolant flow through the engine and EGR cooler, in turn causing the EGR temperatures to rise. • Check for proper engine coolant level.	Coolant level at or above acceptable level? **YES**	4A
	Coolant level at or above acceptable level? **NO** **Repair:** Replenish the cooling system and troubleshoot for loss of coolant, if necessary.	7A

STEP 4:

STEP 4A: Perform the INSITE™ electronic service tool EGR valve actuator test.

Condition:
- Turn the keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
ECM diagnostic tests. • Use INSITE™ electronic service tool menu on the EGR Valve Actuator Test and follow the instructions on the screen. Open and close the EGR valve actuator. When opened, the actuator position will be 100 percent open. When closed, the actuator position will be less than 10 percent closed.	Does the EGR valve pass the INSITE™ electronic service tool EGR valve actuator test? **YES**	4B
	Does the EGR valve pass the INSITE™ electronic service tool EGR valve actuator test? **NO** **Repair:** Replace the EGR valve. • Refer to Procedure 011-022 (EGR Valve) in Section 11 of the Service Manual, ISBe, ISB, QSB (Common Rail Fuel System), Bulletin 4021271.	4B

STEP 4B: Check the EGR cooler for fouling.

Condition:
- Fan control switch in the OFF position.
- Air conditioning turned OFF.
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.
- Coolant temperature above 79°C [174°F].

Action	Specification/Repair	Next Step
If the effectiveness of the cooler is degraded, the cooler will not effectively cool the exhaust gas and will cause the EGR temperature to rise. • Start the engine and set the PTO speed to 2000 rpm. • Perform the EGR Valve Test in INSITE™ electronic service tool and command the EGR valve 100 percent open. • Start the INSITE™ electronic service tool monitor screen and monitor the EGR Cooler Efficiency. • Run the EGR Cooler Effectiveness Test with INSITE™ electronic service tool. • Operate the engine at this condition for 4 minutes. • After 4 minutes, record the value of the EGR Cooler Efficiency.	Is the EGR cooler efficiency parameter greater than 50 percent after 4 minutes? **YES**	5A
	Is the EGR cooler efficiency parameter greater than 50 percent after 4 minutes? **NO** **Repair:** Clean or replace the EGR cooler. • Refer to Procedure 011-019 (EGR Cooler) in Section 11 in the Troubleshooting and Repair Manual, ISBe, ISB, and QSB5.9 Series, Bulletin 4021271.	7A

STEP 5: Check the turbocharger.

STEP 5A: Perform the INSITE™ electronic service tool electronic service tool Turbocharger Operational Test.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Start the engine and run at low idle.

Action	Specification/Repair	Next Step
Select the EGR/Variable Geometry Turbocharger Operational Test using the INSITE™ electronic service tool. • Run the Turbocharger Operational Test.	Does the Turbocharger Operational Test pass in INSITE™ electronic service tool? **YES**	6A
	Does the Turbocharger Operational Test pass in INSITE™ electronic service tool? **NO** **Repair:** Replace the variable geometry turbocharger. Refer to Procedure 010-033 (Turbocharger) in Section 10 in the Troubleshooting and Repair Manual, ISBe, ISB, and QSB5.9 Series, Bulletin 4021271.	7A

STEP 6: Check the EGR differential pressure sensor.

STEP 6A: Check the EGR differential pressure sensor for proper operation.

Condition:
- Turn keyswitch ON.
- Engine running.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Operate the engine until the EGR valve opens. • Use INSITE™ electronic service tool to monitor the EGR valve position and EGR differential pressure. • When the EGR valve position is greater than 0 percent, make sure the EGR differential pressure is greater than 6 mm Hg [0.236 in Hg].	Is the EGR differential pressure greater than 6 mm Hg [0.236 in Hg] when the EGR valve is open? **YES**	7A
	Is the EGR differential pressure greater than 6 mm Hg [0.236 in Hg] when the EGR valve is open? **NO** **Repair:** Replace the EGR differential pressure sensor. Refer to Procedure 019-370 (EGR Differential Pressure Sensor) in Section 19.	7A

STEP 7: Clear the fault codes.

STEP 7A: Disable the fault code.

Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Disable the fault code. • Start the engine and let it idle for 1 minute. • Use INSITE™ electronic service tool to verify that the fault code is inactive.	Fault Code 2961 inactive? **YES**	7B
	Fault Code 2961 inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair location if all steps have been completed and checked again.	1A

STEP 7B: Clear the inactive fault codes.

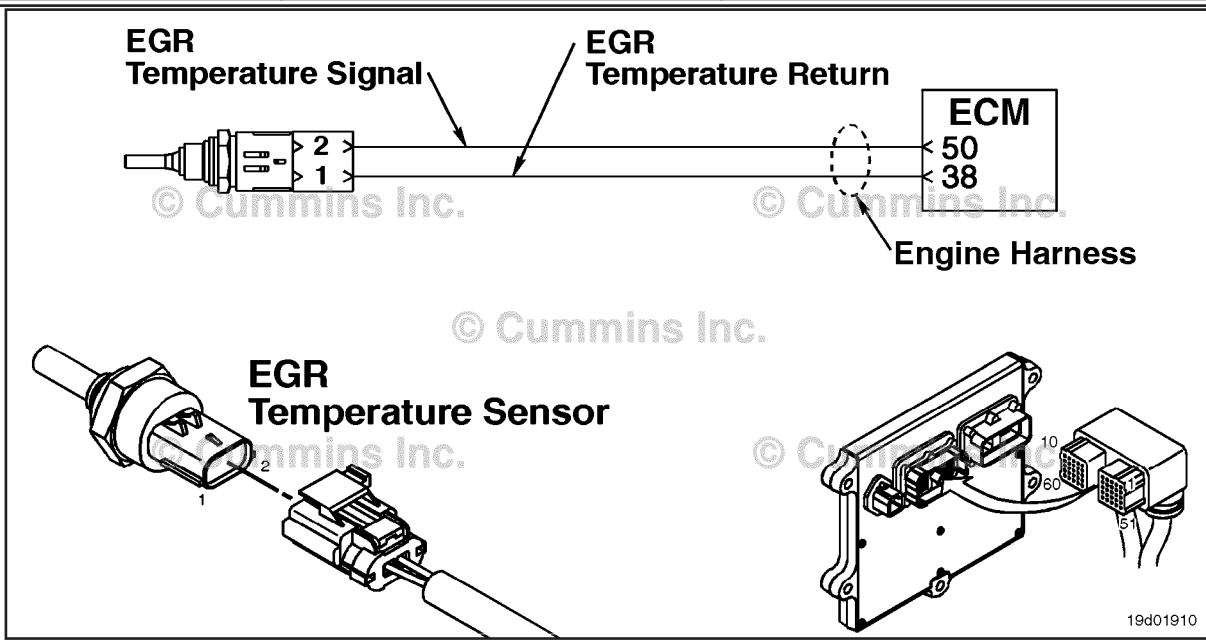
Condition:
- Connect all components.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Clear the inactive fault codes. • Use INSITE™ electronic service tool to clear the inactive fault codes.	All fault codes cleared? **YES**	Repair complete
	All fault codes cleared? **NO** **Repair:** Troubleshoot any remaining active fault codes.	Appropriate troubleshooting steps

Fault Code 2962

EGR Temperature - Data Valid But Above Normal Operating Range, Moderately Severe Level

CODES	REASON	EFFECT
Fault Code: 2962 PID(P), SID(S): P412 SPN: 412 FMI: 0/16 Lamp: Amber SRT:	EGR Temperature - Data Valid But Above Normal Operating Range, Moderately Severe Level.	Severe fueling derate to bring EGR temperature under the maximum limit.



EGR Temperature Sensor Circuit

Circuit Description:

The EGR temperature sensor is used to measure the temperature of the exhaust gas that exits the EGR cooler. This temperature is monitored to protect the engine against extremely high temperatures associated with the EGR system.

Component Location:

The EGR temperature sensor is located in the air horn, on the intake side of the engine. Use the following procedure for a detailed component location view. Refer to Procedure 100-002 in Section E.

Shop Talk:

This fault code can be caused by:

- A fouled EGR cooler
- High coolant temperature
- Low coolant level
- Malfunctioning EGR valve
- Malfunctioning EGR valve position sensor
- High exhaust temperatures
- Improper coolant-and-water mix
- Variable geometry turbocharger stuck closed.

Note: This fault code will probably **not** be active with no load on the engine in the shop. The engine **must** be loaded to trip this fault code and determine if the malfunction has been found and fixed.

Refer to Troubleshooting Fault Code t05-2962

FAULT CODE 2962 - EGR Temperature - Data Valid But Above Normal Operating Range, Moderately Severe Level

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the fault codes.**		
STEP 1A:	Check for active fault codes.	Active fault codes present?	
STEP 1B:	Check for inactive fault codes.	Fault Code 151, 235, 245, 595, 2277, 2346, 2348, 2357, 2359, or 2963 inactive?	
STEP 2:	**Check the air intake system for leaks.**		
STEP 2A:	Check the charge-air cooler for leaks.	Air leak present?	
STEP 2B:	Check the intake manifold inlet and connections for leaks.	Air leak present?	
STEP 3:	**Check the cooling system.**		
STEP 3A:	Check the engine coolant mixture.	Engine coolant proper mixture?	
STEP 3B:	Check the engine coolant level.	Coolant level at or above acceptable level?	
STEP 4:	**Check the EGR cooler.**		
STEP 4A:	Perform INSITE™ electronic service tool EGR valve actuator test.	EGR valve passes INSITE™ electronic service tool EGR valve actuator test?	
STEP 4B:	Check the EGR cooler for fouling.	Is the EGR cooler efficiency parameter greater than 50 percent after 4 minutes?	
STEP 5:	**Check the turbocharger.**		
STEP 5A:	Perform INSITE™ electronic service tool turbocharger operational test.	Turbocharger Operational Test passes in INSITE™ electronic service tool?	
STEP 6:	**Check the EGR differential pressure sensor.**		
STEP 6A:	Check the EGR differential pressure sensor for proper operation.	EGR differential pressure greater than 6 mm-Hg [0.236 in-Hg] when the EGR valve is open?	
STEP 7:	**Clear the fault codes.**		
STEP 7A:	Disable the fault code.	Fault Code 2962 inactive?	
STEP 7B:	Clear the inactive fault codes.	All fault codes cleared?	

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for active fault codes.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Active fault codes present? **YES**	Appropriate troubleshooting tree
	Active fault codes present? **NO**	1B

STEP 1B: Check for inactive fault codes.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for inactive fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 151, 235, 245, 595, 2277, 2346, 2348, 2357, 2359, or 2963 inactive? **YES** **Repair:** Troubleshoot inactive fault codes starting with the fault code containing the highest number of counts.	Refer to Procedure 019-362 in Section 19.
	Fault Code 151, 235, 245, 595, 2277, 2346, 2348, 2357, 2359, or 2963 inactive? **NO**	2A

STEP 2: Check the air intake system for leaks.

STEP 2A: Check the charge-air cooler for leaks.

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check the charge-air cooler for leaks. • Start the engine and check the charge-air cooler and connections for air leaks.	Air leak present? **YES** **Repair:** Repair or replace the leaking component.	7A
	Air leak present? **NO**	2B

STEP 2B: Check the intake manifold inlet and connections for leaks.

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for air leaks in connections and hoses between the turbocharger and intake manifold inlet.	Air leak present? **YES** **Repair:** Repair or replace the leaking component.	7A
	Air leak present? **NO**	3A

STEP 3: Check the cooling system.

STEP 3A: Check engine coolant mixture.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Incorrect coolant mixture will cause high EGR temperatures due to inefficient cooling. • Check the freeze point of the engine coolant to be sure of a proper mixture.	Engine coolant proper mixture? **YES**	3B
	Engine coolant proper mixture? **NO** **Repair:** Drain and fill the cooling system with the proper mixture. Use the following procedure in the Troubleshooting and Repair Manual, ISBe, ISB, and QSB5.9 (Common Rail Fuel System) Series Bulletin, 4021271. Refer to Procedure 008-018 in Section 8.	7A

STEP 3B: Check the engine coolant level.

Condition:
- Turn keyswitch OFF.
- Make sure engine coolant temperature is below 82°C [180°F].

Action	Specification/Repair	Next Step
Check the engine coolant level. • Low engine coolant level can cause erratic coolant flow through the engine and EGR cooler, causing the EGR temperatures to rise. • Check for proper engine coolant level.	Coolant level at or above acceptable level? **YES**	4A
	Coolant level at or above acceptable level? **NO** **Repair:** Replenish the cooling system and troubleshoot for loss of coolant, if necessary.	7A

STEP 4: Check the EGR cooler.

STEP 4A: Perform INSITE™ electronic service tool EGR valve actuator test.

Condition:
- Turn keyswitch ON.
- INSITE™ electronic service tool connected.

Action	Specification/Repair	Next Step
Perform ECM diagnostic tests. • Use INSITE™ electronic service tool menu on the EGR valve actuator test and follow the instructions on the screen. • Open and close the EGR valve actuator. • When opened, the actuator position will be 100 percent open. • When closed, the actuator position will be less than 10 percent open.	Does the EGR valve pass INSITE™ electronic service tool EGR valve actuator test? **YES**	4B
	Does the EGR valve pass INSITE™ electronic service tool EGR valve actuator test? **NO** **Repair:** Replace the EGR valve. Use the following proceudre in the Troubleshooting and Repair Manual, ISBe, ISB, and QSB5.9 (Common Rail Fuel System) Series Bulletin, 4021271. Refer to Procedure 011-022 in Section 11.	4B

STEP 4B: Check the EGR cooler for fouling.

Condition:
- Place fan control switch in the OFF position.
- Turn air conditioning OFF.
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.
- Make sure coolant temperature above 79°C [174°F].

Action	Specification/Repair	Next Step
If the effectiveness of the cooler is degraded, the cooler will not effectively cool the exhaust gas and will cause the EGR temperature to rise. • Start the engine and set the PTO speed to 2000 rpm. • Perform the EGR Valve Test in INSITE™ electronic service tool and command the EGR valve 100 percent open. • Start INSITE™ electronic service tool monitor screen and monitor the EGR cooler efficiency. • Perform the EGR Cooler Effectiveness Test with INSITE™ electronic service tool. • Operate the engine at this condition for 4 minutes. • After 4 minutes, record the value of the EGR cooler efficiency.	EGR cooler efficiency parameter greater than 50 percent after 4 minutes? **YES**	5A
	EGR cooler efficiency parameter greater than 50 percent after 4 minutes? **NO** **Repair:** Clean or replace the EGR cooler. Use the following procedure in the Troubleshooting and Repair Manual, ISBe, ISB, and QSB5.9 (Common Rail Fuel System) Series Bulletin, 4021271. Refer to Procedure 011-019 in Section 11.	7A

STEP 5: Check the turbocharger.

STEP 5A: Perform the INSITE™ electronic service tool turbocharger operational test.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Start the engine and run at low idle.

Action	Specification/Repair	Next Step
Select the EGR/Variable Geometry Turbocharger Operational Test using the INSITE™ electronic service tool. • Perform the Turbocharger Operational Test.	Turbocharger Operational Test passes in INSITE™ electronic service tool? **YES**	6A
	Turbocharger Operational Test passes in INSITE™ electronic service tool? **NO** **Repair:** Replace the variable geometry turbocharger. Use the following procedure in the Troubleshooting and Repair Manual, ISBe, ISB, and QSB5.9 (Common Rail Fuel System) Series, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	7A

STEP 6: Check the EGR differential pressure sensor.

STEP 6A: Check the EGR differential pressure sensor for proper operation.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Operate engine.

Action	Specification/Repair	Next Step
Operate the engine until the EGR valve opens. • Use INSITE™ electronic service tool to monitor the EGR valve position and EGR differential pressure. • When the EGR valve position is greater than 0 percent, make sure the EGR differential pressure is greater than 6 mm-Hg [0.236 in-Hg].	EGR differential pressure greater than 6 mm-Hg [0.236 in-Hg] when the EGR valve is open? **YES**	7A
	EGR differential pressure greater than 6 mm-Hg [0.236 in-Hg] when the EGR valve is open? **NO** **Repair:** Replace the EGR differential pressure sensor. Refer to Procedure 019-370 in Section 19.	7A

STEP 7: Clear the fault code.

STEP 7A: Disable the fault code.

Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable the fault code. • Start the engine and let it idle for 1 minute. • Use INSITE™ electronic service tool to verify the fault code is inactive.	Fault Code 2962 inactive? **YES**	7B
	Fault Code 2962 inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair Location if all steps have been completed and checked again.	1A

STEP 7B: Clear the inactive fault code.

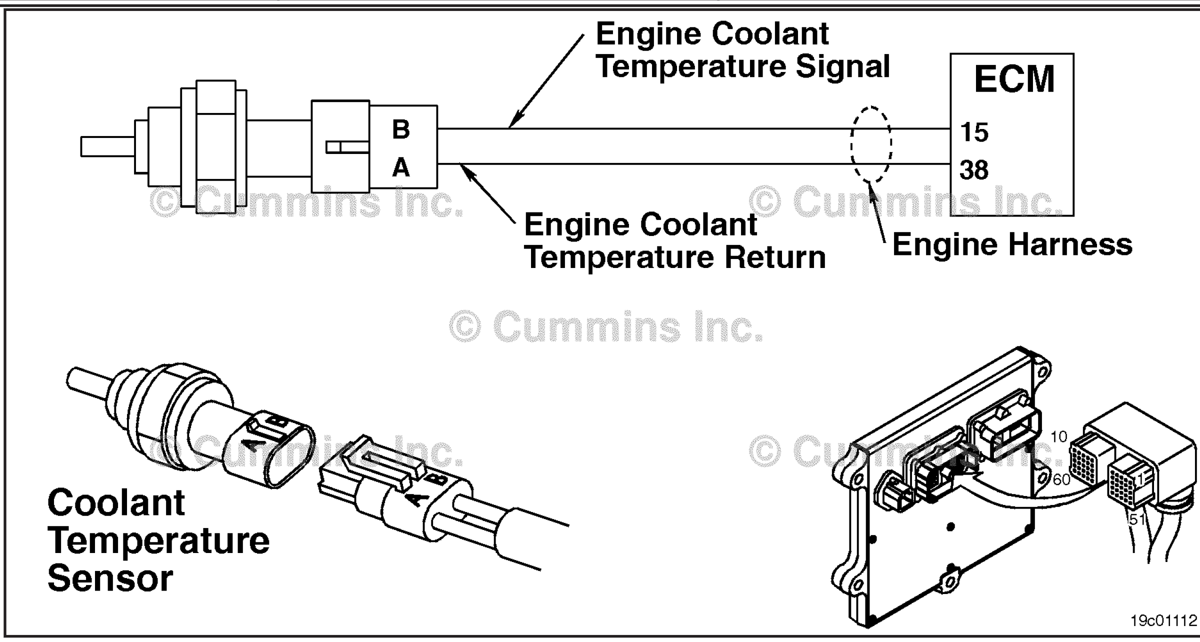
Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Clear the inactive fault codes. • Use INSITE™ electronic service tool to clear the inactive fault codes.	All fault codes cleared? **YES**	Repair complete
	All fault codes cleared? **NO** **Repair:** Troubleshoot any remaining active fault codes.	Appropriate troubleshooting steps

Fault Code 2963

Engine Coolant Temperature High - Data Valid but Above Normal Operational Range - Least Severe Level

CODES	REASON	EFFECT
Fault Code: 2963 PID(P), SID(S): P110 SPN: 110 FMI: 0/15 Lamp: None SRT:	Engine Coolant Temperature High - Data Valid but Above Normal Operational Range - Least Severe Level. Engine coolant temperature signal indicates coolant temperature is above the engine coolant temperature engine protection warning limit.	Progressive power derate increasing in severity from time of alert.



Engine Coolant Temperature Sensor Circuit

Circuit Description:

The engine coolant temperature sensor is used by the ECM to monitor the engine coolant temperature. The ECM monitors the voltage on the signal pin and converts this to a temperature value. The engine coolant temperature value is used by the ECM for the engine protection system and engine emissions control.

Component Location:

The engine coolant temperature sensor is located on the exhaust side of the engine near the thermostat housing. Refer to Procedure 100-002 for a detailed component location view.

Shop Talk:

This fault code indicates that coolant temperature has exceeded the engine protection limits for high coolant temperature. Refer to Engine Coolant Temperature Above Normal symptom troubleshooting tree.

Refer to Troubleshooting Fault Code t05-2963

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the fault codes.**		
STEP 1A:	**Check for Fault Code 2963.**	**Active or inactive counts of Fault Code 2963?**	

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for Fault Code 2963.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for Fault Code 2963. • Using INSITE™, read the fault codes.	Active or inactive counts of Fault Code 2963? **YES** **Repair:** Refer to the Engine Coolant Temperature Above Normal symptom tree in Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418.	Appropriate troubleshooting symptom tree
	Active or inactive counts of Fault Code 2963? **NO**	Repair complete

Fault Code 2964

Intake Manifold Temperature High - Data Valid But Above Normal Operating Range - Least Severe Level

CODES	REASON	EFFECT
Fault Code: 2964 PID(P), SID(S): P105 SPN: 105 FMI: 0/15 Lamp: None SRT:	Intake Manifold Temperature High - Data Valid But Above Normal Operating Range - Least Severe Level. Intake manifold air temperature signal indicates intake manifold air temperature above engine protection warning limit.	Automotive application: Progressive power derate increasing in severity from time of alert. Marine application: None.

Circuit Description:

The intake manifold air temperature sensor monitors intake manifold air temperature and passes information to the electronic control module (ECM) through the engine harness. If the intake manifold air temperature becomes too high, it will cause a derate condition.

Component Location:

The intake manifold air temperature sensor is located in the air intake manifold. Use the following procedure for a detailed component location view. Refer to Procedure 100-002 in Section E.

Shop Talk:

The intake manifold air temperature sensor measures the temperature of the charge-air as it passes through the intake manifold. Possible causes of this fault code include:

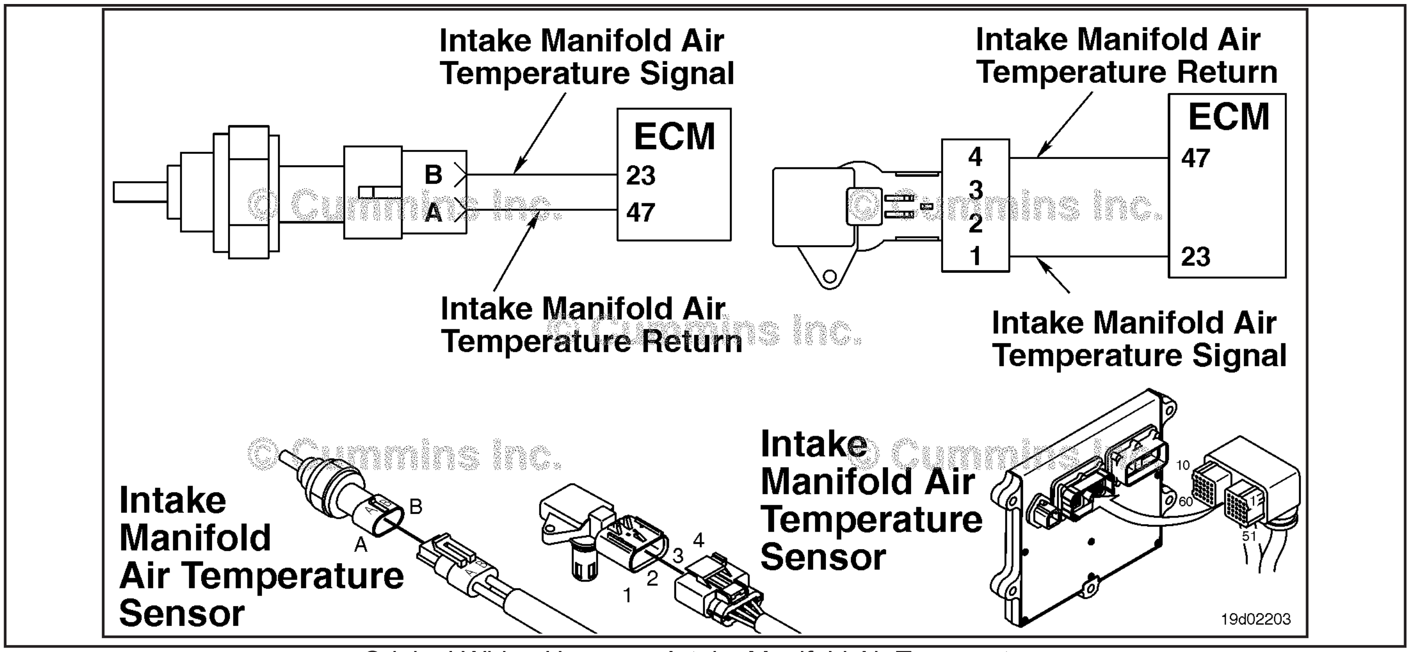
- Plugged charge-air cooler fins
- Restricted airflow through the charge-air cooler
- Undersized charge-air cooler
- High turbocharger compressor outlet temperature.

The sensor return configuration for Euro 4 ISB engines has been changed for automotive wiring harnesses manufactured from February 2012 onward. The new style wiring harnesses can be be identified using the method below:

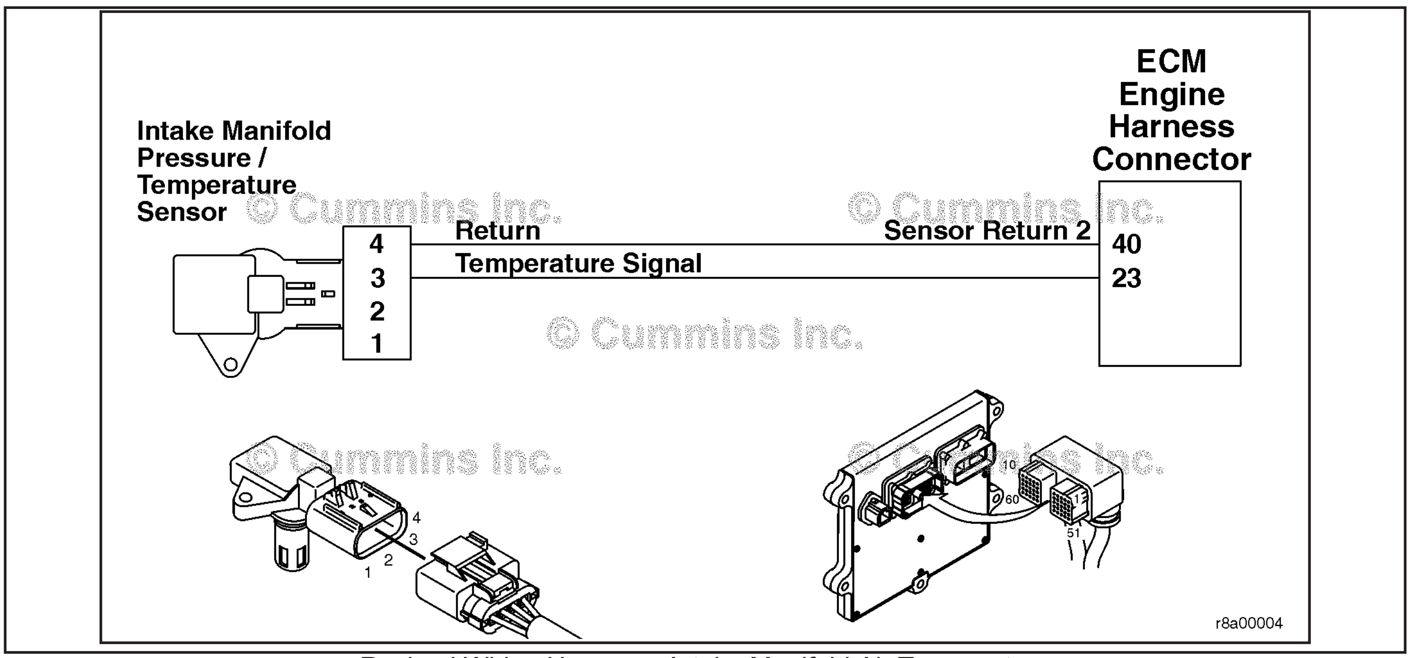
- Disconnect the ECM connector
- Disconnect the camshaft position sensor
- Disconnect the intake manifold pressure/temperature sensor
- Check for continuity between the intake manifold pressure/temperature sensor RETURN pin and the camshaft position sensor RETURN pin
- Check for continuity between ECM pin 47 and the camshaft position sensor RETURN pin
- Use the table below to determine which harness is fitted to the engine.

Engine Harnesses			
From	To	New Harness	Old Harness
Intake manifold pressure/ temperature sensor RETURN pin	Camshaft position sensor RETURN pin	Open circuit	Short circut
ECM pin 47	Camshaft position sensor RETURN pin	Open circuit	Short circuit

NOTE: QSB engines, all C series engines, and all L series engines are **not** affected by this change.



Original Wiring Harness - Intake Manifold Air Temperature



Revised Wiring Harness - Intake Manifold Air Temperature

Refer to Troubleshooting Fault Code t05-2964.

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the fault codes.**		
STEP 1A:	**Check for Fault Code 2964.**	**Active or inactive counts of Fault Codes 2964?**	

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for Fault Code 2964.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Active or inactive counts of Fault Codes 2964? **YES** **Repair:** Refer to the Intake Manifold Air Temperature Above Specification symptom tree in Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418.	Appropriate troubleshooting symptom tree
	Active or inactive counts of Fault Codes 2964? **NO**	Repair complete

Fault Code 2973

Intake Manifold Pressure Sensor Circuit - Data Erratic, Intermittent, or Incorrect

CODES	REASON	EFFECT
Fault Code: 2973 PID(P), SID(S): P102 SPN: 102 FMI: 2/2 Lamp: MIL SRT:	Intake Manifold Pressure Sensor Circuit - Data Erratic, Intermittent, or Incorrect. The electronic control module (ECM) has detected an intake manifold pressure signal that is too high or too low for present engine operating conditions.	Malfunction indicator lamp (MIL) and/or low power complaint.

Circuit Description:

The intake manifold pressure sensor monitors intake manifold pressure and passes information to the ECM through the engine harness. If the intake manifold pressure becomes too low or too high, it will cause a fault code.

Component Location:

The intake manifold pressure/temperature, 1 sensor is located in the air intake manifold.

The barometric pressure sensor can be externally mounted on the engine or can be an internal component within the ECM. Check the engine wiring diagram for circuit details.

Conditions for Running the Diagnostics:

Part 1 of this diagnostic runs a sensor rationality check when the keyswitch is initially turned ON. If the fault code becomes active at key ON **only**, it has failed the first check.

Part 2 of this diagnostic runs a boost pressure rationality check when the engine is operating under normal conditions. The diagnostic runs a boost check when:

- Good boost pressure is measuresd at 2000 rpm and above for 15 consecutive seconds.
- Boost pressure is measured at 1500 rpm in a motoring condition for 15 consecutive seconds.

The diagnostic can pass or fail any of the conditions above and does **not** have to fail both in order to set a fault code.

Conditions for Setting the Fault Codes:

This diagnostic checks the value of the intake manifold pressure sensor at key ON and while the engine is operating. If the value of the intake manifold pressure is **not** reading ambient pressure at key ON or is higher or lower than expected during normal engine operation, this fault code is logged.

Action Taken When the Fault Code is Active:

- The ECM illuminates the malfunction indicator lamp (MIL) immediately when the diagnostic runs and fails twice.
- Follow the troubleshooting tree and rectify the problem.

Conditions for Clearing the Fault Code:

- Run the ECM diagnostic as described above.
- Once the diagnostic has completed, the fault code will go inactive if it passes.
- As soon as the diagnostic has completed and passed one trip, the MIL will remain on but the fault code will be inactive.
- Once the fault code is inactive use "clear all faults" command using the latest version of INSITE™ electronic service tool.

NOTE: To clear the MIL without INSITE™ electronic service tool, you **must** perform the full diagnostic a total of three times. Make sure a full ECM 30 second power down is completed between each cycle.

Shop Talk:

The intake manifold pressure sensor monitors pressure in the intake manifold. This fault is set active when the intake manifold pressure is too high or too low for the present engine operating conditions. The ECM compares the intake manifold pressure reading to turbocharger speed (estimated by the ECM in some engines) to determine if the pressure reading is valid.

Possible causes of this fault are:

- A damaged intake manifold pressure sensor.
- A damaged barometric pressure sensor.
- Leaks in the air intake system between the turbocharger and intake manifold.
- Restriction in the charge-air cooler.
- A damaged turbocharger speed sensor.
- A damaged turbocharger compressor intake temperature sensor.
- A damaged engine wiring harness can cause intermittent fault codes due to intermittent resistances. Check the wiring diagram for shared supply and return circuit on sensors. It is possible that more than one sensor could be reading in range but incorrectly if a common supply/ground problem exists in the circuit. Use INSITE™ electronic service tool to log any fluctuation in sensor voltage/values when the harness is moved.

NOTE: Converting gauge pressure to absolute pressure may be required, depending on the engine.

- Barometric pressure is approximately 29.92 in-Hg at sea level. (Absolute Pressure)
- The intake manifold gauge pressure is approximately 0 in-Hg when the engine is **not** operating.
- 29.92 in-Hg = 1 atmosphere = 1.013 bar

Example: If the barometric (absolute) pressure sensor reads (31) in-Hg and the intake manifold (gauge) pressure reads -5 in-Hg, then the difference can be calculated as follows:

1. Convert intake manifold (gauge) pressure to absolute pressure = (-5 + 29) = 24 in-Hg.

2. Subtract the new 24 in-Hg from the original barometric value 31 in-Hg. (31 - 24) = 7

3. The difference is 7 in-Hg. Since the value is greater than the specification of 3 in-Hg, it will cause the fault to become active at key ON.

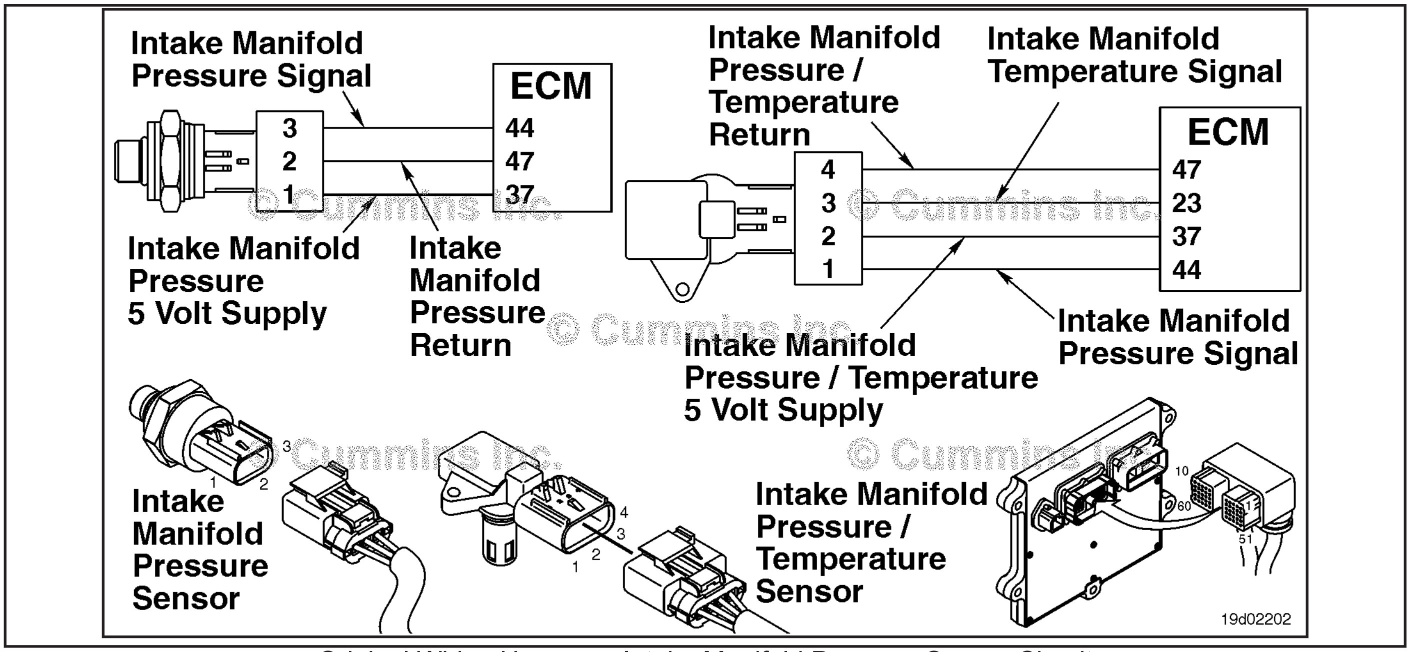
4. Use the Barometric Pressure at Altitude table in the following procedure to help understand ambient pressure at different altitudes. Refer to Procedure 018-028 in Section V.

The sensor return configuration for Euro 4 ISB engines has been changed for automotive wiring harnesses manufactured from February 2012 onward. The new style wiring harnesses can be be identified using the method below:

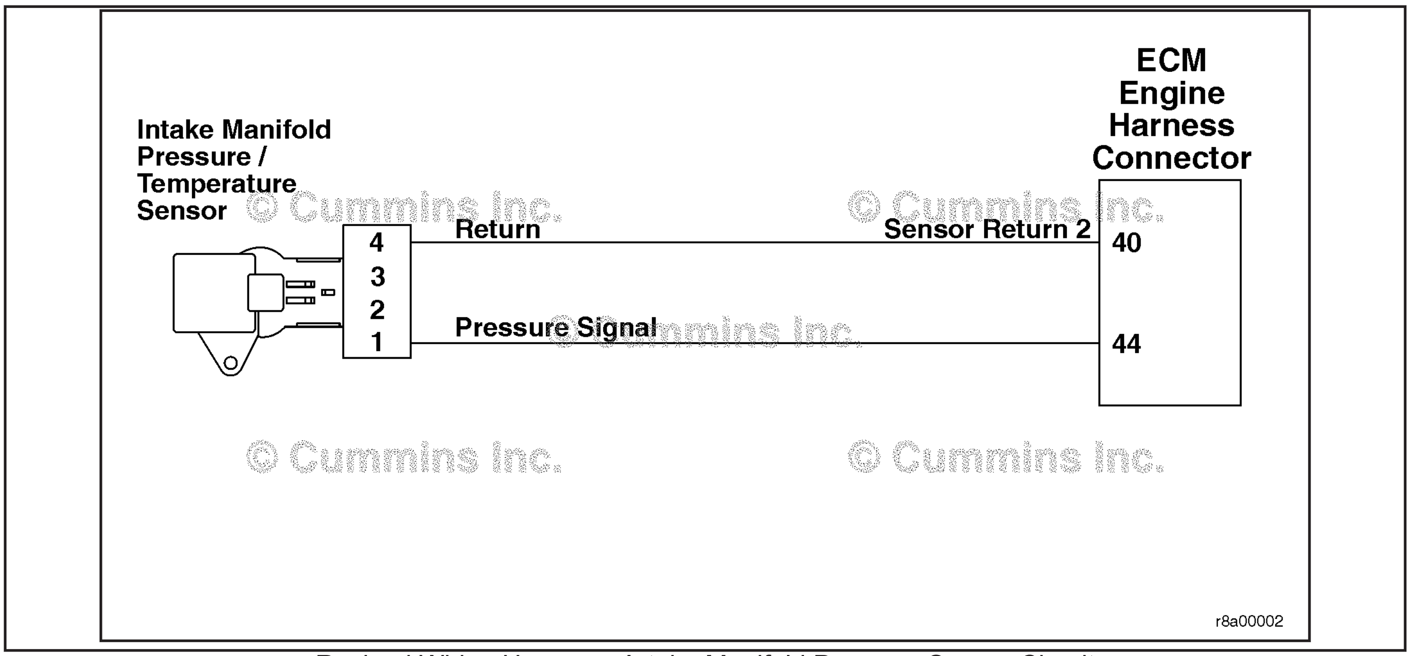
- Disconnect the ECM connector
- Disconnect the camshaft position sensor
- Disconnect the intake manifold pressure/temperature sensor
- Check for continuity between the intake manifold pressure/temperature sensor RETURN pin and the camshaft position sensor RETURN pin
- Check for continuity between ECM pin 47 and the camshaft position sensor RETURN pin
- Use the table below to determine which harness is fitted to the engine.

Engine Harnesses			
From	To	New Harness	Old Harness
Intake manifold pressure/ temperature sensor RETURN pin	Camshaft position sensor RETURN pin	Open circuit	Short circut
ECM pin 47	Camshaft position sensor RETURN pin	Open circuit	Short circuit

NOTE: QSB engines, all C series engines, and all L series engines are **not** affected by this change.



Original Wiring Harness - Intake Manifold Pressure Sensor Circuit



Revised Wiring Harness - Intake Manifold Pressure Sensor Circuit

Refer to Troubleshooting Fault Code t05-2973.

FAULT CODE 2973 - Intake Manifold Pressure Sensor Circuit - Data Erratic, Intermittent, or Incorrect

TROUBLESHOOTING SUMMARY

CAUTION

To reduce the possibility of pin and harness damage, use the following test leads when taking a measurement: Part Number 3822758 - male Deutsch™/AMP™/Metri-Pack™ test lead, Part Number 3822917 - female Deutsch™/AMP™/Metri-Pack™ test lead.

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the fault codes.**		
STEP 1A:	Check for active or high inactive fault codes.	Active or inactive counts of Fault Codes 122, 123, 221, 222, 295, 595, 687, or 2345?	
STEP 2:	**Check the barometric pressure sensor.**		
STEP 2A:	Verify the sensor accuracy.	INSITE™ electronic service tool reading within 77 mm-Hg [3 in-Hg] of local barometric pressure?	
STEP 3:	**Check the engine intake manifold pressure/temperature sensor and circuit.**		
STEP 3A:	Inspect the engine intake manifold pressure/temperature sensor and connector pins.	Dirty or damaged pins?	
STEP 3B:	Verify the sensor accuracy.	INSITE™ electronic service tool reading for intake manifold pressure within 77 mm-Hg [3 in-Hg] of local barometric pressure?	
STEP 3C:	Check the circuit response.	Fault Code 123 active?	
STEP 3D:	Check the circuit response.	Fault Code 122 active?	
STEP 4:	**Check the ECM and engine harness.**		
STEP 4A:	Inspect the ECM and engine harness connector pins.	Dirty or damaged pins?	
STEP 4B:	Check the circuit response.	Fault Code 123 active?	
STEP 4C:	Check the circuit response.	Fault Code 122 active?	
STEP 5:	**Check the air intake system for leaks.**		
STEP 5A:	Check the charge air cooler for leaks.	Air leak present?	
STEP 5B:	Check the intake manifold inlet and connections for leaks.	Air leak present?	
STEP 5C:	Inspect the turbocharger compressor and turbine blades.	Damage or wear found on the turbocharger blades?	
STEP 5D:	Check for a restricted charge air cooler.	Within specifications?	
STEP 6:	**Check the turbocharger speed sensor.**		
STEP 6A:	Inspect the engine harness connector to the turbocharger speed sensor, if applicable.	Dirty or damaged pins?	

STEP 6B:	Measure the turbocharger speed sensor resistance.	Resistance between 600 and 1600 ohms?

STEP 7: Check the exhaust system for restriction.

STEP 7A:	Check exhaust restriction.	Within specifications?

STEP 8: Clear the fault codes.

STEP 8A:	Disable the fault code.	Fault Code 2973 inactive?
STEP 8B:	Clear the inactive fault codes and the malfunctioning indicator lamp (MIL).	All fault codes cleared?

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Check for active or inactive fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for other fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Active or high inactive counts of Fault Codes 122, 123, 221, 222, 295, 595, 687, or 2345? **YES**	Appropriate fault code troubleshooting tree.
	Active or high inactive counts of Fault Codes 122, 123, 221, 222, 295, 595, 687, or 2345? **NO**	2A

STEP 2: Check the barometric pressure sensor.

STEP 2A: Verify the sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Start INSITE™ electronic service tool Data Monitor/Logger and compare the INSITE™ electronic service tool reading for barometric pressure to the local barometric pressure. • Refer to Procedure 018-028 in Section V.	INSITE™ electronic service tool reading is within 77 mm-Hg [3 in-Hg] of local barometric pressure? **YES**	3A
	INSITE™ electronic service tool reading is within 77 mm-Hg [3 in-Hg] of local barometric pressure? **NO** **Repair:** Replace the barometric pressure sensor. Refer to Procedure 019-004 in Section 19.	8A

STEP 3: Check the engine intake manifold pressure/temperature sensor and circuit.

STEP 3A: Inspect the engine intake manifold pressure/temperature sensor and connector pins.

Condition:
- Turn keyswitch OFF.
- Disconnect the engine intake manifold pressure/temperature sensor from the engine harness.

Action	Specification/Repair	Next Step
Inspect the intake manifold pressure/temperature sensor connector and the engine harness connector for signs of 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the intake manifold pressure/temperature sensor or harness connector. • Clean the connector and pins. • Replace the damaged section of the harness or damaged intake manifold pressure/temperature sensor. Refer to the circuit diagram or wiring diagram for all engine harness interconnections. • Refer to Procedure 019-043 in Section 19. • Refer to Procedure 019-061 in Section 19.	8A
	Dirty or damaged pins? **NO**	3B

STEP 3B:

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Turn engine OFF.

Action	Specification/Repair	Next Step
With keyswitch ON and engine OFF, the intake manifold pressure and barometric pressure readings must agree. Start INSITE™ electronic service tool Data Monitor/Logger and compare INSITE™ electronic service tool reading for intake manifold pressure to the reading for barometric pressure.	INSITE™ electronic service tool reading for intake manifold pressure is within 77 mm-Hg [3 in-Hg] of local barometric pressure? **YES**	5A
	INSITE™ electronic service tool reading for intake manifold pressure is within 77 mm-Hg [3 in-Hg] of local barometric pressure? **NO**	3C

STEP 3C: Check the circuit response.

Condition:
- Turn keyswitch OFF.
- Disconnect the engine intake manifold pressure/temperature sensor from the engine harness.

Action	Specification/Repair	Next Step
Check for the appropriate ECM response after 30 seconds. Use INSITE™ electronic service tool to read the fault codes.	Fault Code 123 active? **YES**	3D
	Fault Code 123 active? **NO**	4A

STEP 3D: Check the circuit response.

Condition:
- Turn keyswitch OFF.
- Disconnect the engine intake manifold pressure/temperature sensor from the engine harness.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Place a jumper wire between the engine intake manifold pressure +5 volt SUPPLY pin and the engine intake manifold pressure SIGNAL pin at the engine intake manifold pressure/temperature connector of the engine harness. Refer to the circuit diagram or the wiring diagram for connector pin identification. Check for the appropriate circuit response after 30 seconds. Check for appropriate circuit response after 30 seconds. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 122 active? **YES** **Repair:** An in-range malfunction of the intake manifold pressure/temperature sensor has been detected. Replace the engine intake manifold pressure/temperature sensor. Refer to Procedure 019-061 in Section 19.	8A
	Fault Code 122 active? **NO**	4A

STEP 4: Check the ECM and engine harness.

STEP 4A: Inspect ECM and engine harness connector pins.

Condition:
- Turn keyswitch OFF.
- Disconnect the engine harness from the ECM connector.

Action	Specification/Repair	Next Step
Inspect the engine harness and ECM 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the ECM connector or engine harness connector. Repair the damaged pins. Repair or replace the engine harness or replace the ECM, whichever has the damaged pins. • Flush the dirt, debris, or moisture from the connector pins. Use electrical contact cleaner, Part Number 3824510. • Install the appropriate connector seal if it is damaged or missing. Repair or replace the engine harness. Refer to Procedure 019-043 in Section 19. Replace the ECM. Refer to Procedure 019-031 in Section 19.	8A
	Dirty or damaged pins? **NO**	4B

STEP 4B: Check the circuit response.

Condition:
- Turn keyswitch OFF.
- Disconnect the engine harness from the ECM.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for the appropriate ECM response after 30 seconds. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 123 active? **YES**	4C
	Fault Code 123 active? **NO** **Repair:** Replace the ECM. Refer to Procedure 019-031 in Section 19.	8A

STEP 4C: Check the circuit response.

Condition:
- Turn keyswitch OFF.
- Disconnect the engine harness from the ECM.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Place a jumper wire between the engine intake manifold pressure +5 volt SUPPLY pin and engine intake manifold pressure SIGNAL pin at the engine control module engine connector. Check for the appropriate ECM response after 30 seconds. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 122 active? **YES** **Repair:** High resistance or a short circuit has been detected in the engine harness. Repair or replace the engine harness. Refer to Procedure 019-043 in Section 19.	8A
	Fault Code 122 active? **NO** **Repair:** Replace the ECM. Refer to Procedure 019-031 in Section 19.	8A

STEP 5: Check the air intake system for leaks.

STEP 5A: Check the charge-air cooler for leaks.

Condition:
- Operate engine.

Action	Specification/Repair	Next Step
Check the charge-air cooler and connections for air leaks.	Air leak present? **YES** **Repair:** Repair or replace the leaking component.	8A
	Air leak present? **NO**	5B

STEP 5B: Check the intake manifold inlet and connections for leaks.

Condition:
- Operate engine.

Action	Specification/Repair	Next Step
Check for air leaks in the connections and hoses between the turbocharger and intake manifold inlet. • Use the following procedure in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Refer to Procedure 010-024 in Section 10.	Air leak present? **YES** **Repair:** Repair or replace the leaking component.	8A
	Air leak present? **NO**	5C

STEP 5C: Inspect the turbocharger compressor and turbine blades.

Condition:
- Turn engine OFF.
- Turn keyswitch ON.
- Remove the intake and exhaust connections from the turbocharger.

Action	Specification/Repair	Next Step
Inspect the turbocharger compressor and turbine blades for damage or wear. • Use the following procedure in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Refer to Procedure 010-033 in Section 10.	Damage or wear found on turbocharger blades? **YES** **Repair:** Replace the turbocharger. Use the following procedure in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Refer to Procedure 010-033 in Section 10.	8A
	Damage or wear found on turbocharger blades? **NO**	5D

STEP 5D: Check for a restricted charge-air cooler.

Condition:
- Connect all components.
- Turn keyswitch ON.
- Operate engine.

Action	Specification/Repair	Next Step
Check the pressure differential across the charge air cooler. • Use the following procedure in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Refer to Procedure 010-027 in Section 10.	Within specifications? **YES**	6A
	Within specifications? **NO** **Repair:** Clean or replace the charge-air cooler, if necessary.	8A

STEP 6: Check the turbocharger speed sensor.

STEP 6A: Inspect the engine harness connector to the turbocharger speed sensor, if applicable.

Condition:
- Turn keyswitch OFF.
- Disconnect the engine harness from the turbocharger speed sensor.

Action	Specification/Repair	Next Step
Only perform this step if the engine is equipped with a turbocharger speed sensor. Inspect the turbocharger or refer to the engine wiring diagram to determine if the engine has a turbocharger speed sensor. If no sensor is present, skip to Step 7. Inspect the turbocharger speed sensor connector, the engine harness connector, and the turbocharger speed sensor pigtail harness for signs of 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.	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the engine harness. Repair the damaged pins. Repair or replace the engine harness. • Flush the dirt, debris, or moisture from the connector pins. Use electrical contact cleaner, Part Number 3824510. • Install the appropriate connector seal if it is damaged or missing. • Repair or replace the engine harness. Refer to Procedure 019-043 in Section 19.	8A
	Dirty or damaged pins? **NO**	6B

STEP 6B: Measure the turbocharger speed sensor resistance.

Condition:
- Turn keyswitch OFF.
- Disconnect the turbocharger speed sensor from the engine harness.

Action	Specification/Repair	Next Step
Check the turbocharger speed sensor resistance. • Use a multimeter to measure the resistance from the turbocharger speed SIGNAL (+) pin to the turbocharger speed SIGNAL (-) pin at the sensor. Refer to the circuit diagram or the wiring diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Resistance between 600 and 1600 ohms? **YES**	7A
	Resistance between 600 and 1600 ohms? **NO** **Repair:** • The turbocharger speed sensor has failed. • Replace the turbocharger speed sensor. Refer to Procedure 019-390 in Section 19.	8A

STEP 7: Check the exhaust system for restriction.

STEP 7A: Check exhaust restriction.

Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check exhaust restriction. • Use the following procedure in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Refer to Procedure 011-009 in Section 11.	Within specifications? **YES**	8A
	Within specifications? **NO** **Repair:** Repair or replace the restricted component.	8A

STEP 8: Clear the fault codes.

STEP 8A: Disable the fault code.

Condition:
- Start the engine.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable the fault code. • Start the engine. • Complete the conditions for clearing a fault code per the instructions in Shoptalk.	Fault Code 2973 inactive? **YES**	8B
	Fault Code 2973 inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair location if all steps have been completed and checked again.	1A

STEP 8B: Clear the inactive fault codes and MIL.

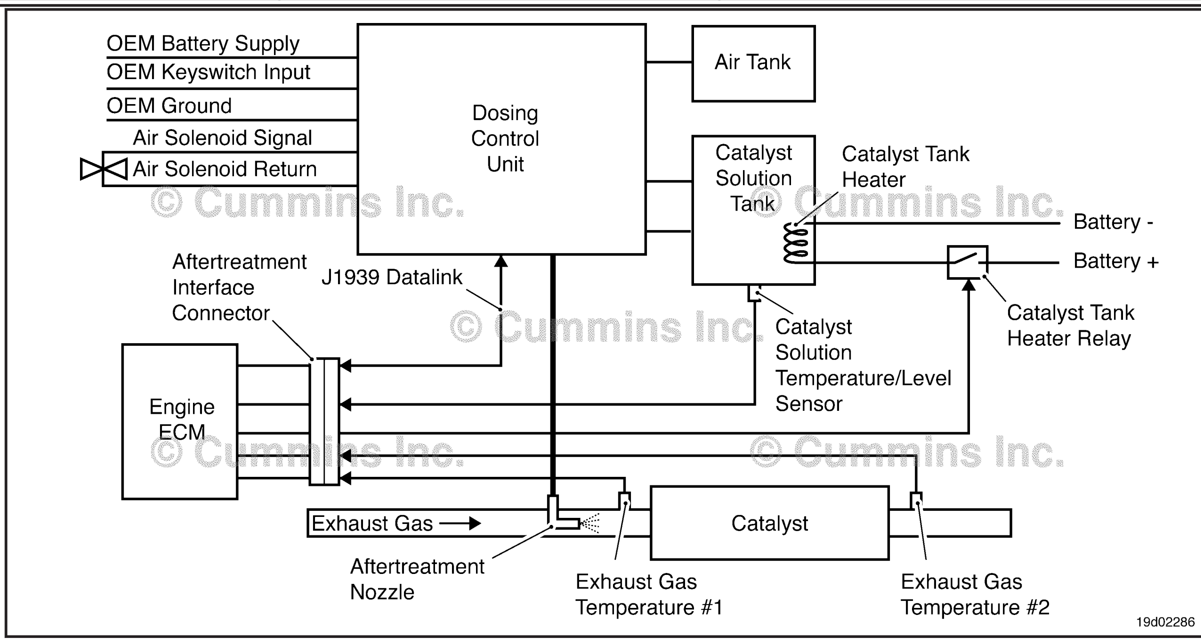
Condition:
- Connect all components.
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Clear the inactive fault codes. • Clear the inactive fault codes and MIL.	All fault codes cleared? **YES**	Repair complete
	All fault codes cleared? **NO** **Repair:** Troubleshoot any remaining active fault codes.	Appropriate troubleshooting steps

Fault Code 2976

Dosing Control Unit Temperature - Data Erratic, Intermittent, or Incorrect

CODES	REASON	EFFECT
Fault Code: 2976 PID(P), SID(S): SPN: 3361 FMI: 2 Lamp: Amber SRT:	Dosing Control Unit Temperature - Data Erratic, Intermittent, or Incorrect. An internal error has been detected in the catalyst dosing control unit.	Catalyst solution injection into the aftertreatment system is disabled.



Circuit: Dosing Control Unit.

Circuit Description:

The dosing control unit communicates to the primary engine electronic control (ECM) through the J1939 data link network.

Component Location:

The dosing control unit location is OEM dependent.

Shop Talk:

Fault Code 2976 is triggered when the dosing control unit internal temperature sensor is reading a different value than the other temperature sensors on the engine. This indicates a problem with the internal temperature sensor of the dosing control unit. Dosing control unit electrical supply issues that cause the dosing control unit to remain powered when the key switch is turned OFF can cause Fault Code 2976 to become active.

On-Board Diagnostics (OBD) Information (Euro 4.5 Certified Engines):

- The ECM illuminates the malfunction indicator lamp (MIL) on the second consecutive ignition cycle that the diagnostic runs and fails.
- An engine torque derate will be activated after 50 hours of engine operation with the fault code active.
- To validate the repair and turn off the MIL, the engine **must** be shut down with the keyswitch in the OFF position for a minimum of 8 hours. After the 8 hour cold soak, if the ambient temperature is below 2°C [36°F] or above 25°C [77°F] start the engine and allow it to idle for 1 minute or run the diagnostic. If these temperatures can **not** be

achieved, calibrate the EMC to the latest version found in the calibration revisions listed in the ECM Calibration Revision History.

- The ECM turns OFF the MIL after 1 ignition cycle that the diagnostic runs and does **not** fail. The MIL lamp can **not** be cleared with INSITE™ electronic service tool. The fault code will be cleared from memory after 400 days or 9,600 hours of engine operation.

Refer to Troubleshooting Fault Code t05-2976

FAULT CODE 2976 - Aftertreatment Diesel Exhaust Fluid Dosing Unit Temperature - Data Erratic, Intermittent, or Incorrect

Associated Procedures			
Procedure Title	**Procedure Number**	**Engine Model**	**Bulletin Number**
Aftertreatment Diesel Exhaust Fluid Dosing Unit	Refer to Procedure 011-058	ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7	4021271
Aftertreatment Diesel Exhaust Fluid Dosing Unit	Refer to Procedure 011-058	ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4 and QSL9	4021418

TROUBLESHOOTING SUMMARY

CAUTION

To reduce the possibility of damaging a new engine control module (ECM), all other active fault codes must be investigated prior to replacing the ECM.

CAUTION

To reduce the possibility of pin and harness damage, use the following test leads when taking a measurement: Part Number 3822758 - male Deutsch™/AMP™/Metri-Pack™ test lead and Part Number 3822917 - female Deutsch™/AMP™/Metri-Pack™ test lead.

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the fault codes.**		
STEP 1A:	**Read the fault codes.**	**Fault Code 2976 inactive?**	
STEP 2:	**Check the diesel exhaust fluid (DEF) dosing unit.**		
STEP 2A:	**Inspect the dosing unit body and condition of the harness.**	**Damaged dosing unit or harness?**	
STEP 2B:	**Inspect the DEF dosing unit connector pins.**	**Dirty or damaged pins?**	
STEP 2C:	**Check for an open circuit in the original equipment manufacturer (OEM) harness.**	**Less than 10 ohms?**	
STEP 2D:	**Read the fault codes.**	**Fault Code 2976 inactive?**	
STEP 3:	**Check ECM calibration and clear fault codes.**		
STEP 3A:	**Check if an ECM calibration update is available.**	**If a calibration update for this fault code is available, does the ECM contain that revision or higher?**	
STEP 3B:	**Disable the fault code.**	**Fault code inactive?**	

TROUBLESHOOTING STEP

STEP 1: Check the fault codes.

STEP 1A: Read the fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 2976 inactive? **YES**	Refer to Procedure 019-362 in section 19.
	Fault Code 2976 inactive? **NO**	2A

STEP 2: Check the diesel exhaust fluid (DEF) dosing unit.

STEP 2A: Inspect the dosing unit body and condition of the harness.

Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the DEF dosing unit.

Action	Specification/Repair	Next Step
Inspect the OEM harness and DEF dosing unit body / casing for the following: • Cracked or damaged DEF dosing unit casing • Melting or heat damage to the DEF • Dosing unit melted wiring harness or connectors • Loose or damaged wires in the OEM wiring harness • Damaged fasteners or wiring harness connectors. Use the following procedure for general inspection techniques. Refer to Procedure 019-361 in Section 19.	Damaged dosing unit or harness? **YES** **Repair:** A damaged OEM wiring harness or DEF dosing unit has been detected. • Repair the damaged harness, connector, or pins if possible. • Replace the DEF dosing unit if damage is detected. Refer to Procedure 019-071 in Section 19.	3A
	Damaged dosing unit or harness? **NO**	2B

STEP 2B: Inspect the DEF dosing unit connector pins.

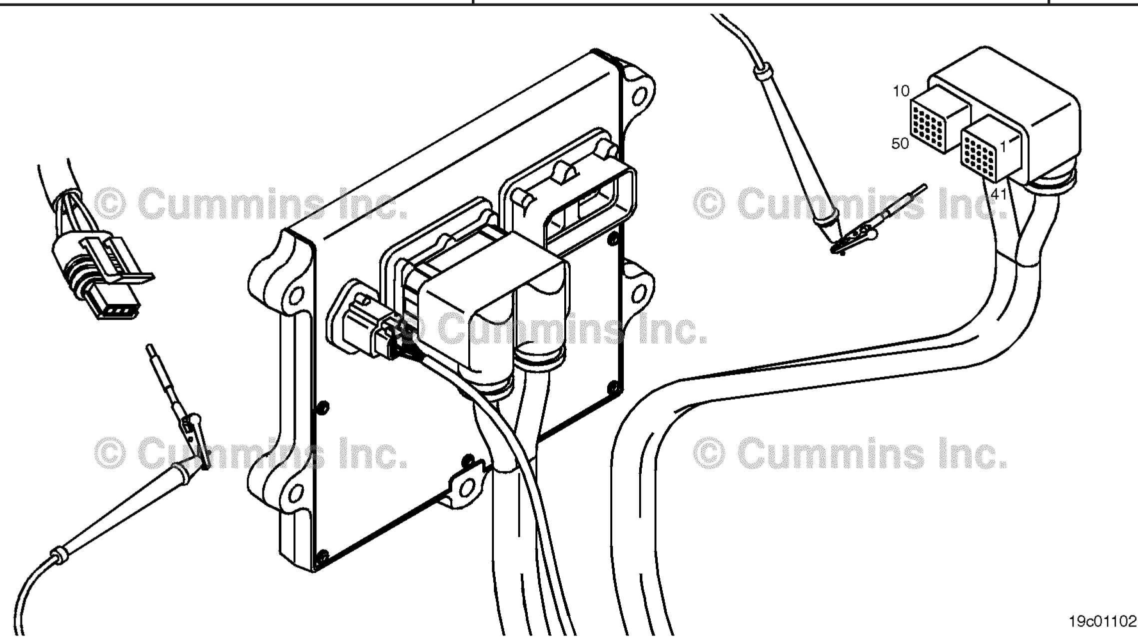
Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the DEF dosing unit.

Action	Specification/Repair	Next Step
Inspect the OEM harness and DEF dosing unit 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. •	Dirty or damaged pins? **YES** **Repair:** A damaged connection has been detected in the DEF dosing unit or harness connector. • Clean the connector and pins. • Repair the damaged harness, connector, or pins if possible. Refer to Procedure 019-071 in Section 19.	3A
	Dirty or damaged pins? **NO**	2C

STEP 2C: Check for an open circuit in the OEM harness.

Condition:
- Turn keyswitch OFF.
- Disconnect the DEF dosing unit from the OEM harness.
- Disconnect the OEM harness from the ECM connector.

Action	Specification/Repair	Next Step
Conduct a pin-to-pin continuity check in the OEM harness. • Measure the resistance from each pin at the DEF dosing unit connector to the corresponding pin on the ECM connector. Refer to the wiring diagram or circuit diagram for connector pin identification. Use the following procedure for general resistance measurement techniques. Refer to Procedure 019-360 in Section 19.	Less than 10 ohms? **YES**	2D
	Less than 10 ohms? **NO** **Repair:** An open circuit has been detected in the J1939 data link harness. Repair or replace the OEM harness. Refer to Procedure 019-043 in Section 19.	3A



STEP 2D: Read the fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Fault Code 2976 inactive? **YES** **Repair:** No Repair. Removal and Installation of the connectors has corrected the fault.	3A
	Fault Code 2976 inactive? **NO** **Repair:** Replace the aftertreatment DEF dosing unit. • Use the following procedure for air-assisted selective catalytic reduction (SCR) dosing systems. Refer to Procedure 019-440 in Section 19. Use the following procedure for airless SCR dosing systems. Refer to Procedure 011-058 in the Associated Procedure Table.	3A

STEP 3: Check ECM calibration and clear fault codes.

STEP 3A: Check if an ECM calibration update is available.

Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Compare the ECM code and revision in the ECM to the calibration revisions listed in the ECM Calibration Revision History for applicable changes related to this fault code. • Use INSITE™ electronic service tool to find the present ECM code and revision number in the ECM. The ECM code and revision number are found in the Calibration Information section of System ID and Dataplate in Features and Parameters.	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **YES**	3B
	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **NO** **Repair:** If necessary, calibrate the ECM. Refer to Procedure 019-032 in Section 19.	3B

STEP 3B: Disable the fault code.

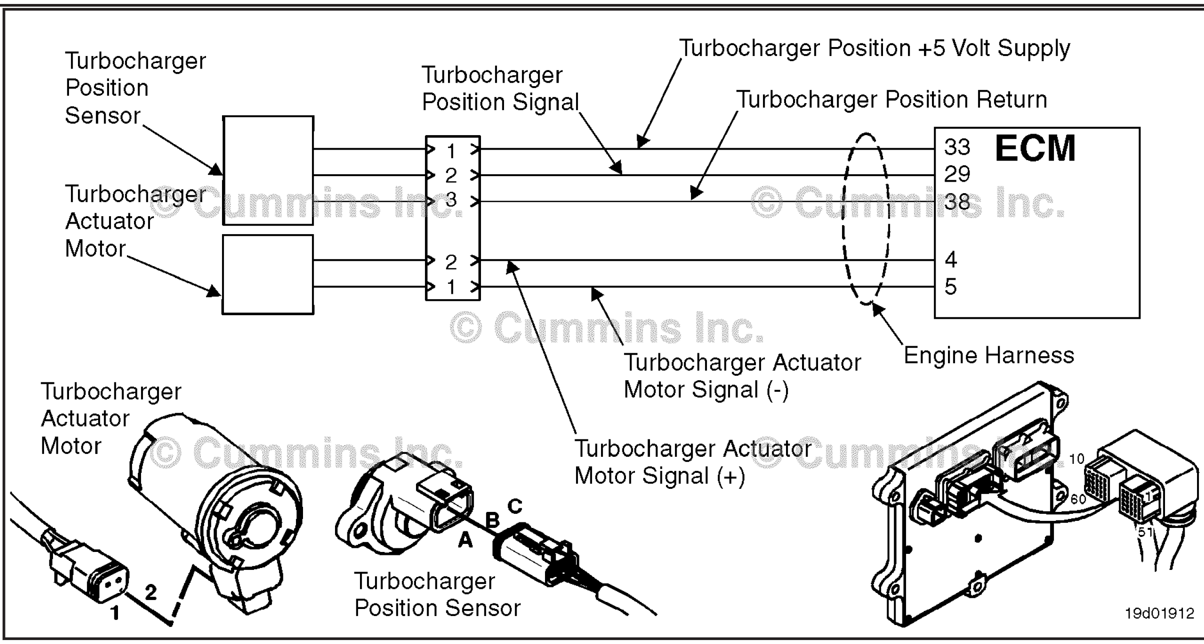
Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable and clear the fault code. • Operate the engine within the "Conditions for Clearing the Fault Code" found in the Overview section of this troubleshooting procedure.	Fault code inactive? **YES**	Repair complete.
	Fault code inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair Location if all steps have been completed and checked again.	1A

Fault Code 9122

VGT Actuator Driver Over Temperature (Calculated) - Data Valid But Above Normal Operating Range - Least Severe Level

CODES	REASON	EFFECT
Fault Code: 9122 PID(P), SID(S): S027 SPN: 641 FMI: 0/15 Lamp: SRT:	VGT Actuator Driver Over Temperature (Calculated) - Data Valid But Above Normal Operating Range - Least Severe Level. High internal variable geometry turbocharger (VGT) actuator temperature has been detected.	None on performance.



VGT Actuator Circuit

Circuit Description:

The VGT is electronically activated by the VGT actuator. The VGT actuator is a smart device and receives information via the J1939 data link from the primary engine engine control module (ECM). The VGT actuator performs its own diagnostics and reports failures back to the primary engine ECM using the J1939 data link.

Component Location:

The VGT actuator is located on the turbocharger bearing housing.

Conditions for Running the Diagnostics:

The diagnostic runs continuously when the keyswitch is turned ON.

Conditions for Setting the Fault Codes:

The fault code will log when the internal temperature of the VGT actuator exceeds 125°C [257°F] continuously for 30 minutes.

Action Taken When the Fault Code is Active:

The ECM illuminates the amber CHECK ENGINE light immediately when the diagnostic runs and fails.

Conditions for Clearing the Fault Code:

The ECM will turn OFF the amber CHECK ENGINE light immediately after the internal actuator temperature drops below 125°C [257°F].

Shop Talk:

Verify the 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. Refer to Procedure 019-032 in Section 19 in the corresponding Troubleshooting and Repair Manual for the engine being serviced.

This fault code will log when the internal temperature of the VGT actuator exceeds 125°C [257°F].

This fault code will be inactive when the vehicle is in the shop because the VGT actuator temperature has cooled down.

Troubleshoot multiple inactive counts of this fault code as an active fault code.

Also check for exhaust leaks blowing on the VGT actuator. Repair any external leaks.

Refer to Troubleshooting Fault Code t05-9122.

FAULT CODE 9122 - VGT Actuator Driver Over Temperature (Calculated) - Data Valid But Above Normal Operating Range - Least Severe Level

Associated Procedures			
Procedure Title	**Procedure Number**	**Service Model Name**	**Bulletin Number**
Turbocharger Coolant Hoses	Refer to Procedure 010-041	ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7	4021271

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Check the variable geometry turbocharger actuator cooling system.**		
STEP 1A:	**Check for active fault codes.**	**Fault codes related to high coolant temperature active or high count or inactive coolant temperature related faults?**	
STEP 1B:	**Inspect variable geometry turbocharger actuator coolant lines.**	**Blockages found in the variable geometry turbocharger actuator cooling plate or coolant lines?**	
STEP 2:	**Check engine control module (ECM) calibration and clear fault codes.**		
STEP 2A:	**Check if an ECM calibration update is available.**	**If a calibration update for this fault code is available, does the ECM contain that revision or higher?**	
STEP 2B:	**Disable the fault code.**	**Fault code inactive?**	

TROUBLESHOOTING STEP

STEP 1: Check the variable geometry turbocharger actuator cooling system.

STEP 1A: Check for fault codes.

Condition:
- Turn keyswitch ON.
- Connect the INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Fault codes related to high coolant temperature active or high count or inactive coolant temperature related faults? **YES** **Repair:** The variable geometry turbocharger actuator internal temperature has exceeded the maximum limit. No repair is necessary. This fault code is for information **only**.	Troubleshoot other fault codes
	Fault codes related to high coolant temperature active or high count or inactive coolant temperature related faults? **NO**	1B

STEP 1B: Inspect variable geometry turbocharger actuator coolant lines.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Inspect the variable geometry turbocharger actuator coolant lines for kinks and blockages. • Blow shop air in reverse flow through the variable geometry turbocharger actuator cooling plate to check blockages	Blockages found in the variable geometry turbocharger actuator cooling plate or coolant lines? **YES** **Repair:** Repair or replace the blocked coolant line. • Refer to Procedure 010-041 in the Assoicated Procedures Table.	Repair complete
	Blockages found in the variable geometry turbocharger actuator cooling plate or coolant lines? **NO**	2A

STEP 2: Check ECM calibration and clear fault codes.

STEP 2A: Check if an ECM calibration update is available.

Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Compare the ECM code and revision number in the ECM to the calibration revisions listed in the ECM Calibration Revision History for applicable changes related to this fault code. • Use INSITE™ electronic service tool to find the present ECM code and revision number in the ECM. The ECM code and revision number are found in the Calibration Information section of System ID and Dataplate in Features and Parameters.	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **YES**	2B
	If a calibration update for this fault code is available, does the ECM contain that revision or higher? **NO** **Repair:** If necessary, calibrate the ECM. Refer to Procedure 019-032 in Section 19.	2B

STEP 2B: Disable the fault code.

Condition:
- Connect all components.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Disable and clear the fault code. • Operate the engine within the "Conditions for Clearing the Fault Code" found in the Overview section of this troubleshooting procedure.	Fault code inactive? **YES**	Repair complete
	Fault code inactive? **NO** **Repair:** Return to the troubleshooting steps or contact a Cummins® Authorized Repair Location if all steps have been completed and checked again.	1A

Section TS - Troubleshooting Symptoms

Section Contents

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Troubleshooting Procedures and Techniques

General Information

A thorough analysis of the customer's complaint is the key to successful troubleshooting. The more information known about a complaint, the faster and easier the problem can be solved.

The Troubleshooting Symptom Charts are organized so that a problem can be located and corrected by doing the easiest and most logical things first. Complete all steps in the sequence shown from top to bottom.

It is **not** possible to include all the solutions to problems that can occur; however, these charts are designed to stimulate a thought process that will lead to the cause and correction of the problem.

Follow these basic troubleshooting steps:

- Get all the facts concerning the complaint
- Analyze the problem thoroughly
- Relate the symptoms to the basic engine systems and components
- Consider any recent maintenance or repair action that can relate to the complaint
- Double-check before beginning any disassembly
- Solve the problem by using the symptom charts and doing the easiest things first
- Determine the cause of the problem and make a thorough repair
- After repairs have been made, operate the engine to make sure the cause of the complaint has been corrected

Troubleshooting Symptoms Charts

General Information

Use the charts on the following pages of this section to aid in diagnosing specific symptoms. Read each row of blocks from top to bottom. Follow through the chart to identify the corrective action.

WARNING

Troubleshooting presents the risk of equipment damage, personal injury or death. Troubleshooting must be performed by trained, experienced technicians.

Communication Error - Electronic Service Tool or Control Device

This is symptom tree t016

Cause	Correction
STEP 1 Error 5023: No connection to the ECM was established or detected	Refer to Procedure 019-472 in Section 19.
OK Go To Next Step	
STEP 2 Error 5080: ECM is ROM Booted and **must** be recalibrated	Calibrate ECM with the appropriate ECM code. Refer to Procedure 019-032 in Section 19.
OK Go To Next Step	
STEP 3 Error 5081: ECM is ROM Booted and **must** be recalibrated	Calibrate ECM with the appropriate ECM code. Refer to Procedure 019-032 in Section 19.
OK Go To Next Step	
STEP 4 Error 5089: ECM is in an invalid state **must** be recalibrated	Power OFF for 30 seconds and reconnect. Refer to Procedure 019-472 in Section 19.
OK Go To Next Step	
STEP 5 Error 5091: ECM is seeded and **must** be recalibrated	Calibrate ECM with the appropriate ECM code. Refer to Procedure 019-032 in Section 19.
OK Go To Next Step	
STEP 6 Error 5092: INSITE™ electronic service tool has detected some ECM(s) can **not** operate and **must** be recalibrated. INSITE™ electronic service tool has detected the following ECM(s) are currently calibrated: ECM NAME, Service ECM Marketing Name, INSITE™ electronic service tool has detected some ECM(s) can **not** operate and **must** be calibrated. INSITE™ electronic service tool has detected the following ECM(s) have incompatible calibrations: ECM Name, Source Address	Recalibrate the ECM(s) that are **not** currently calibrated. Refer to Procedure 019-032 in Section 19.
OK Go To Next Step	
STEP 7 Error 5200: Communication between the PC and the data link has been lost	Refer to Procedure 019-472 in Section 19.
OK Go To Next Step	

Communication Error - Electronic Service Tool or Control Device

This is symptom tree t016

Cause	Correction
STEP 8 Error 5201: Communication between the data link and the ECM has been lost	Refer to Procedure 019-472 in Section 19.
OK Go To Next Step	
STEP 9 Error 5202: Communication between the data link and the ECM has been lost	Refer to Procedure 019-472 in Section 19.
OK Go To Next Step	
STEP 10 Error 5204: Communication between the data link adapter and the ECM could **not** be established	Refer to Procedure 019-472 in Section 19.

Engine Fan Does Not Operate, Operates Erratically, or Operates Continuously

This is symptom tree t046

Cause	Correction
STEP 1 Programmable parameters or selected features are **not** correct	Check the programmable parameters and the selected features with an electronic service tool. Set the parameters and features again if necessary. Refer to Procedure 019-078 in Section 19.
OK Go To Next Step	
STEP 2 Manual fan ON/OFF switch and circuit is malfunctioning	Check the manual fan ON/OFF switch and circuit. Refer to Manual Fan ON/OFF Switch, Resistance Check, and Short Circuit to Ground Check. Refer to Procedure 019-045 in Section 19.
OK Go To Next Step	
STEP 3 Air conditioner sensor or circuit is malfunctioning	Check the air conditioner sensor and circuit. Refer to Air Conditioner Pressure Switch, Resistance Check, and Short Circuit to Ground Check. Refer to Procedure 019-262 in Section 19.
OK Go To Next Step	
STEP 4 Fan clutch actuator or circuit is malfunctioning	Check the fan clutch actuator circuit. Refer to Procedure 019-045 in Section 19.
OK Go To Next Step	
STEP 5 Engine electrical ground is malfunctioning	Check engine ground to chassis and chassis ground to battery negative (-) post. Refer to the OEM service manual and Procedure 013-009 in Section 13 in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.

Engine Will Not Shut Off

This is symptom tree t081

Cause	Correction
STEP 1 Keyswitch circuit is malfunctioning	Check the vehicle keyswitch circuit. Refer to Procedure 019-064.
OK Go To Next Step	
STEP 2 Engine is running on fumes drawn into the air intake	Check the air intake ducts. Locate and isolate the source of the fumes. Repair as necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 3 Turbocharger oil seal is leaking	Check the turbocharger compressor and turbine seals. Refer to Procedure 010-033 in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418.

Fault Code Warning Lamps Stay On (No Apparent Reason)

This is symptom tree t083

Cause	Correction
STEP 1 Electronic fault codes active or high counts of inactive fault codes	Read the fault codes with an electronic service tool. Refer to Section TF for fault code troubleshooting.
OK Go To Next Step	
STEP 2 Diagnostic switch is in the ON position	Turn off the diagnostic switch.
OK Go To Next Step	
STEP 3 Diagnostic shorting plug is installed	Remove the diagnostic shorting plug.
OK Go To Next Step	
STEP 4 Diagnostic switch or circuit is malfunctioning	Check the diagnostic switch and circuit. Refer to Procedures 019-027 and 019-028.
OK Go To Next Step	
STEP 5 Fault code warning lamp circuit is malfunctioning	Check the fault code warning lamp circuit. Refer to Procedure 019-047.

Fault Code Warning Lamps Do Not Illuminate

This is symptom tree t084

Cause	Correction
STEP 1 Keyswitch is in the OFF position	Turn the keyswitch to the ON position.
OK Go To Next Step	
STEP 2 Fault code warning lamps are burned out	Check the warning lamps for voltage. Replace the bulbs if necessary. Refer to Procedure 019-046.
OK Go To Next Step	
STEP 3 Fault code warning lamp circuit is malfunctioning	Check the fault code warning lamp circuit. Refer to Procedure 019-047.
OK Go To Next Step	
STEP 4 Keyswitch circuit is malfunctioning	Check the vehicle, equipment, or vessel keyswitch circuit. Refer to Procedure 019-064.

Intake Manifold Air Temperature Above Specification

This is symptom tree t096

Cause	Correction
STEP 1 Fan drive belt is broken	Check the fan drive belt. Replace the belt, if necessary. Refer to Procedure 008-002 in Section 8 in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.
OK Go To Next Step	
STEP 2 Fan drive belt is loose	Check the belt tension and tighten, if necessary. Refer to Procedure 008-002 in Section 8 in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.
OK Go To Next Step	
STEP 3 Cold weather radiator cover or winterfront is closed	Open the cold weather radiator cover or the winterfront. Maintain a minimum of 387 cm2 [60 in2] of opening at all times. Refer to Operation of Diesel Engines in Cold Climates, Service Bulletin 3379009.
OK Go To Next Step	
STEP 4 Charge-air cooler fins, radiator fins, or air conditioner condenser fins are damaged or obstructed with debris	Inspect the charge-air cooler, air conditioner condenser, and radiator fins. Clean, if necessary. Refer to Procedure 010-027 in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.
OK Go To Next Step	
STEP 5 Intake manifold temperature gauge is malfunctioning, if equipped	Refer to the OEM service manual.
OK Go To Next Step	
STEP 6 Electronic fault codes active or high counts of inactive fault codes	Refer to Section TF for fault code troubleshooting.
OK Go To Next Step	
STEP 7 Programmable parameters or selected features are **not** correct	Check the programmable parameters and the selected features with an electronic service tool. Set the parameters and features again, if necessary. Refer to Procedure 019-078 in Section 19.
OK Go To Next Step	

Intake Manifold Air Temperature Above Specification

This is symptom tree t096

Cause	Correction
STEP 8 Fan drive or fan controls are malfunctioning	Check the fan drive and controls. Refer toProcedure 019-045 in Section 19.
OK Go To Next Step	
STEP 9 Fan is **not** correct	Check the fan part number and compare it to the OEM-specified part number. Replace the fan, if necessary. Refer to the OEM service manual.
OK Go To Next Step	
STEP 10 Fan shroud is damaged or missing or the air recirculation baffles are damaged or missing	Inspect the shroud and the recirculation baffles. Repair, replace, or install, as necessary. Refer toProcedure 008-038 in Section 8 in the ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.
OK Go To Next Step	
STEP 11 Vehicle speed is too low for adequate cooling with high engine load	Reduce the engine load. Increase the engine (fan) rpm by downshifting.
OK Go To Next Step	
STEP 12 Intake manifold pressure sensor is malfunctioning	Check the intake manifold pressure sensor. Refer to Procedure 019-061 in Section 19.
OK Go To Next Step	
STEP 13 Vehicle cooling system is **not** adequate	Verify that the engine and vehicle cooling systems are using the correct components. Refer to the OEM service manual.
OK Go To Next Step	
STEP 14 Fan is **not** an adequate size for the application	Verify that the fan is the correct size. Refer to the OEM service manual.

Low Idle Adjust Switch Does Not Work

This is symptom tree t099

Cause	Correction
STEP 1 Engine idle speed is set at either the minimum or the maximum allowable value	The idle adjust switch will **not** adjust the idle speed outside the allowable range. Refer to Procedure 019-052.
OK Go To Next Step	
STEP 2 Low-idle adjust switch feature is **not** enabled	Check the low-idle adjust switch feature with an electronic service tool. Refer to Procedure 019-078.
OK Go To Next Step	
STEP 3 Low-idle adjust switch and circuit is malfunctioning	Check the idle adjust switch and circuit. Refer to Procedures 019-052 and 019-053.

PTO or Cruise Control Does Not Operate

This is symptom tree t112

Cause	Correction
STEP 1 Programmable parameters or selected features are **not** correct	Check the programmable parameters and the selected features with an electronic service tool. Set the parameters and features again if necessary. Refer to Procedure 019-078.
OK Go To Next Step	
STEP 2 Electronic control module (ECM) calibration is malfunctioning	Verify the ECM calibration is correct. Check the calibration revision history for applicable fixes to the calibration stored in the ECM. Refer to the calibration history spreadsheet ecm_calibration_rev_history.xlson QuickServe® Online or the INCAL™ CD-ROM. Compare the calibration stored in the ECM with the engine rating and the Control Parts List (CPL), Bulletin 4021326 or 4021327. If necessary, recalibrate the ECM. Refer to the appropriate electronic service tool manual and Procedure 019-032.
OK Go To Next Step	
STEP 3 Vehicle speed sensor (VSS) or circuit is malfunctioning	Use an electronic service tool to monitor the vehicle speed while the vehicle is **not** moving. Refer to the appropriate electronic service tool manual. If the monitor shows speed, check the sensor and circuit. Refer to Procedure 019-090, 019-091, and 019-093.
OK Go To Next Step	
STEP 4 Clutch switch or circuit is malfunctioning	Check the clutch switch adjustment, switch, and circuit. Refer to Procedure 019-009 or 019-010.
OK Go To Next Step	
STEP 5 Engine brake on/off switch or circuit is malfunctioning	Check the engine brake on/off switch and circuit. Refer to Procedure 019-034 and 019-035.
OK Go To Next Step	
STEP 6 Vehicle brake switch or circuit is malfunctioning	Check the vehicle brake switch and circuit. Refer to Procedure 019-088 and 019-089.
OK Go To Next Step	
STEP 7 Cruise control/PTO on/off switch or circuit is malfunctioning	Check the cruise control/PTO on/off switch and the circuit. Refer to Procedure 019-021 and 019-022.
OK Go To Next Step	

PTO or Cruise Control Does Not Operate

This is symptom tree t112

Cause	Correction
STEP 8 Cruise control/PTO selector switch or circuit is malfunctioning	Check the cruise control/PTO selector switch and circuit. Refer to Procedure 019-023 and 019-024.

Air Shutoff Valve will not Activate

This is symptom tree t164

Cause	Correction
STEP 1 Active air shutoff valve fault code(s)	Troubleshoot any active air shutoff valve fault codes first.
OK Go To Next Step	
STEP 2 Air shutoff lamp stays illuminated	Troubleshoot the air shutoff lamp circuit. Verify the proximity switch operation. The switch is normally open. The circuit is closed when the valve is in the closed position.
OK Go To Next Step	
STEP 3 Fault Code 1117 active	Troubleshoot active Fault Code 1117.
OK Go To Next Step	
STEP 4 Battery charge low	Check the batteries. Charge or replace if necessary.
OK Go To Next Step	
STEP 5 Verify the truck switches and wiring	Check the resistance and wiring in the truck dash for the air shutoff valve switches.
OK Go To Next Step	
STEP 6 Verify the proximity switch resistance	Disconnect the proximity switch from the OEM harness and check the resistance of the switch. The switch resistance should be between 15 and 25 ohms. Replace the switch if **not** within specification.
OK Go To Next Step	
STEP 7 Verify the diagnostic voltage from the ECM connector	Disconnect the OEM harness from the ECM and verify the diagnostic voltage. Replace the ECM if 5-VDC is present. Refer to Procedure 019-031 in Section 19. If 5-VDC is **not** present, troubleshoot the OEM harness. Refer to Procedure 019-043 in Section 19.
OK Go To Next Step	
STEP 8 Verify the air shutoff valve operation. **Note:** The air shutoff valve may become sluggish over time.	The air shutoff valve **must** close. Replace, as necessary.

Air Shutoff Valve will not Deactivate

This is symptom tree t165

Cause	Correction
STEP 1 Active air shutoff valve fault code(s)	Troubleshoot any active air shutoff valve fault codes first.
OK Go To Next Step	
STEP 2 Air shutoff lamp stays illuminated	Troubleshoot the air shutoff lamp circuit. Verify the proximity switch operation. The switch is normally open. The circuit is closed when the valve is in the closed position.
OK Go To Next Step	
STEP 3 Turn the keyswitch OFF and back ON	Verify the air shutoff valve has reset by checking the solenoid shaft position. Attempt to start the engine.
OK Go To Next Step	
STEP 4 Use INSITE™ electronic service tool to verify the engine rpm reading is zero	Connect INSITE™ electronic service tool and open the data monitor/logger. Monitor the rpm parameter. Verify the ECM rpm reading is zero with the engine off.
OK Go To Next Step	
STEP 5 Verify the shutoff solenoid resistance	Disconnect the air shutoff valve from the engine harness and check the resistance of the air shutoff valve solenoid. The resistance should be between 15 and 25 ohms. Replace the air shutoff solenoid if **not** within specification.
OK Go To Next Step	
STEP 6 Verify the diagnostic voltage from the OEM connector at the air shutoff solenoid	Disconnect the air shutoff solenoid from the engine harness. Verify the diagnostic voltage from the signal pin is 0-VDC.
OK Go To Next Step	
STEP 7 Verify the diagnostic voltage from the ECM connector	Disconnect the OEM harness from the ECM and verify the diagnostic voltage. Replace the ECM if 5-VDC is present. Refer to Procedure 019-031 in Section 19. If 5-VDC is **not** present, troubleshoot the OEM harness. Refer to Procedure 019-043 in Section 19.

Notes

Section TT - Troubleshooting Symptoms (New Format)

Section Contents

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ECM - No Communication Troubleshooting Tree

This troubleshooting procedure should be followed for the following symptoms:

- No communication and engine will **not** start
- No communication and engine will start
- No communication related INSITE™ electronic service tool errors
- Communication with some ECMs but **not** all ECMs on a multi-module engine.

How to Use This Troubleshooting Procedure:

This troubleshooting procedure can be used to troubleshoot J1939 and J1587 data link communication issues between the electronic service tool and the ECM. There are four procedures that can be used to support this troubleshooting tree:

- Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, in the appropriate electronic control system troubleshooting and repair manual.
- Procedure 019-165 (Data Link Circuit, SAE J1939) in Section 19 in the appropriate electronic control system troubleshooting and repair manual.
- Procedure 019-166 (Data Link Circuit, SAE J1587) in Section 19 in the appropriate electronic control system troubleshooting and repair manual.

The troubleshooting steps in this procedure build upon information obtained in previous steps. The troubleshooting steps **must** be performed in the sequence specified in the troubleshooting procedure.

This troubleshooting procedure supports several engine families, therefore some instructions are stated in a general manner. Apply the requested procedures and actions to the specific engine family with the support of engine specific documentation that can be found in the Troubleshooting and Repair manuals for the specific engine family.

Shop Talk:

Three basic principles were used to define and sequence the troubleshooting steps that are listed in this tree.

- Verify high level system operation prior to troubleshooting individual components of the system. The purpose for this is to learn from the behavior of the system in order to direct the next steps for troubleshooting.
- Use the Bench Top Harness to separate the ECM from the vehicle so the ECM can be isolated from vehicle issues that could be causing no communication.
- Use a second vehicle or a second ECM to isolate high level system issues before troubleshooting individual components of the system.

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**INSITE™ electronic service tool error code check**		
STEP 1A:	Check for INSITE™ electronic service tool error code 5023.	Is INSITE™ electronic service tool error code 5023 present?	
STEP 1B:	INSITE™ electronic service tool error code 5080 or 5081 check.	Is INSITE™ electronic service tool error code 5080 or 5081 present?	
STEP 1C:	INSITE™ electronic service tool other error code checks.	Are any INSITE™ electronic service tool error codes present other than 5023, 5080, or 5081?	
STEP 1D:	ECM password check	Does INSITE™ electronic service tool indicate the ECM is password protected?	
STEP 2:	**Initial data link adapter and INSITE™ electronic service tool check**		
STEP 2A:	Initial data link adapter check	Are the communication lights on the data link adapter flashing?	
STEP 2B:	data link adapter reset check	Does the ECM communicate?	
STEP 2C:	Initial INSITE™ electronic service tool check	Does the ECM communicate?	
STEP 2D:	data link adapter verification check	Is an Inline or Inline I being use to communicate with the ECM?	
STEP 2E:	data link adapter firmware check	Is firmware version compatible with ECM?	
STEP 3:	**Bench communication setup checks**		
STEP 3A:	Bench setup availability check	Is a bench setup available?	
STEP 3A-1:	Engine start check	Will engine start?	
STEP 3B:	Initial bench setup communication check	Does the ECM communicated using bench setup?	
STEP 3B-1:	Engine start check	Will engine start?	
STEP 3C:	Second vehicle or second ECM availability check for bench setup	Is second vehicle or second ECM available to connect to the bench setup?	
STEP 3D:	Initial bench setup functionality check	Does the second ECM communicate using bench setup?	
STEP 3E:	Troubleshoot bench setup	Does bench setup check OK?	
STEP 3F:	data link adapter replacement check	Does bench setup communicate with the second ECM using a replacement data link adapter?	
STEP 4:	**ECM power up circuit check**		
STEP 4A:	Engine configuration check	Is the engine equipped with a fuel shutoff valve?	
STEP 4A-1:	Check fuel shutoff valve voltage	Is the fuel shutoff valve voltage within 1-VDC of vehicle system voltage?	

STEP 4A-2:	Coolant temperature sensor signal voltage check	Is the coolant temperature signal voltage greater than 4.5-VDC?
STEP 4B:	ECM keyswitch voltage check	Is the keyswitch voltage within 1-VDC or vehicle system voltage?
STEP 4C:	Check the ECM power and ground	Is the ECM battery supply voltage equal to the battery voltage?

STEP 5: Initial electronic tool check

STEP 5A:	Bench setup previously used for troubleshooting check	In Step 3 checks, was bench setup used to successfully communicate with the ECM?
STEP 5B:	Second vehicle availability check for electronic tool	Is a second vehicle available to connect to the electronic tool?
STEP 5C:	Initial electronic tool functionality check	Does the second ECM communicate using electronic tool?

STEP 6: data link adapter power check

STEP 6A:	data link adapter determination check	Is an Inline I data link adapter being used to communicate with INSITE™ electronic service tool?
STEP 6B:	Check data link adapter power	Is the data link adapter power light on?
STEP 6C:	Determination if communication is being attempted at OEM dash connector	Is the communication being attempted at the OEM data link dash connector?
STEP 6D:	OEM data link dash connector voltage check	Is the voltage equal to or greater than 9-VDC?
STEP 6E:	Check voltage at data link adapter auxiliary power supply	Is the voltage equal to or greater than 9-VDC?
STEP 6F:	Check voltage at vehicle battery	Is the voltage equal or greater than 11-VDC?
STEP 6G:	Computer serial port voltage check	Is a minimum of 5 VDC available?

STEP 7: data link circuit check

STEP 7A:	Check J1939 or J1587 circuits	Does the circuit check OK?

STEP 8: Initial electronic tool check

STEP 8A:	Second vehicle availability check for electronic tool	Is a second vehicle available to connect to the electronic tool?
STEP 8B:	Initial electronic tool functionality check	Does the second ECM communicate using the electronic tool?

STEP 9: Detailed electronic tool check

STEP 9A:	Troubleshoot electronic tool hardware	Does the electronic tool hardware check OK?

STEP 10: Serial cable and computer check

STEP 10A:	Troubleshoot serial cable and computer	Do the serial cable and computer check OK?

STEP 11: ROM boot ECM

STEP 11A:	ROM boot tool availability check	Is the ROM boot tool available?
STEP 11B:	ROM boot ECM	Does the ECM communicate?

TROUBLESHOOTING STEP

STEP 1: INSITE™ electronic service tool error code check

STEP 1A: INSITE™ electronic service tool error code 5023 check

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for INSITE™ electronic service tool error code 5023. • Use INSITE™ electronic service tool to read the error codes.	Is INSITE™ electronic service tool error code 5023 present? **YES**	2A
	Is INSITE™ electronic service tool error code 5023 present? **NO**	1B

STEP 1B: INSITE™ electronic service tool error code 5080 or 5081 check

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for INSITE™ error code 5080 or 5081. • Use INSITE™ electronic service tool to read the error codes.	Is INSITE™ electronic service tool error code 5080 or 5081 present? **YES** **Repair:** Perform the ECM calibration download	Repair complete
	Is INSITE™ electronic service tool error code 5080 or 5081 present? **NO**	1C

STEP 1C: INSITE™ electronic service tool other error code checks.

Condition:
- Connect Is INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Are any INSITE™ electronic service tool error codes present other than 5023, 5080, or 5081? • Use INSITE™ electronic service tool to read the error codes.	Are any INSITE™ electronic service tool error codes present other than 5023, 5080, or 5081? **YES** **Repair:** See the INSITE™ Electronic Service Tool manual for troubleshooting guidelines.	Repair Complete
	Are any INSITE™ electronic service tool error codes present other than 5023, 5080, or 5081? **NO**	1D

STEP 1D: ECM password check

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Does INSITE™ electronic service tool indicate the ECM is password protected? • Use INSITE™ electronic service tool.	Does INSITE™ electronic service tool indicate the ECM is password protected? **YES** **Repair:** Enter correct password If password is unavailable, contact customer to request password information. If customer can **not** supply password information, see the INSITE™ electronic service tool manual for password removal information. Normal warranty guidelines will apply if ECM password removal is required.	Repair complete
	Does INSITE™ electronic service tool indicate the ECM is password protected? **NO**	2A

STEP 2: Initial data link adapter and INSITE™ electronic service tool check

STEP 2A: Initial data link adapter check

Condition:
- data link adapter connected to OEM data link connector in vehicle.
- INSITE™ electronic service tool computer **must not** be connected.
- Note: If connected to the 3 pin engine data link connector the communication lights will **not** blink, continue to Step 2B.

Action	Specification/Repair	Next Step
Turn keyswitch on.	Are the communication lights on the data link adapter flashing? • J1708 light for Inline • J1708 or J1939 for Inline II, Inline 4, and Inline 5. **YES** **Repair:** No Repair	2C
	Are the communication lights on the data link adapter flashing? • J1708 light for Inline • J1708 or J1939 for Inline II, Inline 4, and Inline 5. **NO**	2B

STEP 2B: data link adapter reset check

Condition:

INSITE™ electronic service tool connected to vehicle.

Action	Specification/Repair	Next Step
Data link adapter reset check • Disconnect power from the data link adapter. • Leave disconnected for 30 seconds • Connect power again to the Inline adapter • Turn keyswitch ON.	Does the ECM communicate? **YES**	Repair complete
	Does the ECM communicate? **NO**	3A

STEP 2C: Initial INSITE™ electronic service tool check

Condition:
- INSITE™ electronic service tool connected to vehicle
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Reboot INSITE™ electronic service tool PC. • Launch INSITE™ electronic service tool • Check for communication.	Does the ECM communicate? **YES**	Repair complete
	Does the ECM communicate? **NO**	2D

STEP 2D: data link adapter verification check

Condition:

None

Action	Specification/Repair	Next Step
Verify if an Inline or Inline I data link adapter is being used to communicate with ECM. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, for General Information - data link Adapters, in the appropriate electronic control system troubleshooting and repair manual for data link adapter identification information.	Is an Inline or Inline I being used to communicate with the ECM? **YES**	8A
	Is an Inline or Inline I being used to communicate with the ECM? **NO**	2E

STEP 2E: data link adapter firmware check

Condition:

None

Action	Specification/Repair	Next Step
Verify data link adapter firmware version is compatible with ECM. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, for General Information - data link Adapters, in the appropriate Electronic Control System Troubleshooting and Repair manual for data link adapter identification information.	Is firmware version compatible with the ECM? **YES**	8A
	Is firmware version compatible with the ECM? **NO** **Repair:** Load correct firmware version	2C

STEP 3: Bench communication setup checks

STEP 3A: Bench setup availability check

Condition:
- Bench setup available.

Action	Specification/Repair	Next Step
Verify bench setup is available.	Is a bench setup available? **YES**	3B
	Is a bench setup available? **NO**	3A-1

STEP 3A-1: Engine start check

Condition:
- None

Action	Specification/Repair	Next Step
Verify if engine will start.	Will engine start? **YES**	5A
	Will engine start? **NO**	4A

STEP 3B: Initial bench setup communication check.

Condition:
- Use the same INSITE™ electronic service tool PC as was used for the previous checks
- Bench setup connected to ECM
- Bench top calibration harness keyswitch ON.

Action	Specification/Repair	Next Step
Attempt to comunicate with the ECM using bench setup.	Does the ECM communicate with bench setup? **YES**	3B-1
	Does the ECM communicate with bench setup? **NO**	3C

STEP 3B-1: Engine start check

Condition:
- None

Action	Specification/Repair	Next Step
Disconnect the bench top calibration cable from the ECM. Reconnect the ECM to the original engine or OEM wiring harness connector. Verify if the engine will start.	Will the engine start? **YES**	5A
	Will the engine start? **NO**	4A

STEP 3C: Second vehicle or second ECM availability check for bench setup

Condition:
- Second vehicle or second ECM available for testing.

Action	Specification/Repair	Next Step
Verify if a second vehicle or second ECM is available to connect to the bench setup.	Is a second vehicle or second ECM available to connect to the bench setup? **YES**	3D
	Is a second vehicle or second ECM available to connect to the bench setup? **NO**	3E

STEP 3D: Initial bench setup functionality check

Condition:
- Use the same INSITE™ electronic service tool PC and bench setup tools that were originally used on the problem vehicle.
- Bench setup connected to second vehicle or second ECM
- Bench top calibration harness keyswitch ON.

Action	Specification/Repair	Next Step
Attempt to communicate with the ECM on the second vehicle or a spare ECM using bench setup.	Does the second ECM communicate using bench setup? **YES**	11A
	Does the second ECM communicate using bench setup? **NO**	3E

STEP 3E: Troubleshoot bench setup hardware

Condition:
- None

Action	Specification/Repair	Next Step
Troubleshoot bench calibration cable, bench calibration harness, and serial cable. • Perform troubleshooting procedures for evaluating the bench calibration cable, bench calibration harness, and serial cable. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, for Resistance Check - Serial Cable, Benchtop Calibration Harness, Benchtop Calibration Cable, in the appropriate Electronic Control System Troubleshooting and Repair manual.	Does bench setup check OK? **YES**	3F
	Does bench setup check OK? **NO** **Repair:** Repair or replace bench calibration cable, bench calibration harness, or serial cable.	3B

STEP 3F: data link adapter replacement check

Condition:
- None

Action	Specification/Repair	Next Step
Try to communicate with the bench setup using a replacement datalink.	Does bench setup communicate with the second ECM using a replacement data link adapter? **YES** **Repair:** Use replacement data link adapter.	3B
	Does bench setup communicate with the second ECM using a replacement data link adapter? **NO** **Repair:** Issue with bench setup should have been found. Troubleshoot the bench setup again.	3E

STEP 4: ECM power up circuit check

STEP 4A: Engine configuration check

Condition:
- None

Action	Specification/Repair	Next Step
Determine if the engine is equipped with a fuel shutoff valve	Is the engine equipped with a fuel shutoff valve? **YES**	4A-1
	Is the engine equipped with a fuel shutoff valve? **NO**	4A-2

STEP 4A-1: Check fuel shutoff valve voltage

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Measure the voltage from the fuel shutoff valve post to engine block ground. There are 12 and 24 volt systems, the fuel shutoff valve voltage needs to be within 1-VDC of the vehicle system voltage.	Is the fuel shutoff valve voltage within 1-VDC of vehicle system voltage? **YES**	5A
	Is the fuel shutoff valve voltage within 1 VDC of vehicle system voltage? **NO**	4B

STEP 4A-2: Coolant temperature sensor signal voltage check

Condition:
- Turn keyswitch ON.
- Disconnect the coolant temperature sensor connector.

Action	Specification/Repair	Next Step
Measure the voltage across the two pins of the coolant temperature sensor on the wiring harness connector. Reference the wiring diagram or circuit diagram for connector pin identification.	Is the coolant temperature signal voltage greater than 4.5-VDC? **YES**	5A
	Is the coolant temperature signal voltage greater than 4.5-VDC? **NO**	4B

STEP 4B: ECM keyswitch voltage check

Condition:
- Turn keyswitch OFF.
- Disconnect the wiring harness connector that contains the keyswitch signal from the ECM.
- Turn the keyswitch ON.

Action	Specification/Repair	Next Step
Measure the voltage from the keyswitch input SIGNAL wire of the wiring harness to engine block ground. Reference the wiring diagram or circuit diagram for connector pin identification.	Is the keyswitch voltage within 1-VDC of vehicle system voltage? **YES**	4C
	Is the keyswitch voltage within 1-VDC of vehicle system voltage? **NO** **Repair:** Repair or replace the wiring harness that contains the keyswitch signal, or repair or replace the keyswitch, or check the battery connection. Reference Procedure 019-064 (Key Switch Battery Supply Circuit) in Section 19 in the appropriate troubleshooting and repair manual. See the Engine Performance Troubleshooting Tree in the appropriate troubleshooting and repair manual, if the no start condition is still present.	Repair complete

STEP 4C: Check the ECM power and ground

Condition:
- Turn keyswitch OFF
- Disconnect from the ECM the wiring harness connector that contains the ECM battery SUPPLY (-) and SUPPLY (+) wiring.

Action	Specification/Repair	Next Step
Measure the voltage from each ECM battery SUPPLY (+) pin to all battery SUPPLY (-) pins in the wiring harness connector. Reference the wiring diagram or circuit diagram for connector pin identification.	Is the ECM battery supply voltage equal to the battery voltage? **YES** **Repair:** Call for authorization. Replace the ECM. Reference Procedure 019-031 (Electronic Control Module (ECM)) in Section 19 in the appropriate troubleshooting and repair manual.	Repair complete
	Is the ECM battery supply voltage equal to the battery voltage? **NO** **Repair:** Repair or replace the wiring harness that contains the ECM battery SUPPLY (+) and battery SUPPLY (-) wiring. See the Engine Performance Troubleshooting Tree if no start condition is still present.	Repair complete

STEP 5: Initial electronic tool check

STEP 5A: Bench setup previously used for troubleshooting check

Condition:
- None

Action	Specification/Repair	Next Step
In Step 3 checks, was bench setup used to successfully communicate with the ECM?	In Step 3 checks, was bench setup used to successfully communicate with the ECM? **YES** **Repair:** ECM is OK, repair complete if communication is **not** required through OEM data link connector or harness. If communication is required through the OEM data link connector or harness continue to Step 6A.	6A
	In Step 3 checks, was bench setup used to successfully communicate with the ECM? **NO**	5B

STEP 5B: Second vehicle availability check for electronic tool

Condition:
- Second vehicle available for testing

Action	Specification/Repair	Next Step
Verify a second vehicle is available to connect to the electronic tool.	Is a second vehicle available to connect to the electronic tool? **YES**	5C
	Is a second vehicle available to connect to the electronic tool? **NO**	6A

STEP 5C: Initial electronic tool functionality check

Condition:
- Electronic tool connected to a second vehicle.
- Keyswitch ON.

Action	Specification/Repair	Next Step
Attempt to communicate with the ECM on the second vehicle using the same electronic tool hardware used on the problem vehicle.	Does the second ECM communicate using electronic tool? **YES**	6A
	Does the second ECM communicate using electronic tool? **NO**	9A

STEP 6: data link adapter power check

STEP 6A: data link adapter determination check

Condition:
- None

Action	Specification/Repair	Next Step
Determine if an Inline I datalink adapter is being used to communicate with INSITE™ electronic service tool. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, for General Information - data link adapter, in the appropriate electronic control system troubleshooting and repair manual.	Is an Inline I data link adapter being used to communicate with INSITE™ electronic service tool? **YES**	6G
	Is an Inline I data link adapter being used to communicate with INSITE™ electronic service tool? **NO**	6B

STEP 6B: Check data link adapter power

Condition:
- Do **not** use an Inline I
- Electronic tool hardware connected to the vehicle.
- INSITE™ electronic service tool launched
- Keyswitch ON.

Action	Specification/Repair	Next Step
Note: For all datalink adapters except Inline I. Attempt to communicate with INSITE™ electronic service tool and check to see if the data link adapter power light is on. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, for General Information - data link Adapter, in the appropriate electronic control system troubleshooting and repair manual.	Is the data link adapter power light on? **YES**	7A
	Is the data link adapter power light on? **NO**	6C

STEP 6C: Determination if communication is being attempted at the OEM data link dash connector

Condition:
- None

Action	Specification/Repair	Next Step
Check to see if communication is being attempted at the OEM datalink dash connector.	Is communication being attempted at the OEM data link dash connector? **YES**	6D
	Is communication being attempted at the OEM data link dash connector? **NO**	6E

STEP 6D: OEM data link dash connector voltage check

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Measure voltage across the SUPPLY and ground pins of the OEM datalink connector. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, for In Cab data link Connector or 6-pin In Cab data link connector, in the appropriate Electronic Control System Troubleshooting and Repair manual for pin locations.	Is the voltage equal to or greater than 9 VDC? **YES** **Repair:** Replace data link adapter	Repair complete
	Is the voltage equal to or greater than 9 VDC? **NO**	6F

STEP 6E: Check voltage at data link adapter auxiliary power supply

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Measure the data link adapter supply voltage at the datalink adapter harness connector. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, for 3-pin data link Cable, in the appropriate Electronic Control System Troubleshooting and Repair manual for pin locations.	Is the voltage equal to or greater than 9-VDC? **YES** **Repair:** Replace data link adapter.	Repair complete
	Is the voltage equal to or greater than 9-VDC? **NO**	6F

STEP 6F: Check voltage at vehicle battery

Condition:
- None

Action	Specification/Repair	Next Step
Measure vehicle battery voltage in all cases except if using an Inline I. If using an Inline I measure data link adapter voltage supply from computer.	Is the voltage equal to or greater than 11-VDC? **YES** **Repair:** Repair or replace damaged wiring.	Repair complete
	Is the voltage equal to or greater than 11-VDC? **NO** **Repair:** Clean the battery connections or replace the batteries.	Repair complete

STEP 6G: Computer serial port voltage check

Condition:
- None

Action	Specification/Repair	Next Step
Note: For Inline I only. Measure voltage across the SIGNAL ground pin and the data terminal ready pin and the SIGNAL ground pin and the request to send pin on the computer serial port. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, for Serial Cable, in the appropriate Electronic and Control System Troubleshooting and Repair manual for pin locations.	Is a minimum of 5 VDC available? **YES** **Repair:** Replace data link adapter	Repair complete
	Is a minimum of 5 VDC available? **NO** **Repair:** Contact PC administration support.	Repair complete

STEP 7: data link circuit check

STEP 7A: Check J1939 or J1587 circuits

Condition:
- None

Action	Specification/Repair	Next Step
Use the following procedures to perform J1939 or J1587 circuit checks depending on the datalink circuit being used. Reference Procedure 019-165 (Data Link Circuit, SAE J1939) in Section 19 in the appropriate troubleshooting and repair manual. This procedure gives information for a complete resistance check, check for short circuit to ground, and check for short circuit from pin-to-pin. Reference Procedure 019-166 (Data Link Circuit, SAE J1587) in Section 19 in the appropriate troubleshooting and repair manual. This procedure gives information for a complete resistance check, check for short circuit to ground, check for short circuit from pin-to-pin, and voltage check. Reference Procedure 019-428 (Engine data links) in Section 19 in the appropriate troubleshooting and repair manual. Complete resistance check, check for short circuit to ground, and check for short circuit from pin-to-pin.	Does the circuit check OK? **YES**	11A
	Does the circuit check OK? **NO** **Repair:** Repair or replace the harness with the data link problem, either the engine or OEM harness.	Repair complete

STEP 8: Initial electronic tool check

STEP 8A: Second vehicle availability check for electronic tool

Condition:
- Second vehicle available for testing

Action	Specification/Repair	Next Step
Verify if a second vehicle is available to connect to electronic tool?	Is a second vehicle available to connect to the electronic tool? **YES**	8B
	Is a second vehicle available to connect to the electronic tool? **NO**	10A

STEP 8B: Initial electronic tool functionality check

Condition:
- Electronic tool connected to second vehicle

Action	Specification/Repair	Next Step
Attempt to communicate with the ECM on the second vehicle using the electronic tool.	Does the second ECM communicate using the electronic tool? **YES**	11A
	Does the second ECM communicate using the electronic tool? **NO**	10A

STEP 9: Detailed electronic tool check

STEP 9A: Troubleshoot electronic tool hardware

Condition:
- None

Action	Specification/Repair	Next Step
Perform troubleshooting procedures for evaluating electronic tool hardware: • data link adapter cable • data link adapter power supply cable • data link adapter • Serial cable • Computer. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, in the appropriate troubleshooting and repair manual. Complete the following checks: • Initial Check - INSITE™ electronic service tool • Initial Check - data link Adapters • Resistance Check - Serial Cable • Resistance Check for data link adapter cable and data link adapter power supply cable.	Does the electronic tool hardware check OK? **YES** **Repair:** Communication issue found.	11A
	Does the electronic tool hardware check OK? **NO** **Repair:** Repair or replace damaged hardware.	Repair complete

STEP 10: Serial cable and computer check

STEP 10A: Troubleshoot serial cable and computer

Condition:
- None

Action	Specification/Repair	Next Step
Perform troubleshooting procedures for evaluating the serial cable and computer. Reference Procedure 022-999 (Service Tools and Hardware - Overview) in Section F, in the appropriate troubleshooting and repair manual. Complete the following checks: • Initial Check - INSITE™ electronic service tool • Resistance Check - Serial Cable.	Do the serial cable and computer check OK? **YES** **Repair:** Communication issue found	11A
	Do the serial cable and computer check OK? **NO** **Repair:** Repair or replace damaged hardware.	Repair complete

STEP 11: ROM boot ECM

STEP 11A: ROM boot tool availability check

Condition:
- None

Action	Specification/Repair	Next Step
Verify if ROM boot tool is available for specific ECM.	Is the ROM boot tool available? **YES**	11B
	Is the ROM boot tool available? **NO** **Repair:** Call for pre-authorization Replace the ECM. Reference Procedure 019-031 (Electronic Control Module (ECM)) in Section 19 in the appropriate troubleshooting and repair manual.	Repair complete

STEP 11B: ROM boot the ECM

Condition:
- None

Action	Specification/Repair	Next Step
ROM boot the ECM. Reference Procedure 019-427 (ECM ROM Boot) in Section 19 in the appropriate troubleshooting and repair manual.	Does the ECM communicate? **YES** **Repair:** Calibrate the ECM again.	Repair complete
	Does the ECM communicate? **NO** **Repair:** Call for pre-authorization Replace the ECM. Reference Procedure 019-031 (Electronic Control Module (ECM)) in Section 19 in the appropriate troubleshooting and repair manual.	Repair complete

Engine Performance Troubleshooting Tree - ISC/QSC/ISL/QSL with CM850 Electronic Control System

This troubleshooting procedure should be followed for the following symptoms:

- Engine Acceleration or Response Poor
- Cranking Fuel Pressure is Low
- Engine Operating Fuel Pressure is Low
- Engine Decelerates Slowly
- Engine Difficult to Start or Will Not Start (Exhaust Smoke)
- Engine Difficult to Start or Will Not Start (No Exhaust Smoke)
- Engine Power Output Low
- Engine Runs Rough at Idle
- Engine Runs Rough or Misfires
- Engine Speed Surges at Low or High Idle
- Engine Speed Surges Under Load or in Operating Range
- Smoke, Black - Excessive
- Smoke, White - Excessive
- Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration
- Engine Starts but Will Not Keep Running
- Engine Will Not Reach Rated Speed (RPM)
- Intake Manifold Pressure (Boost) is Below Normal

How to Use This Troubleshooting Procedure:

This symptom tree can be used to troubleshoot all performance based symptoms listed above. Start by performing Step 1 troubleshooting. Step 2 will ask a series of questions and will provide a list of troubleshooting steps to perform depending on the symptom. Perform the list of troubleshooting steps in the sequence shown in the Specifications/ Repair section of the tree.

Shop Talk:

Driveability is a term that in general describes vehicle performance on the road. Driveability problems for an engine can be caused by several different factors. Some of the factors are engine-related and some are **not**. Before troubleshooting it is important to determine the exact complaint and whether the engine has a real driveability problem or if it simply does **not** meet driver expectations.

Low power is a term that is used in the field to describe many different performance problems. Low power is defined as the inability of the engine to produce the power necessary to move the vehicle at a speed that can be reasonably expected under the given conditions of load, grade, wind, and so on.

Poor acceleration or response is described as the inability of the vehicle to accelerate satisfactorily from a stop or from the bottom of a grade. It can also be the lag in acceleration during an attempt to pass or overtake another vehicle at conditions less than rated speed and load. Poor acceleration or response is difficult to troubleshoot since it can be caused by several factors.

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Perform basic troubleshooting procedures.**		
STEP 1A:	Check for active fault codes or high counts of inactive fault codes.		
STEP 1B:	Perform basic troubleshooting checks.		
STEP 2:	**Determination of engine symptom.**		
STEP 2A:	Low power, poor acceleration, or poor response.		
STEP 2B:	Engine misfire, engine speed surge, or engine speed unstable.		
STEP 2C:	Excessive white or black smoke.		
STEP 2D:	Low intake manifold pressure.		
STEP 2E:	Engine will not start or difficult to start, engine shuts off unexpectedly.		
STEP 3:	**No-start troubleshooting procedures.**		
STEP 3A:	Verify the operation of cold weather starting aids.		
STEP 3B:	Verify the low-pressure fuel lines are routed correctly.		
STEP 3C:	Check the ECM keyswitch voltage.		
STEP 3D:	Check the ECM battery supply voltage.		
STEP 3E:	Check engine speed during cranking.		
STEP 3F:	Verify rail fuel pressure sensor accuracy.		
STEP 3G:	Check for fuel rail pressure while cranking the engine.		
STEP 3G-1:	Check fuel gear pump pressure.		
STEP 3G-2:	Check fuel lift pump pressure.		
STEP 3H:	Check for other fault codes that explain a no-start condition.		
STEP 4:	**Fuel system troubleshooting procedures.**		
STEP 4A:	Check for fault codes.		
STEP 4B:	Check for air in the high-pressure pump fuel supply.		
STEP 4C:	Measure fuel gear pump pressure.		

STEP 4C-1: Measure the fuel inlet restriction.

STEP 4D: Perform single cylinder cutout test.

STEP 4E: Perform cylinder balance diagnostic test.

STEP 4F: Measure fuel drain line restriction.

STEP 4G: Monitor fuel pressure at idle.

STEP 5: Air handling troubleshooting procedures.

STEP 5A: Inspect the turbocharger blades for damage.

STEP 5B: Check the turbocharger axial and radial clearances.

STEP 5C: Determination of turbocharger type.

STEP 5D: Check variable geometry actuator rod for correct travel.

STEP 5D-1: Check for air leaks and inspect air lines.

STEP 5D-2: Check for air pressure at the turbocharger control valve outlet.

STEP 5D-3: Check for air pressure at turbocharger control valve outlet.

STEP 5D-4: Check for vehicle air tank pressure at turbocharger control valve inlet.

STEP 5D-5: Check for correct turbocharger actuator travel.

STEP 5E: Check for broken shaft inside the turbocharger.

STEP 5F: Inspect wastegate actuator - wastegated turbochargers only.

STEP 5G: Inspect wastegate actuator rod for travel.

STEP 5G-1: Inspect the wastegate actuator rod for travel.

STEP 6: Electronic feature troubleshooting procedures.

STEP 6A: Verify throttle pedal travel.

STEP 6B: Check ambient air pressure sensor accuracy.

STEP 6C: Check intake manifold pressure sensor accuracy.

STEP 6D: Verify electronic feature settings are correct.

STEP 7: Base engine troubleshooting procedures.

TROUBLESHOOTING STEP

STEP 1: Perform basic troubleshooting procedures.

STEP 1A: Check for active fault codes or high counts of inactive fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Active fault codes or high counts of inactive fault codes? **YES** **Repair:** Follow the electronic fault code trees for the appropriate troubleshooting procedures.	Repair complete
	Active fault codes or high counts of inactive fault codes? **NO**	1B

STEP 1B: Perform basic troubleshooting checks.

Condition:

None.

Action	Specification/Repair	Next Step
The following items must be checked or verified before continuing: • Verify the fuel level in the tanks • Verify there have **not** been any changes to CPL components on the engine • Verify fuel grade is correct for application • Verify the engine is operating within the recommended altitude • Verify engine oil is at the correct level • Verify engine parasitics have **not** changed • Verify engine duty cycle has **not** changed • Verify engine cranking speed is greater than 150 rpm • Verify battery voltage is adequate.	All steps have been verified to be correct? **YES**	2A
	All steps have been verified to be correct? **NO** **Repair:** Correct the condition and verify complaint is no longer present after repair.	Repair complete

STEP 2: Determination of engine symptoms.

STEP 2A: Low power, poor acceleration, or poor response.

Condition:

None.

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint.	Is the engine symptom low power, poor acceleration, or poor response? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: • Step 4 - Fuel System Checks • Step 5 - Air Handling Checks • Step 6 - Electronics Checks • Step 7 - Base Engine Checks.	Perform the troubleshooting steps suggested in the repair procedure
	Is the engine symptom low power, poor acceleration, or poor response? **NO**	2B

STEP 2B: Engine misfire, engine speed surge, or engine speed unstable.

Condition:

None.

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint.	Is the engine symptom engine misfire, engine speed surge, or engine speed unstable? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: • Step 4 - Fuel System Checks • Step 5 - Air Handling Checks • Step 6 - Electronics Checks.	Perform the troubleshooting steps suggested in the repair procedure
	Is the engine symptom engine misfire, engine speed surge, or engine speed unstable? **NO**	2C

STEP 2C: Excessive white or black smoke.

Condition:

None.

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint.	Is the engine symptom excessive white or black smoke? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: • Step 5 - Air Handling Checks • Step 4 - Fuel System Checks • Step 7 - Base Engine Checks.	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom excessive white or black smoke? **NO**	2D

STEP 2D: Low intake manifold pressure.

Condition:

None.

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint.	Is the engine symptom low boost pressure? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: • Step 5 - Air Handling Checks • Step 4 - Fuel System Checks • Step 7 - Base Engine Checks.	Perform the troubleshooting steps suggested in the repair procedure
	Is the engine symptom low boost pressure? **NO**	2E

STEP 2E: Engine will not start or difficult to start, engine shuts off unexpectedly.

Condition:

None.

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint.	Is the symptom engine will not start or difficult to start, engine shuts off unexpectedly? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: • Step 3 - No Start Checks • Step 4 - Fuel System Checks • Step 5 - Air Handling Checks • Step 6 - Electronics Checks.	Perform the troubleshooting steps suggested in the repair procedure
	Is the symptom engine will not start or difficult to start, engine shuts off unexpectedly? **NO**	Return to correct symptom tree

STEP 3: No-start troubleshooting procedures.

STEP 3A: Verify the operation of cold weather starting aids.

Condition:
- Turn keyswitch ON.

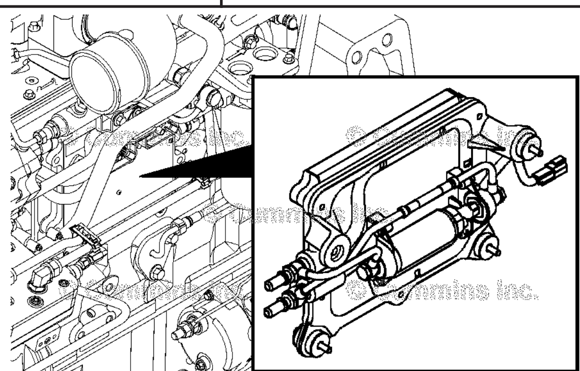
Action	Specification/Repair	Next Step
Make sure the intake air heater and other cold starting aids are operational. Refer to Procedure 008-011 in Section 8. Refer to Procedure 010-029 in Section 10.	Are necessary cold weather starting aids operating properly? **YES**	3B
	Are necessary cold weather starting aids operating properly? **NO** **Repair:** Install or repair cold weather starting aids. Refer to Procedure 010-029 in Section 10.	Repair complete

STEP 3B: Verify the low-pressure fuel lines are routed correctly.

Condition:

None.

Action	Specification/Repair	Next Step
It is sometimes possible to get the low-pressure fuel lines connected to the ECM cooling plate installed improperly. The top connection to the ECM cooling plate is the inlet and the bottom connection is the outlet. Verify these connections if the low-pressure fuel lines have been removed and installed on the engine.	Are the low-pressure fuel lines connected properly to the ECM cooling plate? **YES**	3C
	Are the low-pressure fuel lines connected properly to the ECM cooling plate? **NO** **Repair:** Properly connect the low-pressure fuel lines to the ECM cooling plate. The fuel inlet is the top connection.	Repair complete



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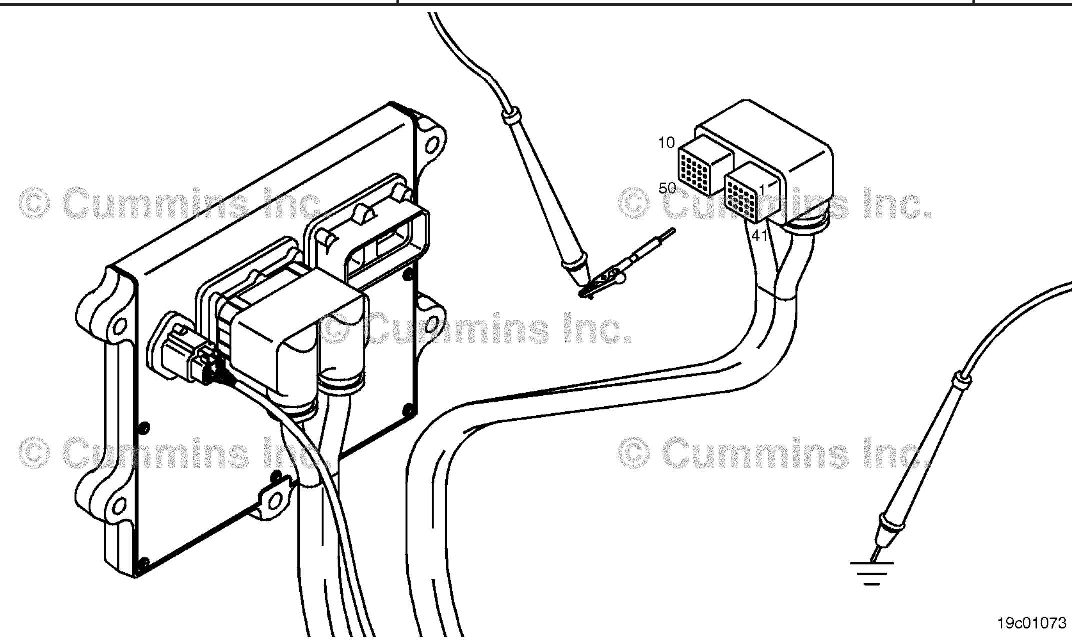
STEP 3C: Check the ECM keyswitch voltage.

Condition:
- Disconnect the OEM harness from the ECM.
- Turn keyswitch ON.

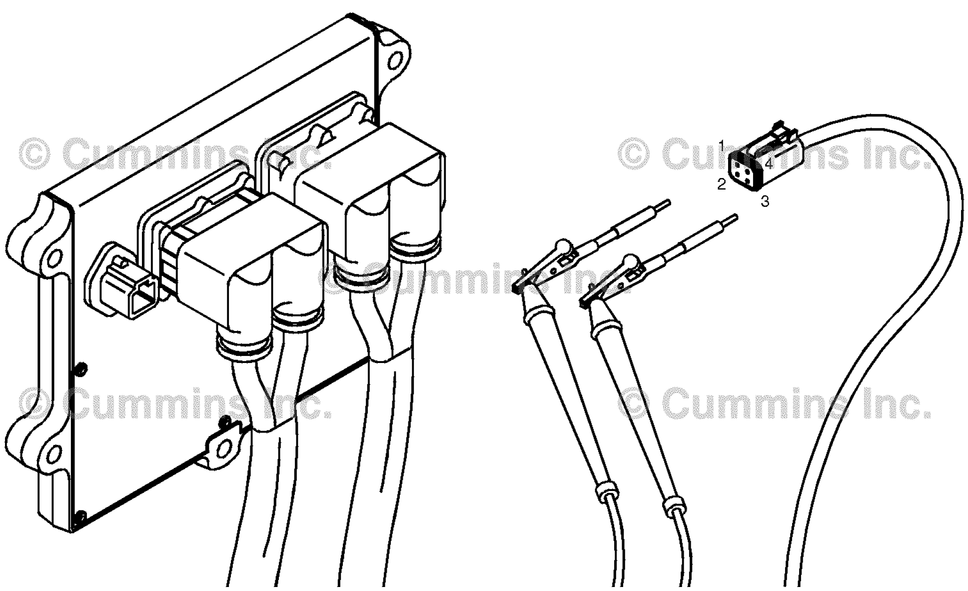
Action	Specification/Repair	Next Step
Measure the signal voltage from the keyswitch input SIGNAL wire of the OEM harness to the engine block ground. Measure the keyswitch voltage with the keyswitch in the ON position and also with the keyswitch in the Cranking position. Refer to the wiring diagram for connector pin identification.	Is the keyswitch voltage equal to battery voltage? **YES**	3D
	Is the keyswitch voltage equal to battery voltage? **NO** **Repair:** Repair or replace the OEM power harness, keyswitch, or check the battery connections.	Repair complete



STEP 3D: Check the ECM battery supply voltage.

Condition:
- Turn keyswitch OFF.
- Disconnect the ECM power harness from the ECM.

Action	Specification/Repair	Next Step
Measure the voltage from the ECM battery SUPPLY (-) pin to the ECM battery SUPPLY (+) pins in the ECM power harness connector. Measure the ECM voltage with the keyswitch in the ON position and also with the keyswitch in the Cranking position. Refer to the wiring diagram for connector pin identification.	Is the ECM battery supply voltage equal to the battery voltage? **YES**	3E
	Is the ECM battery supply voltage equal to the battery voltage? **NO** **Repair:** Repair or replace the ECM power harness. Check the battery connections and fuse terminals.	Repair complete



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STEP 3E: Check engine speed during cranking.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to monitor Engine Speed while cranking the engine.	Is the engine cranking speed greater than 150 rpm? **YES**	3F
	Is the engine cranking speed greater than 150 rpm? **NO** **Repair:** Find and correct the cause for low cranking speed. Check the batteries, engine starting motor, and accessory loads.	Repair complete

STEP 3F: Verify rail fuel pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to monitor the Rail Fuel Pressure Sensor (Measured) with the keyswitch ON and the engine not running.	Is the rail fuel pressure sensor (measured) value less than 30 Bar [435 psi]? **YES**	3G
	Is the rail fuel pressure sensor (measured) value less than 30 Bar [435 psi]? **NO** **Repair:** Replace the rail fuel pressure sensor. Use the following procedure in the Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC and ISL Engines, Bulletin 4021416. Refer to Procedure 019-115 in Section 19.	Repair complete

STEP 3G: Check for fuel rail pressure while cranking the engine.

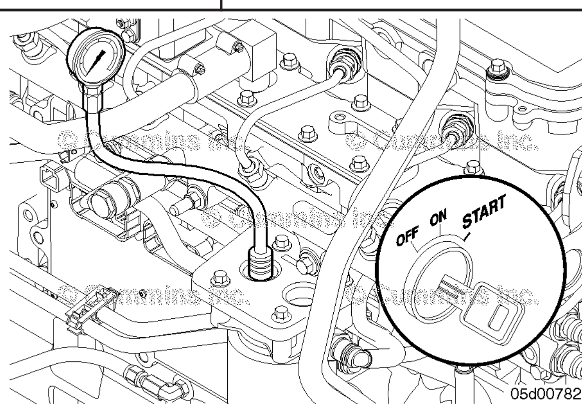
Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Attempt to start the engine by engaging the engine starting motor for at least 30 continous seconds. • Use INSITE™ electronic service tool to monitor Fuel Rail Pressure (Measured) and Fuel Rail Pressure (Commanded). • Use INSITE™ electronic service tool to read the fault codes. Attempting to start the engine for 30 continuous seconds allows the fault code logic time to run. If Fault Code 2215 becomes active, fuel rail pressure is **not** being developed. If the engine starts during this attempt, it is possible that fuel prime to the high pressure pump has been lost. Look for loose fuel lines or filters that allow for loss of fuel prime.	Did Fault Code 2215 become active during the failed the start attempt? **YES**	3G-1
	Did Fault Code 2215 become active during the failed the start attempt? **NO**	3H

STEP 3G-1: Check fuel gear pump pressure.

Condition:
- Install a pressure gauge at the pressure side fuel filter head. Refer to Procedure 005-025 in Section 5.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Measure the fuel gear pump output pressure while cranking the engine. Cranking speed **must** be greater than 150 rpm. Refer to Procedure 005-025 in Section 5.	Is the fuel gear pump pressure while cranking greater than the specification outlined in 005-025? **YES** **Repair:** Follow Fault Code 2215 troubleshooting tree.	Repair complete
	Is the fuel gear pump pressure, while cranking, greater than the specification outlined in 005-025? **NO**	3G-2

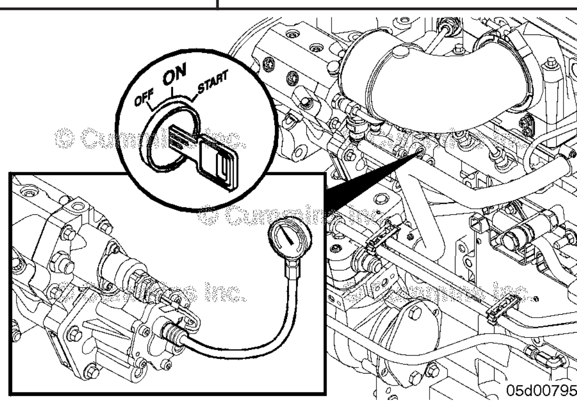


STEP 3G-2: Check fuel lift pump pressure.

Condition:

- Install a pressure gauge at the inlet port of the high pressure pump gear pump.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Measure the fuel lift pump output pressure. Refer to Procedure 005-045 in Section 5. At initial key ON, the lift pump will run for 30 seconds and then stop.	Is the fuel lift pump pressure greater than the specifications outlined in Procedure 005-045 in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418? **YES** **Repair:** Replace the gear pump. Refer to Procedure 005-025 in Section 5.	Repair complete
	Is the fuel lift pump pressure greater than the specifications outlined in Procedure 005-045 in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418? **NO** **Repair:** Verify fuel prime by making sure the OEM fuel filter is full or fuel and air is purged from the low pressure fuel lines. Perform INSITE™ electronic service tool Lift Pump Override Test if necessary. If the low pressure fuel system is primed, replace the fuel lift pump. Refer to Procedure 005-045 in Section 5.	Repair complete



STEP 3H: Check for other fault codes that explain a no-start condition.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to read fault code information. Look for fault codes that come active during a failed start attempt that can be the cause for a no-start condition.	Do any fault codes that can cause a no-start condition come active during cranking? **YES** **Repair:** Follow the electronic fault code trees for the appropriate troubleshooting procedures.	Repair complete
	Do any fault codes that can cause a no-start condition come active during cranking? **NO**	4A

STEP 4: Fuel system troubleshooting procedures.

STEP 4A: Check for fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to read the fault code information. Determine if there are active fuel system fault codes related to the complaint.	Are fuel system fault codes active? **YES** **Repair:** Follow the electronic fault code trees for the appropriate troubleshooting procedures.	Repair complete
	Are fuel system fault codes active? **NO**	4B

STEP 4B: Check for air in the high-pressure pump fuel supply.

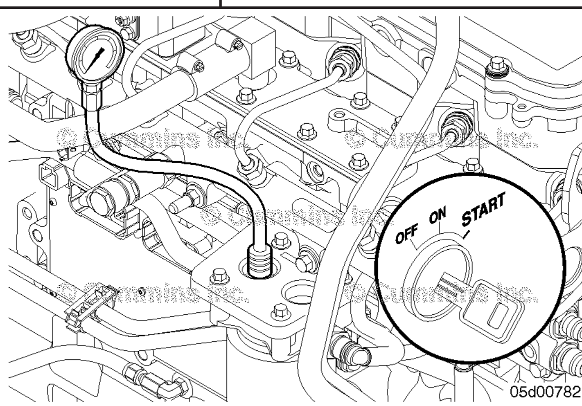
Condition:
- Refer to Procedure 006-003 in Section 6.

Action	Specification/Repair	Next Step
Check for air in the fuel. Refer to Procedure 006-003 in Section 6.	Is air present in the fuel supply? **YES** **Repair:** Locate and correct the cause of air ingestion in the fuel supply system. Sources of air ingestion include loose fuel filters, loose fuel line fittings, loose or cracked fuel tank stand-pipes, or severe restrictions in the fuel supply lines and filters.	Repair complete
	Is air present in the fuel supply? **NO**	4C

STEP 4C: Measure fuel gear pump pressure.

Condition:
- Refer to Procedure 005-025 in Section 5.

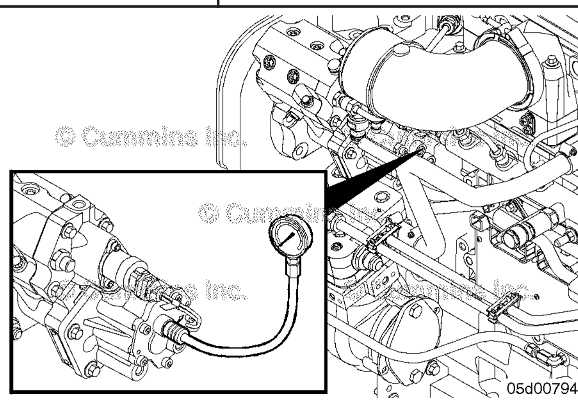
Action	Specification/Repair	Next Step
Check the fuel gear pump pressure. Refer to Procedure 005-025 in Section 5.	Is the fuel gear pump pressure within specification? **YES**	4D
	Is the fuel gear pump pressure within specification? **NO**	4C-1



STEP 4C-1: Measure the fuel inlet restriction.

Condition:
- Measure the fuel pump inlet restriction at the diagnostics port on the fuel gear pump. Refer to Procedure 006-020 in Section 6 .

Action	Specification/Repair	Next Step
Check the fuel inlet restriction. Refer to Procedure 006-020 in Section 6 .	Is the fuel inlet restriction above specification? **YES** **Repair:** Find and correct the cause of high inlet restriction. Look for plugged OEM fuel filters or screens, or a restricted ECM cooler, restricted lift pump bypass check valve (in the ECM cooler), pinched OEM fuel lines or restricted stand-pipe in the OEM fuel tank.	Repair complete
	Is the fuel inlet restriction above specification? **NO** **Repair:** Replace the fuel gear pump. Refer to Procedure 005-025 in Section 5.	Repair complete



STEP 4D: Perform single cylinder cutout test.

Condition:

- Turn keyswitch ON.
- Engine running at low idle.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Operate the engine at load. Use INSITE™ electronic service tool to perform the Cylinder Cutout Test to disable individual injectors.	Can the miss or excessive smoke be attributed to a single cylinder? **YES** **Repair:** Look for a cause of the complaint including valve lash and excessive crankcase pressure that can indicate power cylinder damage or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder identified by the single cylinder cutout test. Refer to Procedure 006-026 in Section 6.	Repair complete
	Can the miss or excessive smoke be attributed to a single cylinder? **NO**	4E

STEP 4E: Perform cylinder balance diagnostic test.

Condition:

- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to run the Cylinder Performance Test to determine if a single cylinder is contributing to the engine symptom.	Does the Cylinder Performance Test identify any cylinder that is contributing to a power imbalance? **YES** **Repair:** Look for a cause of the power imbalance including valve lash and excessive crankcase pressure that can indicate power cylinder damage or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder contributing to the power imbalance. Refer to Procedure 006-026 in Section 6.	Repair complete
	Does the Cylinder Performance Test identify any cylinder that is contributing to a power imbalance? **NO**	4F

STEP 4F: Measure fuel drain line restriction.

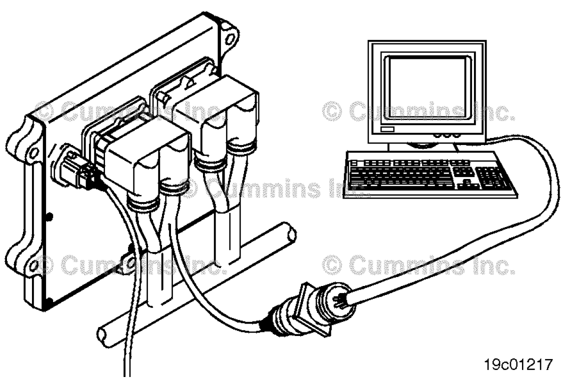
Condition:
- Refer to Procedure 006-012 in Section 6.

Action	Specification/Repair	Next Step
Check the fuel drain line restriction. • Use the following procedure in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418. Refer to Procedure 006-012 in Section 6.	Is the drain line restriction less than specification? **YES**	4G
	Is the drain line restriction less than specification? **NO** **Repair:** Look for causes of high drain line restriction, such as kinked or blocked fuel lines.	Repair complete

STEP 4G: Monitor fuel pressure at idle.

Condition:
- Connect INSITE™ electronic service tool.
- Start engine.

Action	Specification/Repair	Next Step
Run engine at idle for at least one minute to purge air induced from previous steps. Use INSITE™ electronic service tool to monitor commanded fuel rail pressure and measured fuel rail pressure for a minimum of 10 seconds. To verify your results, repeat this step with the Fuel System Leakage Test active in the INSITE™ electronic service tool.	Does measured fuel rail pressure deviate more than 200 bar [2900 psi] from commanded pressure and surge at idle, or does the engine start and stall? **YES** **Repair:** Replace the fuel pump actuator. Use the following procedure in the Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC and ISL Engines, Bulletin 4021416. Refer to Procedure 019-117 in Section 19.	Repair complete.
	Does measured fuel rail pressure deviate more than 200 bar [2900 psi] from commanded pressure and surge at idle, or does the engine start and stall? **NO**	2A



STEP 5: Air handling troubleshooting procedures.

STEP 5A: Inspect the turbocharger blades for damage.

Condition:
- Turn keyswitch OFF.
- Remove the intake and exhaust pipes from the turbocharger.

Action	Specification/Repair	Next Step
Inspect the compressor and turbine blades for damage or wear. Refer to Procedure 010-033 in Section 10.	Damage or wear found on turbocharger blades? **YES** **Repair:** Replace the turbocharger assembly. Refer to Procedure 010-033 in Section 10.	Repair complete
	Damage or wear found on turbocharger blades? **NO**	5B

STEP 5B: Check the turbocharger axial and radial clearances.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the turbocharger for correct axial and radial clearance. Refer to Procedure 010-033 in Section 10.	Are the turbocharger axial and radial bearing clearances within specification? **YES**	5C
	Are the turbocharger axial and radial bearing clearances within specification? **NO** **Repair:** Replace the turbocharger. Refer to Procedure 010-033 in Section 10.	Repair complete

STEP 5C: Determination of turbocharger type.

Condition:

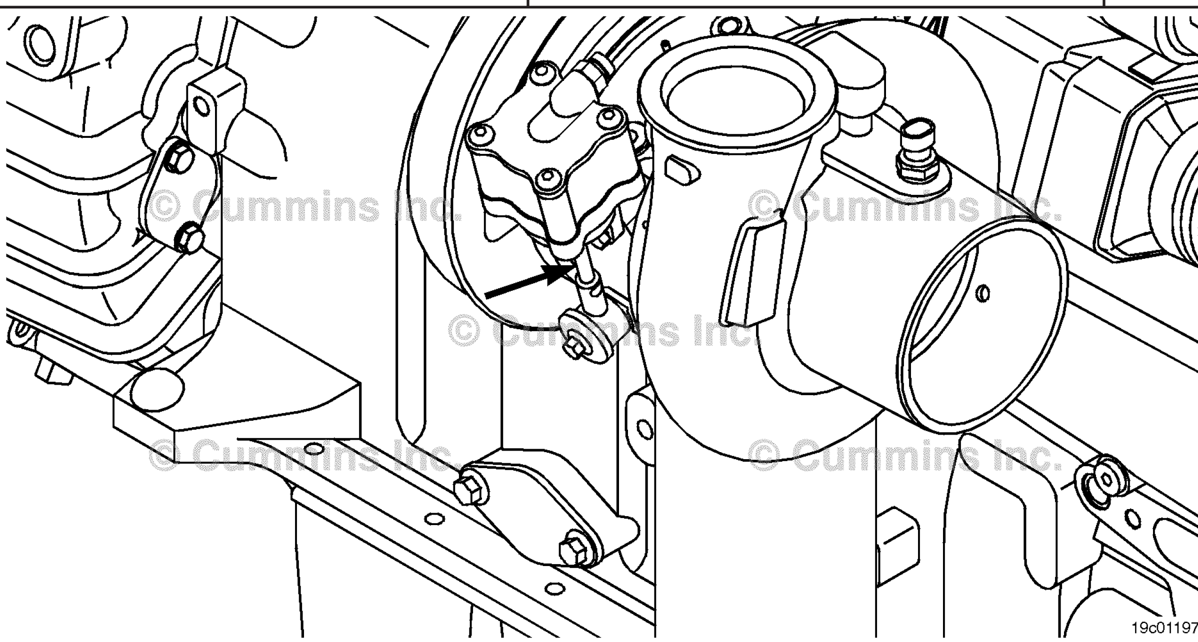
None

Action	Specification/Repair	Next Step
Determine if the turbocharger is a wastegated or variable geometry turbo.	Is the turbocharger a variable geometry turbocharger? **YES**	5D
	Is the turbocharger a variable geometry turbocharger? **NO**	5F

STEP 5D: Check variable geometry actuator rod for correct travel.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Verify vehicle air tanks are fully charged (greater than 689 kPa [100 psi]).

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to start the Turbocharger Actuator Test • Adjust the delay timer in the Turbocharger Actuator Test so that the rod movement can be observed. • Select the Retract Actuator position with INSITE™ electronic service tool. • Mark or scribe the variable geometry actuator rod at the base of the actuator. • Select the Extend Actuator position with INSITE™ electronic service tool. • Measure the rod travel by measuring the distance from the base of the variable geometry actuator to the scribe mark. The variable geometry actuator **must** move quickly and crisply. If the actuator rod movement is slow, there could be a problem with the air supply or mechanical problems with the variable geometry turbocharger assembly.	Does the turbocharger actuator rod extend between 8 and 9 mm [0.32 and 0.36 in]? **YES**	5E
	Does the turbocharger actuator rod extend between 8 and 9 mm [0.32 and 0.36 in]? **NO**	5D-1



STEP 5D-1: Check for air leaks and inspect air lines.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Verify vehicle air tanks are fully charged (greater than 689 kPa [100 psi]).

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to perform the Turbocharger Actuator Test. Select the Extended Actuator position and listen for air leaks in the following components: • Turbocharger control valve • Turbocharger control valve inlet connection • Turbocharger control valve outlet connection • Turbocharger actuator inlet connection • Turbocharger actuator • All air lines including OEM supply line to turbocharger control valve and between the turbocharger control valve and the variable geometry turbocharger. A small amount of air will be heard escaping from the turbocharger control valve. This is a normal condition. Do **not** replace the turbocharger control valve for this condition.	Air leaks found in the system or damaged air lines? **YES** **Repair:** Repair air leaks or replace damaged or broken air lines.	Repair complete
	Air leaks found in the system or damaged air lines? **NO**	5D-2

STEP 5D-2: Check for air pressure at the turbocharger control valve outlet.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Verify vehicle air tanks are fully charged (greater than 689 kPa [100 psi]).

Action	Specification/Repair	Next Step
Remove the air line connection at the outlet of the turbocharger control valve. Install a Compuchek™ fitting in the turbocharger control valve outlet. Install an air pressure gauge that is capable of reading at least 1034 kPa [150 psi]. Use INSITE™ electronic service tool to perform the Turbocharger Actuator Test. Select the Extend position.	Is vehicle tank air pressure present at the turbocharger control valve outlet? **YES**	5D-3
	Is vehicle tank air pressure present at the turbocharger control valve outlet? **NO**	5D-4

STEP 5D-3: Check for air pressure at turbocharger control valve outlet.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Verify vehicle air tanks are fully charged (greater than 689 kPa [100 psi]).

Action	Specification/Repair	Next Step
Remove the air line connection at the outlet of the turbocharger control valve. Install an air pressure gauge that is capable of reading at least 1034 kPa [150 psi]. Use INSITE™ electronic service tool to perform the Turbocharger Actuator Test. Select the Retract position.	Can air be heard escaping from the turbocharger control valve outlet? **YES** **Repair:** The turbocharger control valve is stuck open. It **must not** be allowing air to escape when in the Retract position. Replace the turbocharger control valve. Use the following procedure in the Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC and ISL Engines, Bulletin 4021416. Refer to Procedure 019-388 in Section 19.	Repair complete
	Can air be heard escaping from the turbocharger control valve outlet? **NO**	5D-4

STEP 5D-4: Check for vehicle air tank pressure at turbocharger control valve inlet.

Condition:
- Turn keyswitch ON.
- Verify vehicle air tanks are fully charged (greater than 689 kPa [100 psi]).

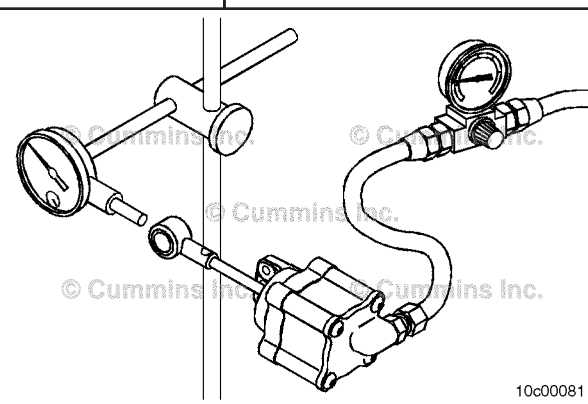
Action	Specification/Repair	Next Step
Disconnect the air inlet connection to the turbocharger control valve. Verify vehicle air tank pressure is available at the turbocharger control valve inlet.	Vehicle air tank pressure available at the turbocharger control valve inlet? **YES**	5D-5
	Vehicle air tank pressure available at the turbocharger control valve inlet? **NO** **Repair:** No air pressure available at the turbocharger control valve inlet. Troubleshoot OEM air plumbing and determine why air pressure is **not** present.	Repair complete

STEP 5D-5: Check for correct turbocharger actuator travel.

Condition:

- Remove the variable geometry actuator from the turbocharger assembly. Refer to Procedure 010-113 in Section 10.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to perform the Turbocharger Actuator Test. Select the Extend Actuator position.	Does the variable geometry actuator rod travel at least 12 mm [0.472 in]? **YES** **Repair:** The variable geometry actuator has correct air pressure and correct travel. The variable geometry mechanism in the turbocharger is seized. Replace the turbocharger assembly. Refer to Procedure 010-033 in Section 10.	Repair complete
	Does the variable geometry actuator rod travel at least 12 mm [0.472 in]? **NO** **Repair:** The variable geometry actuator has correct air pressure but the variable geometry actuator rod is **not** extending. Replace the turbocharger actuator. Refer to Procedure 010-113 in Section 10.	Repair complete

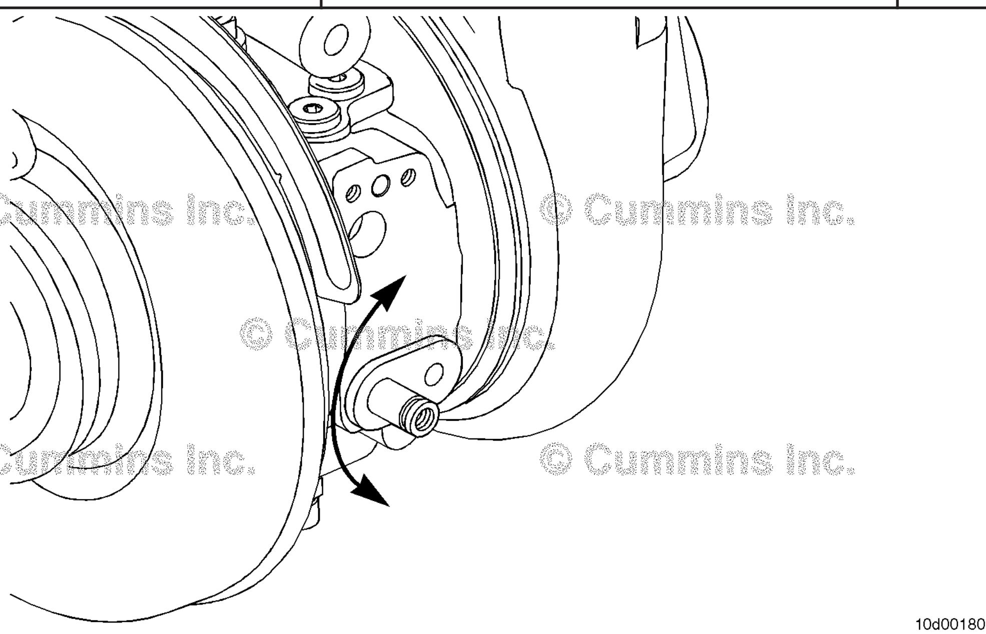


STEP 5E: Check for broken shaft inside the turbocharger.

Condition:

- Turn keyswitch OFF.
- Remove the variable geometry actuator from the turbocharger assembly. Refer to Procedure 010-113 in Section 10.

Action	Specification/Repair	Next Step
Check for a broken linkage inside the turbocharger by moving the variable geometry actuator on the turbocharger up and down. The actuator lever **must** move evenly and crisply as it is moved.	Does the sliding nozzle move correctly? **YES**	2A
	Does the sliding nozzle move correctly? **NO** **Repair:** The variable geometry has mechanical damage inside the turbocharger. The actuator moves properly, but the linkage attaching the actuator to the nozzle is broken. Replace the turbocharger assembly. Refer to Procedure 010-033 in Section 10.	Repair complete



STEP 5F: Inspect wastegate actuator - wastegated turbochargers only.

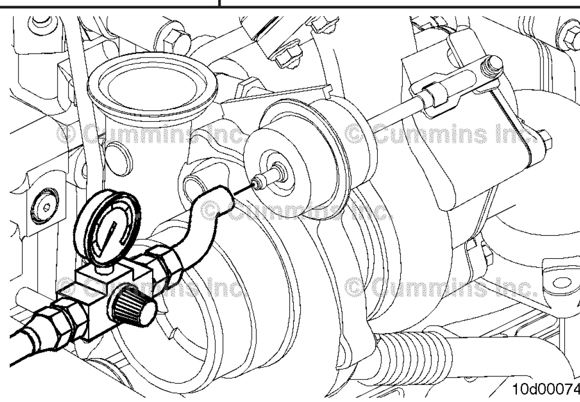
Condition:
- Turn keyswitch OFF.
- Remove the turbocharger if the wastegate actuator is inaccessible.

Action	Specification/Repair	Next Step
Inspect the integral wastegate actuator hose for cracks or holes.	Holes or cracks found in the wastegate actuator hose? **YES** **Repair:** Replace the wastegate actuator hose.	Repair complete
	Holes or cracks found in the wastegate actuator hose? **NO**	5G

STEP 5G: Inspect wastegate actuator rod for travel.

Condition:
- Turn keyswitch OFF.
- Remove the integral boost line from the wastegate actuator.

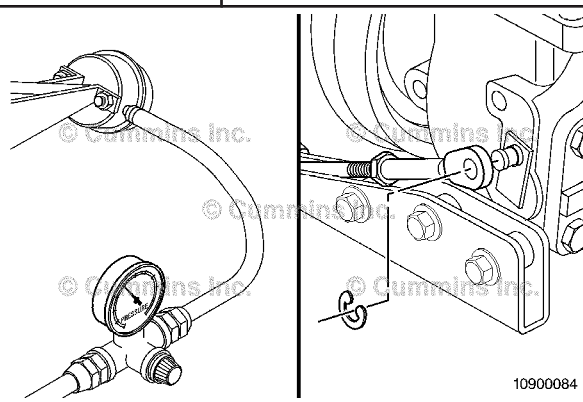
Action	Specification/Repair	Next Step
Apply a regulated air supply of 138 kPa [20 psi] to the actuator and check for actuator movement.	Does the wastegate actuator rod move? **YES**	Repair complete
	Does the wastegate actuator rod move? **NO**	5G-1



STEP 5G-1: Inspect the wastegate actuator rod for travel.

Condition:
- Turn keyswitch OFF.
- Remove the e-clip from the wastegate pin and disconnect the actuator rod.

Action	Specification/Repair	Next Step
Apply a regulated air supply of 138 kPa [20 psi] to the actuator and check for actuator movement.	Does the wastegate actuator rod move? **YES** **Repair:** Move the wastegate lever on the turbocharger back and forth, and check for smooth operation. Replace the turbocharger assembly if the wastegate is seized. Refer to Procedure 010-033 in Section 10.	Repair complete
	Does the wastegate actuator rod move? **NO** **Repair:** Replace the wastegate actuator. Refer to Procedure 010-050 in Section 10.	Repair complete



STEP 6: Electronic feature troubleshooting procedures.

STEP 6A: Verify throttle pedal travel.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to monitor Throttle Position while fully depressing and releasing the throttle pedal.	Does the throttle position read 0 percent when the throttle is released and 100 percent when the throttle is depressed? **YES**	6B
	Does the throttle position read 0 percent when the throttle is released and 100 percent when the throttle is depressed? **NO** **Repair:** Determine and correct the cause of the throttle pedal restriction.	Repair complete

STEP 6B: Check ambient air pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Start INSITE™ electronic service tool Data Monitor/Logger and compare INSITE™ electronic service tool reading for Barometric Air Pressure to the local barometric pressure. Refer to Procedure 018-028 in Section V.	The INSITE™ electronic service tool reading is within 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **YES**	6C
	The INSITE™ electronic service tool reading is within 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **NO** **Repair:** Replace the barometric pressure sensor. Use the following procedure in the Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC and ISL Engines, Bulletin 4021416. Refer to Procedure 019-004 in Section 19.	Repair Complete

STEP 6C: Check intake manifold pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to monitor the value of Intake Manifold Pressure without the engine running.	Intake manifold pressure reading is less than 102 mm-Hg [4 in -Hg]? **YES**	6D
	Intake manifold pressure reading is less than 102 mm-Hg [4 in-Hg]? **NO** **Repair:** Replace the intake manifold pressure sensor. Use the following procedure in the Troubleshooting and Repair Manual, CM850 Electronic Control System, ISC and ISL Engines, Bulletin 4021416. Refer to Procedure 019-061 in Section 19.	Repair complete

STEP 6D: Verify electronic feature settings are correct.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool; to verify the following adjustable parameters are correctly set: • Maximum Vehicle Speed • Powertrain Protection • Rear Axle Ratio • Tailshaft Teeth • Tire Revolutions per Mile • Gear-Down Protection • Cruise Control Droop Settings • Cruise Control Maximum Vehicle Speed.	Are the electronic features set correctly? **YES**	2A
	Are the electronic features set correctly? **NO** **Repair:** Use INSITE™ electronic service tool to correct programmable features.	Repair complete

STEP 7: Base engine troubleshooting procedures.

STEP 7A: Verify overhead adjustments are correct.

Condition:
- Turn keyswitch OFF.
- Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3.

Action	Specification/Repair	Next Step
Measure the overhead setting. Refer to Procedure 003-004 in Section 3.	Are the overhead settings within the reset limits? **YES**	7B
	Are the overhead settings within the reset limits? **NO** **Repair:** Adjust the overhead settings. Refer to Procedure 003-004 in Section 3.	Repair complete

STEP 7B: Verify engine brake adjustment.

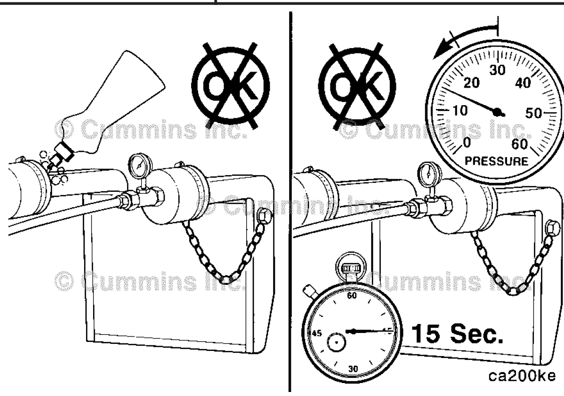
Condition:
- Turn keyswitch OFF.
- Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3.

Action	Specification/Repair	Next Step
Verify that the engine brakes are operating correctly. Measure the engine brake settings. Refer to Procedure 020-004 in Section 20.	Are the engine brake settings within the reset limits? **YES**	7C
	Are the engine brake settings within the reset limits? **NO** **Repair:** Adjust the engine brake settings. Refer to Procedure 020-004 in Section 20.	Repair complete

STEP 7C: Inspect charge-air cooler.

Condition:
- Refer to Procedure 010-027 in Section 10.

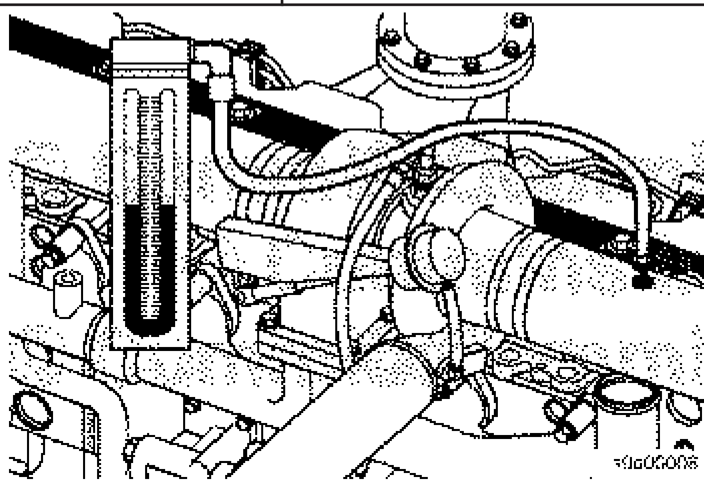
Action	Specification/Repair	Next Step
Inspect the charge-air cooler for cracks, holes, or other damage. Refer to Procedure 010-027 in Section 10.	Is the charge-air cooler free of cracks or other damage? **YES**	7D
	Is the charge-air cooler free of cracks or other damage? **NO** **Repair:** Repair the charge-air cooler assembly.	Repair complete



STEP 7D: Check air intake restriction.

Condition:
- Refer to Procedure 010-031 in Section 10.

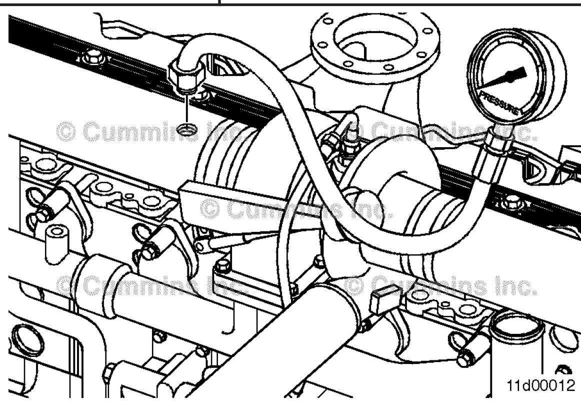
Action	Specification/Repair	Next Step
Check the intake system restriction by installing a vacuum gauge into the air intake system. Refer to Procedure 010-031 in Section 10.	Is air intake restriction greater than 635 mm-H_2O [25 in-H_2O]? **YES** **Repair:** Correct the cause of high intake air restriction. Check for plugged air filter or restricted air intake piping.	Repair complete
	Is air intake restriction greater than 635 mm-H_2O [25 in-H_2O]? **NO**	7E



STEP 7E: Check exhaust restriction.

Condition:
- Refer to Procedure 011-009 in Section 11.

Action	Specification/Repair	Next Step
Check the exhaust system back pressure by installing a pressure gauge into the exhaust system just past the turbocharger outlet. Refer to Procedure 011-009 in Section 11.	Is exhaust back pressure less than 40 in-H_2O [3 in-Hg]? **YES**	7F
	Is exhaust back pressure less than 40 in-H_2O [3 in-Hg]? **NO** **Repair:** Inspect exhaust system for source of high restriction.	Repair complete



STEP 7F: Check engine blowby.

Condition:
- Refer to Procedure 014-005 in Section 14.

Action	Specification/Repair	Next Step
Measure the engine blowby as outlined in Procedure 014-005.	Are the engine blowby measurements within specification? **YES**	Return to Step 2 or contact a Cummins® Authorized Repair Location for further diagnostic and troubleshooting instructions.
	Are the engine blowby measurements within specification? **NO**	Go to step 7F-1.

STEP 7F-1: Verify turbocharger contribution to engine blowby.

Condition:

- Turn keyswitch OFF.
- Connect the appropriate orifice to the end of the blowby draft tube.
- Remove the turbocharger oil drain line from the block and drain into a bucket.
- Start the engine.

Action	Specification/Repair	Next Step
Load engine to rated rpm on a chassis dynamometer. Measure the engine blowby as outlined in Procedure 014-005 Section 14.	Has the total engine blowby dropped more than 30 percent of the total? **YES** **Repair:** Replace the turbocharger assembly. Refer to Procedure 010-033 in Section 10.	Repair complete
	Has the total engine blowby dropped more than 30 percent of the total? **NO** **Repair:** The engine might need to be rebuilt. See the engine rebuild specifications.	Repair Complete

Engine Performance Troubleshooting Tree - ISB, ISBe, and QSB engines without EGR (CM800 and CM850 Electronic Control System)

This troubleshooting procedure should be followed for the following symptoms:

- Engine Acceleration or Response Poor
- Engine Difficult to Start or Will **Not** Start (Exhaust Smoke)
- Engine Difficult to Start or Will **Not** Start (No Exhaust Smoke)
- Engine Power Output Low
- Engine Runs Rough at Idle
- Engine Runs Rough or Misfires
- Engine Speed Surges at Low or High Idle
- Engine Speed Surges Under Load or in Operating Range
- Smoke, Black - Excessive
- Smoke, White - Excessive
- Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration
- Engine Decelerates Slowly
- Engine Starts but Will **Not** Keep Running
- Engine Will **Not** Reach Rated Speed (RPM)
- Intake Manifold Pressure (Boost) is Below Normal
- Engine Vibration Excessive

How to Use This Troubleshooting Procedure:

This symptom tree can be used to troubleshoot all performance-based symptoms listed above. Start by performing Step 1 troubleshooting. Step 2 will ask a series of questions and will provide a list of troubleshooting steps to perform, depending on the symptom.

Many steps will reference using INSITE™ electronic service tool to check for fault codes, perform tests, monitor data, and check features and parameters. It is recommended that INSITE™ electronic service tool remain connected while using this troubleshooting tree, to periodically check for fault codes. If any fault codes become active during use of the troubleshooting tree, discontinue using this troubleshooting tree and troubleshoot the active fault code.

This symptom tree often references other procedures and symptom trees. The procedures and symptom trees referenced may **not** be located in the same service literature as this symptom tree. Use the following procedure for a listing of the service literature available for the engine being serviced. Refer to Procedure 205-001 in Section L.

Shop Talk:

Driveability is a term that in general describes vehicle performance on the road. Driveability problems for an engine can be caused by several different factors. Some of the factors are engine-related and some are **not**. Before troubleshooting, it is important to determine the exact complaint and whether the engine has a real driveability problem or if it simply does **not** meet driver expectations.

Low power is a term that is used in the field to describe many different performance problems. Low power is defined as the inability of the engine to produce the power necessary to move the vehicle at a speed that can be reasonably expected under the given conditions of load, grade, wind, and so on. With industrial equipment, low power might relate to the inability of the equipment to pick up or maintain load.

Poor acceleration or response is described as the inability of the vehicle to accelerate satisfactorily from a stop or from the bottom of a grade. It can also be the lag in acceleration during an attempt to pass or overtake another vehicle at conditions less than rated speed and load. Poor acceleration or response is difficult to troubleshoot, since it can be caused by several factors.

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Perform basic troubleshooting procedures.**		
STEP 1A:	Check for active fault codes or high counts of inactive fault codes.	Active fault codes or high counts of inactive fault codes?	
STEP 1B:	Perform basic troubleshooting checks.	All steps have been verified to be correct?	
STEP 2:	**Determination of engine symptom.**		
STEP 2A:	Engine Difficult to Start or Will Not Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration, or Engine Starts but Will Not Keep Running.	Is the engine symptom Engine Difficult to Start or Will Not Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration, or Engine Starts but Will Not Keep Running?	
STEP 2B:	Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range.	Is the engine symptom Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range?	
STEP 2C:	Smoke, Black - Excessive.	Is the engine symptom Smoke, Black - Excessive?	
STEP 2D:	Smoke, White - Excessive.	Is the engine symptom Smoke, White - Excessive?	
STEP 2D-1:	Smoke, White - Excessive.	Is the engine using coolant?	
STEP 2D-2:	Smoke, White - Excessive.	Is the white smoke excessive complaint only occurring when the engine is cold and during cold ambient conditions?	
STEP 2E:	Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will Not Reach Rated Speed (RPM).	Is the engine symptom - Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will Not Reach Rated Speed (RPM)?	
STEP 2F:	Engine vibration is excessive.	Is the engine symptom - Engine Vibration Excessive?	
STEP 3:	**Engine will not start or stalls troubleshooting procedures.**		
STEP 3A:	Verify the operation of cold weather starting aids.	Are the necessary cold weather starting aids being used and are they operational as required?	
STEP 3B:	Check electronic features and programmable parameters.	Are electronic features and programmable parameters the cause for the engine shutting down or the no-start complaint?	
STEP 3C:	Monitor the engine speed during cranking.	Is the engine speed greater than 150 rpm during cranking?	

STEP 3D:	Monitor the ECM keyswitch input.	Does the User Fueling State indicate cranking or is keyswitch voltage equal to battery voltage?
STEP 3E:	Monitor the ECM battery supply.	Is the ECM battery supply voltage greater than +11-VDC for 12 volt systems or +22-VDC for 24 volt systems?
STEP 3F:	Check the load carrying capabilities of the ECM power and ground circuits.	Do the headlights illuminate brightly?
STEP 3G:	Check orientation of connector.	Is the rail fuel pressure sensor connector installed correctly?
STEP 3H:	Verify rail fuel pressure sensor accuracy.	Is the Fuel Rail Pressure (measured) less than 30 bar [435 psi]?
STEP 3I:	Monitor fuel rail pressure while cranking the engine.	Did the Fuel Rail Pressure (measured) equal the Fuel Rail Pressure (commanded)?

STEP 4: Fuel system troubleshooting procedures.

STEP 4A:	Check for air in the fuel supply line.	Is air present in the fuel supply?
STEP 4B:	Check for air in the high pressure pump fuel supply.	Is the pressure measured within specification?
STEP 4B-1:	Measure the fuel inlet restriction.	Is the pressure measured within specification?
STEP 4C:	Measure fuel pressure at the outlet of the on engine fuel filter.	Is the pressure drop across the filter greater than the specification?
STEP 4D:	Perform INSITE™ electronic service tool single cylinder cutout test.	Can the miss or excessive smoke be attributed to a single cylinder?
STEP 4E:	Perform a manual single cylinder cut-out test.	Did the engine start after blocking off a cylinder(s) or can the miss or excessive smoke be attributed to a cylinder(s)?
STEP 4F:	Measure the injector return fuel drain flow from the cylinder head.	Is injector fuel drain flow from the cylinder head greater than specification?
STEP 4G:	Determine which cylinder(s) is causing excessive injector fuel drain flow from the cylinder head.	Did blocking off a cylinder(s) decrease the flow rate below the maximum specified flow rate?
STEP 4H:	Monitor Commanded Fuel Rail Pressure and Measured Fuel Rail Pressure.	Does the Measured Fuel Rail Pressure vary more than ± 35 bar [± 500 psi] from the Commanded Fuel Rail Pressure?
STEP 4I:	Check the fuel pressure relief valve for excessive leakage.	Is the fuel pressure relief valve within specification?
STEP 4J:	Measure the high-pressure fuel supply pump fuel drain flow.	Is the high pressure fuel supply pump fuel return flow greater than specification?
STEP 4K:	Measure fuel drain line restriction.	Is the drain line restriction less than specification?

STEP 5: Air handling troubleshooting procedures.

STEP 5A:	Check intake manifold pressure sensor accuracy.	Intake manifold pressure reading is less than 102 mm-Hg [4 in-Hg]?
STEP 5B:	Check the air intake system for leaks.	Were any air intake system leaks found?
STEP 5C:	Check air intake restriction.	Is the air intake restriction greater than the specification?
STEP 5D:	Inspect the turbocharger compressor blades for damage.	Damage found on turbocharger blades?
STEP 5E:	Determine if the turbocharger is a wastegated turbocharger.	Is the turbocharger a wastegated turbocharger?
STEP 5F:	Inspect the wastegate actuator hose.	Holes or cracks found in the wastegate actuator hose?
STEP 5G:	Inspect the turbocharger wastegate capsule for air leaks.	Did the wastegate actuator capsule leak air?
STEP 5G-1:	Inspect the turbocharger wastegate for proper operation.	Did the wastegate actuator rod move?
STEP 5G-2:	Inspect the turbocharger wastegate for proper operation.	Does the wastegate actuator rod move?
STEP 5H:	Measure turbocharger axial and radial clearance.	Are the axial and radial clearances within specification?
STEP 5I:	Inspect the charge-air cooler.	Does the charge-air cooler pass the visual inspection as well as the pressure test and temperature differential test?

STEP 6: Verify electronic features are operating correctly.

STEP 6A:	Verify accelerator (throttle) pedal travel.	Does the accelerator (throttle) position read 0 percent when the accelerator (throttle) is fully released and 100 percent when the accelerator (throttle) is fully depressed?
STEP 6B:	Monitor the vehicle speed.	Does the vehicle speed read zero when the vehicle is not moving?
STEP 6C:	Verify electronic feature settings are correct.	Are electronic features set correctly?
STEP 6D:	Check temperature sensor accuracy.	Are all temperature readings within 5.6°C or 10°F of each other?
STEP 6E:	Check ambient air pressure sensor accuracy.	INSITE™ electronic service tool reading is within 50.8 mm-Hg [2 in-Hg] of local barometric pressure?

STEP 7: Perform base engine mechanical checks.

STEP 7A:	Verify overhead adjustments are correct.	Are the overhead settings within the lash check limits?

STEP 7B:	Check exhaust restriction.	Is the exhaust back pressure greater than the specification?
STEP 7C:	Verify engine crankcase pressure (blowby) is within specification.	Is the engine crankcase pressure (blowby) less than specification?
STEP 7D:	Check for internal engine damage.	Did cutting the oil filter open reveal evidence of internal engine damage?

STEP 8: Excessive vibration checks.

STEP 8A:	Check engine idle speed.	Is the engine idle speed within specification?
STEP 8B:	Check if the feature Fast Idle Warm Up is available and enabled.	Is the feature Fast Idle Warm Up available and enabled?
STEP 8B-1:	Monitor if the Fast Idle Warm Up Status.	Is the feature Fast Idle Warm Up becoming active?
STEP 8C:	Check front engine driven accessory(s).	Did isolating the front engine driven accessory(s) correct the vibration?
STEP 8D:	Check the vibration damper/ crankshaft speed indicator ring.	Is the vibration damper/ crankshaft speed indicator ring damaged?
STEP 8E:	Check the engine support brackets, mounts, and/or isolators.	Are the engine support brackets, mounts, and/or isolators or damaged?
STEP 8F:	Check engine gear driven accessory(s).	Does the engine have an engine gear driven/air compressor driven hydraulic pump?
STEP 8F-1:	Isolate engine gear driven accessory(s).	Did isolating/removing engine gear driven/air compressor driven hydraulic pump correct the vibration?
STEP 8F-2:	Check if the engine is equipped with an air compressor.	Is the engine equipped with an engine gear driven air compressor?
STEP 8F-3:	Unload the air compressor and operate.	Did unloading the air compressor significantly reduce or eliminate the vibration?
STEP 8F-4:	Check air compressor timing.	Was the air compressor correctly timed to the engine?
STEP 8G:	Check/isolate engine driven components.	Did isolating/removing any engine driven component correct the vibration?
STEP 8H:	Check the flywheel housing alignment.	Is the flywheel housing bore and face runout within specification?
STEP 8I:	Check if engine is equipped with an internal engine balancer.	Is the engine equipped with an internal engine balancer?
STEP 8I-1:	Check the internal engine balancer.	Is the internal engine balancer timing incorrect or is the balancer damaged?

TROUBLESHOOTING STEP

STEP 1: Perform basic troubleshooting procedures.

STEP 1A: Check for active fault codes or high counts of inactive fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for any active fault code. • Use INSITE™ electronic service tool to read the fault codes. • See the corresponding Electronic Control System Troubleshooting and Repair Manual for the engine being serviced. • For engines equipped with a CM800 Electronic Control Module, refer to Bulletin 3666477. • For engines equipped with a CM850 Electronic Control Module, refer to Bulletin 4021416.	Active fault codes or high counts of inactive fault codes? **YES** **Repair:** Follow the electronic fault code trees for the appropriate troubleshooting procedures.	Repair complete
	Active fault codes or high counts of inactive fault codes? **NO**	1B

STEP 1B: Perform basic troubleshooting checks.

Condition:

N/A

Action	Specification/Repair	Next Step
The following items must be checked or verified before continuing: • Verify the fuel level in the tanks. • Verify the vehicle is in good working order • Check if any recent maintenance or service work has been performed • Verify there have **not** been any changes to CPL components on the engine. • Verify fuel grade is correct for the application. • Verify the engine is operating within the recommended altitude. • Verify the engine oil is in good condition and at the correct level. • Verify the engine parasitics have **not** changed. • Verify the engine duty cycle has **not** changed. • Verify the air filter is **not** excessively plugged by checking filter minder. • Listen for air and exhaust leaks. • Verify there are no visible external fuel leaks. • Verify there are no visible coolant leaks. • Verify the crankshaft position and the camshaft position sensors are correctly connected to the engine harness.	All steps have been verified to be correct? **YES**	2A
	All steps have been verified to be correct? **NO** **Repair:** Correct the step and verify complaint is no longer present after repair.	Repair complete

STEP 2: Determination of engine symptom.

STEP 2A: Engine Difficult to Start or Will Not Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration, or Engine Starts but Will Not Keep Running

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Engine Difficult to Start or Will **Not** Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration, or Engine Starts but Will **Not** Keep Running? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 3 - Engine will **Not** Start or Stalls Troubleshooting Procedures Step 4 - Fuel System Checks Step 5 - Air Handling Checks Step 6 - Electronics Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Engine Difficult to Start or Will **Not** Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration, or Engine Starts but Will **Not** Keep Running? **NO**	2B

STEP 2B: Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range.

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 4 - Fuel System Checks Step 6 - Electronic Checks Step 5 - Air Handling Checks Step 7 - Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range? **NO**	2C

STEP 2C: Smoke, Black - Excessive.

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Smoke, Black - Excessive? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 5 - Air Handling Checks Step 4 - Fuel System Checks Step 6 - Electronics Checks Step 7 - Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Excessive White Smoke and is the engine using coolant? **NO**	2D

STEP 2D: Smoke, White - Excessive

Condition: N/A		
Action	**Specification/Repair**	**Next Step**
Interview the driver and verify the complaint. N/A	Is the engine symptom Smoke, White - Excessive? **YES**	2D-1
	Is the engine symptom Smoke, White - Excessive? **NO**	2E

STEP 2D-1: Smoke, White - Excessive

Condition: N/A		
Action	**Specification/Repair**	**Next Step**
Interview the driver and verify the complaint. Verify if, along with the white smoke complaint, coolant is being used. Check the coolant level.	Is the engine using coolant? **YES**	See the Coolant Loss - Internal Troubleshooting Symptom (TS) Tree.
	Is the engine using coolant? **NO**	2D-2

STEP 2D-2: Smoke, White - Excessive

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. Check if the white smoke excessive complaint is only occurring when the engine is cold and during cold ambient conditions? Some white smoke after a cold start in cold ambient conditions is **not** uncommon. If white smoke persists once the engine has reached the minimum operating coolant temperature, troubleshoot the white smoke complaint. Minimum Operating Coolant Temperature: 60°C [140°F].	Is the white smoke excessive complaint only occurring when the engine is cold and during cold ambient conditions? **YES** **Repair:** Perform the checks in Step 3A only. Step 4 - Fuel System Checks. Step 6 - Electronics Checks.	Perform the troubleshooting steps suggested in the repair procedure.
	Is the white smoke excessive complaint only occurring when the engine is cold and during cold ambient conditions? **NO** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 4 - Fuel System Checks Step 7 - Perform Base Engine Mechanical Checks.	N/A

STEP 2E : Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will Not Reach Rated Speed (RPM).

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will **Not** Reach Rated Speed (RPM)? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 5 - Air Handling Checks Step 4 - Fuel Systems Checks Step 6 - Electronic Checks Step 7 - Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will **Not** Reach Rated Speed (RPM)? **NO**	2F

STEP 2F : Engine Vibration - Excessive

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Engine Vibration Excessive? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Perform Step 4E of the Fuel System Checks Step 8 - Excessive Vibration Checks Step 7 - Base Engine Checks Is the engine symptom Engine Vibration Excessive?	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Engine Vibration Excessive? **NO**	For engine related symptoms, see the correct troubleshooting symptom (TS) tree.

STEP 3: Engine will Not Start or Stalls Troubleshooting Procedures

STEP 3A: Verify the operation of cold weather aids.

Condition:
- Engine and Ambient Conditions Cold
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Make sure that necessary cold weather starting aids are operational as required: Minimum Ambient Air Temperature for Unaided Cold Start is minus 12.2°C [10°F]. INSITE™ electronic service tool Intake Air Heater Override test can be used to diagnose intake air heater problems. For engines equipped with air intake heaters, the air intake heaters should begin to function at 19°C [66°F].	Are the necessary cold weather starting aids being used and are they operational as required? **YES**	3B
	Are the necessary cold weather starting aids being used and are they operational as required? **NO** **Repair:** Install or repair cold weather starting aids. Use the following procedures in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System), Bulletin 4021271.Refer to Procedure 008-011 in Section 8. Refer to Procedure 007-001 in Section 7. For any OEM installed cold starting aids (radiator shutters, etc.), refer to the OEM service manual.	Repair complete

STEP 3B: Check electronic features and programmable parameters.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check if the electronic features and programmable parameters are the cause for the engine shutting down or the no-start complaint. The electronic features and programmable parameters include: Idle Shutdown, Engine Protection Shutdown, and Vehicle Anti-theft Protection.	Are electronic features and programmable parameters the cause for the engine shutting down or the no-start complaint? **YES** **Repair:** Program the electronic features per the customer or OEM requirements.	Repair Complete
	Are electronic features and programmable parameters the cause for the engine shutting down or the no-start complaint? **NO**	3C

STEP 3C: Monitor the engine speed during cranking.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- INSITE Monitor

Action	Specification/Repair	Next Step
Monitor the engine speed during cranking. Use INSITE™ electronic service tool. Attempt to start the engine; engage the engine starter for at least 30 continuous seconds. Do **not** overheat the starter. Attempting to start the engine for 30 continuous seconds also allows the fault code logic time to run. If any fault codes become active, stop using this troubleshooting tree and reference the corresponding fault code troubleshooting tree.	Is the engine speed greater than 150 rpm during cranking? **YES** **Repair:** N/A	3D
	Is the engine speed greater than 150 rpm during cranking? **NO** **Repair:** Find and correct the cause for low cranking speed. Consider the batteries, engine starting motor, drive units, and accessory loads.	See the Engine Will **not** Crank or Cranks Slowly (Electric or Air Starter) troubleshooting symptom (TS) tree.

STEP 3D: Monitor the ECM Keyswitch Input.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine **not** operating

Action	Specification/Repair	Next Step
Monitor User Fueling State and key switch while cranking the engine. Use INSITE™ electronic service tool. If the engine is intermittently shutting down, User Fueling State can also be monitored during engine shut down. If INSITE™ electronic service tool is **not** available: Disconnect the OEM harness from the ECM. Turn keyswitch ON. Measure the signal voltage from the keyswitch input signal wire of the OEM harness to the engine block ground. Measure the keyswitch voltage with the keyswitch in the ON position and also with the keyswitch in the cranking position. Consult the corresponding wiring diagram for the engine being serviced for connector pin identification.	Does the User Fueling State indicate cranking or is keyswitch voltage equal to battery voltage? **YES**	3E
	Does the User Fueling State indicate Cranking or is keyswitch voltage equal to battery voltage? **NO** **Repair:** Check the keyswitch battery supply circuit. Use the following procedure in the Electronic Control System Troubleshooting and Repair manual. Refer to Procedure 019-064 in Section 19. Repair or replace the OEM harness or keyswitch, or check the battery connections. Refer to the OEM service manual for the proper procedures.	Repair Complete

STEP 3E: Monitor the ECM Battery Supply.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine **not** operating

Action	Specification/Repair	Next Step
Monitor Battery Voltage while cranking the engine. Use INSITE™ electronic service tool. If INSITE™ electronic service tool is **not** available: • Disconnect the ECM power supply connection. • Turn keyswitch ON. Measure the voltage from the ECM battery SUPPLY (-) pin(s) to the ECM battery SUPPLY (+) pin(s) in the ECM connector. Measure the ECM voltage with the keyswitch in the ON position and also with the keyswitch in the cranking position. See to the corresponding wiring diagram for the engine being serviced for connector pin identification.	Is the ECM battery supply voltage greater than +11-VDC for 12 volt systems or +22-VDC for 24 volt systems? **YES**	3F
	Is the ECM battery supply voltage greater than +11-VDC for 12 volt systems or +22-VDC for 24 volt systems? **NO** **Repair:** Repair or replace the ECM power and ground connections. Check the battery connections and fuse terminals.	Repair complete

STEP 3F: Check the load carrying capabilities of the ECM power and ground circuits.

Condition:
- Turn keyswitch OFF.
- Disconnect the ECM power supply connector from the ECM.

Action	Specification/Repair	Next Step
Connect a headlight (12 volt or 24 volt systems). A headlight **must** be used to make sure that the wattage rating will put enough of a load on the circuit. Use the ECM battery SUPPLY (+) pin in the ECM power supply connection for the battery positive (+) and the ECM battery SUPPLY (-) pin in the ECM power harness connector for the battery negative (-). Consult the corresponding wiring diagram for the engine being serviced for connector pin identification.	Do the headlights illuminate brightly? **YES**	3G
	Do the headlights illuminate brightly? **NO** **Repair:** Repair or replace the ECM power and ground connections. Check the battery connections and fuse terminals.	Repair complete

STEP 3G: Check orientation of connector.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for the appropriate orientation of the rail fuel pressure sensor connector. Connector can be incorrectly installed, rotated 180 degrees.	Is the rail fuel pressure sensor connector installed correctly? **YES**	3H
	Is the rail fuel pressure sensor connector installed correctly? **NO** **Repair:** Reorient connector.	Repair complete

STEP 3H: Verify rail fuel pressure sensor accuracy.

Condition:
- Turn keyswitch ON
- Connect INSITE™ electronic service tool
- INSITE™ Monitor
- Engine **not** operating.

Action	Specification/Repair	Next Step
Monitor the fuel rail pressure. Use INSITE™ electronic service tool to measure the fuel rail pressure.	Is the Fuel Rail Pressure (measured) less than 30 bar (435 psi)? **YES**	3I
	Is the Fuel Rail Pressure (measured) less than 30 bar (435 psi)? **NO** **Repair:** Replace the rail fuel pressure sensor. Use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-115 in Section 19. Use the following procedure in the ISB, ISBe2, ISBe3, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 CM850 Electronic Control System Troubleshooting and Repair Manual, Bulletin 4021416. Refer to Procedure 019-115 in Section 19.	Repair Complete

STEP 3I: Monitor fuel rail pressure while cranking the engine.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool
- INSITE™ Monitor.

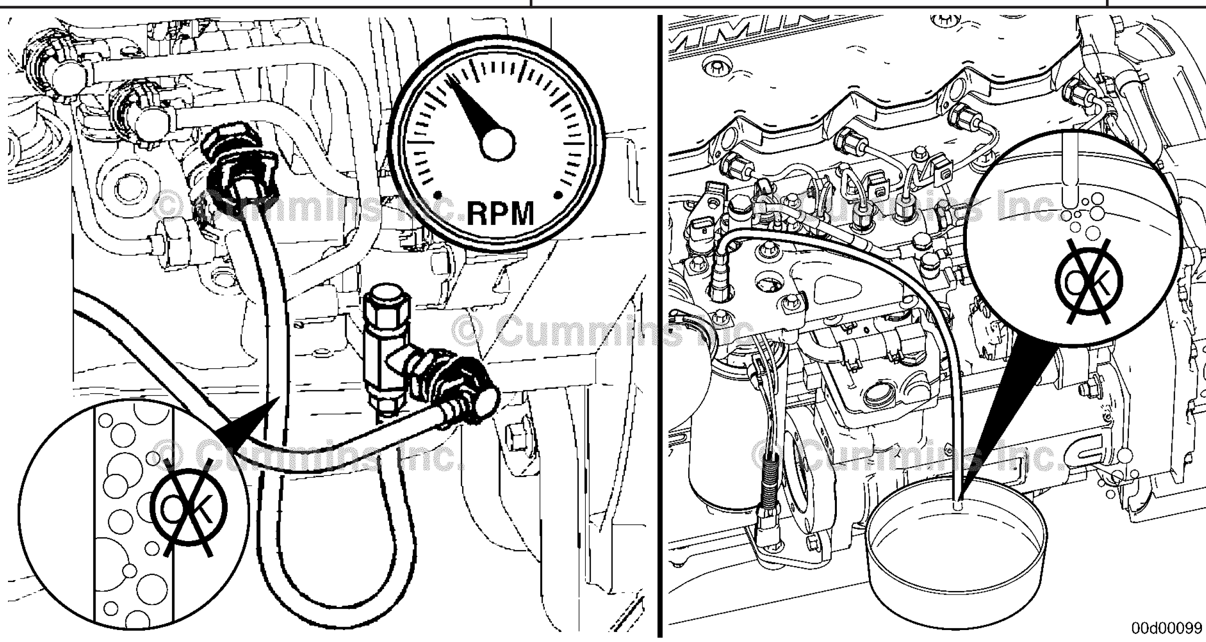
Action	Specification/Repair	Next Step
Monitor Fuel Rail Pressure (measured) and Fuel Rail Pressure (commanded). Use INSITE™ electronic service tool. Fuel Rail Pressure (commanded) can also be referred to as HPCR fuel setpoint. Attempt to start the engine, engage the engine starter for at least 30 continuous seconds. Do **not** overheat the starter. A minimum of 100 bar [1450 psi] of fuel rail pressure is required before the injectors will open and provide fuel. Attempting to start the engine for 30 continuos seconds allows the fault code logic time to perform. If Fault Code 2215 or 559 becomes active, adequate fuel rail pressure is **not** being developed. Discontinue using this troubleshooting tree and troubleshoot Fault Code 2215 or 559.	Did the Fuel Rail Pressure (measured) equal the Fuel Rail Pressure (commanded)? **YES**	5A
	Did the Fuel Rail Pressure (measured) equal the Fuel Rail Pressure (commanded)? **NO**	4A

STEP 4: Fuel system troubleshooting procedures.

STEP 4A: Check for air in the fuel supply line.

Condition:
- Turn keyswitch OFF.
- Engine OFF.
- Connect required service tools at the gear pump inlet.

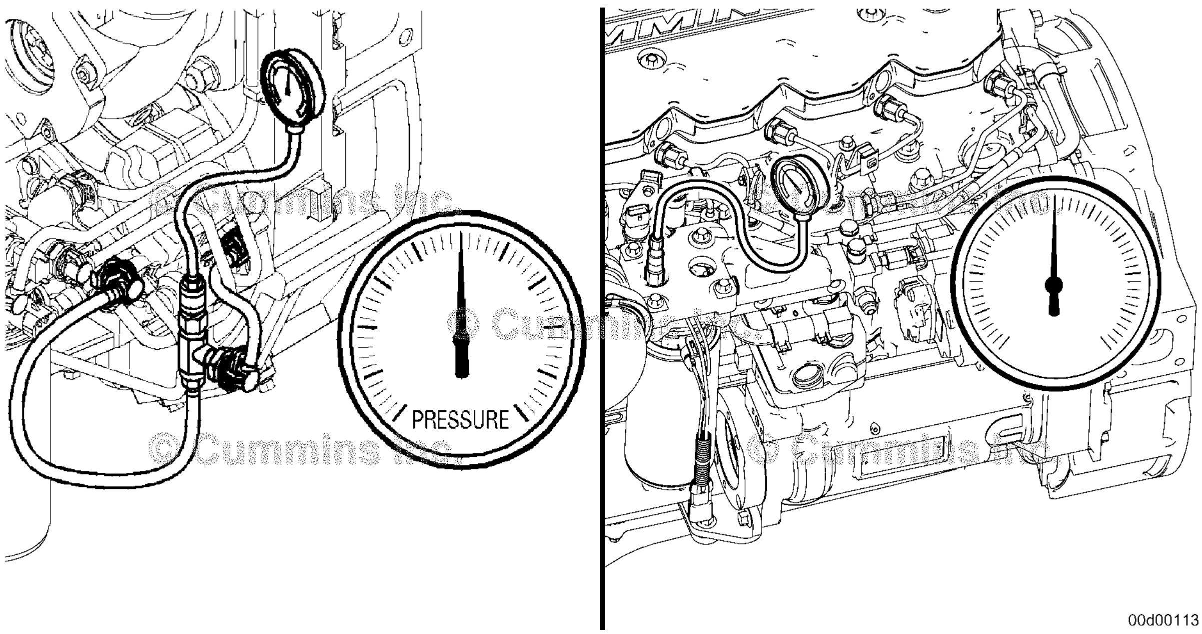
Action	Specification/Repair	Next Step
Check for air in the fuel Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-003 in Section 6. Operate the engine at idle and check for air bubbles. If the engine will **not** start, check while cranking the engine. Do **not** overheat the starter.	Is air present in the fuel supply? **YES** **Repair:** Locate and correct the cause of air ingestion in the fuel supply system. Sources of air ingestion include loose fuel filters, loose fuel line fittings, loose or cracked fuel tank stand-pipes, or severe restrictions in the fuel supply lines and filters that cause cavitation at high fuel flow rates.	Repair complete
	Is air present in the fuel supply? **NO**	4B



STEP 4B: Measure fuel pressure at the inlet of the on engine fuel filter.

Condition:
- Turn keyswitch OFF.
- Engine OFF.
- Connect required service tools at the inlet to the fuel filter, or if equipped, the fuel filter head diagnostic port (inlet).

Action	Specification/Repair	Next Step
Check for air in the fuel Use the following procedure in Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271.Refer to Procedure 006-015 in Section 6. Measure the fuel pressure at low idle: • Fuel pressure range: 5 to 13 bar [73 to 189 psi]. If the engine will **not** start, measure the fuel pressure during engine cranking • Fuel pressure range: 3 to 11 bar [44 to 160 psi]. Record the fuel filter inlet pressure measured.	Is the pressure measured within specification? Record the measured fuel inlet pressure for use in the next step. **YES**	4C
	Is the pressure measured within specification? **NO**	4B-1



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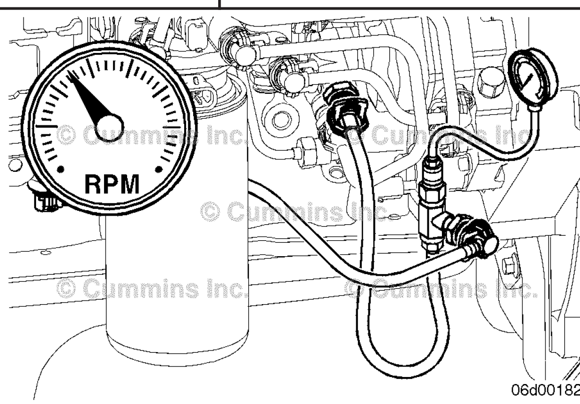
STEP 4B-1: Measure the fuel inlet restriction.

Condition:

- Turn keyswitch OFF.
- Engine OFF.
- Connect required service tools at the gear pump inlet.

Action	Specification/Repair	Next Step
Measure the fuel inlet restriction. Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Operate the engine at high idle: Maximum inlet restriction - 50.8 kPa [15 in-Hg] (vacuum) If the engine will **not** start, measure fuel restriction while the engine is cranking. Do **not** overheat the starter. If the issue is intermittent (no start or engine shuts off unexpectedly) and no issues can be found while the engine is being serviced, there can be debris in the fuel system causing an intermittent restriction. Install a fuel filter minder, Fleetguard® Part Number 3892576, at the connection between the OEM fuel supply lines and the engine. A fuel filter minder will capture the peak restriction in millimeters and inches of mercury. If the issue occurs again, the fuel filter minder can be checked to see if there is something on the OEM side causing an intermittent high restriction.	Is the fuel inlet restriction greater than the specification? **YES** **Repair:** Find and correct cause of high inlet restriction. Look for plugged OEM fuel filters or screens, or a restricted ECM cooler, pinched OEM fuel lines, or restricted stand pipe in the OEM fuel tank.	Repair Complete
	Is the fuel inlet restriction greater than the specification? **NO** **Repair:** Replace the high pressure fuel pump. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-016 in Section 5.	Repair Complete



STEP 4C: Measure fuel pressure at the outlet of the on engine fuel filter.

Condition:
- Turn keyswitch OFF.
- Engine OFF.
- Connect required service tools at the outlet of the fuel filter, or if equipped, the fuel filter head diagnostic port (outlet).

Action	Specification/Repair	Next Step
Measure fuel pressure at the outlet of the fuel filter. Use the following procedure in Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271.Refer to Procedure 006-015 in Section 6. Calculate the pressure drop across the fuel filter by subtracting the pressure measured here from the pressure from Step 4B. Measure the fuel pressure at high idle: • Maximum pressure drop across the fuel filter - 2 bar [29 psi]. If the engine will **not** start, measure the fuel pressure during engine cranking	Is the pressure drop across the filter greater than the specification? **YES** **Repair:** Replace the fuel filter. Use the following procedure in Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271.Refer to Procedure 006-015 in Section 6.	Repair Complete
	Is the pressure drop across the filter greater than the specification? **NO**	4D

STEP 4D: Perform INSITE electronic service tool single cylinder cutout test.

Condition:
- Turn keyswitch ON.
- Engine operating at low idle.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
If the engine will not start or is difficult to start, move to the next step. • In the ECM Diagnostic Tests menu of INSITE™ electronic service tool, click on the Cylinder Cutout Test, and follow the instructions on the screen. • Operate the engine under the conditions in which the complaint occurs. • Use INSITE™ electronic service tool to perform the Cylinder Cutout Test to disable individual injectors. If this test is performed and there is **not** a significant change while cutting out one injector, there can be a problem with more than one injector. It may be necessary to cut out multiple cylinders at a time.	Can the miss or excessive smoke be attributed to a single cylinder? **YES** **Repair:** Look for a cause of the complaint, including valve lash and excessive crankcase pressure that may indicate power cylinder damage or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder that was identified using the single cylinder cutout test. Use the following procedure in Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 006-026 in Section 6	Repair Complete
	Can the miss or excessive smoke be attributed to a single cylinder? **NO**	4E

STEP 4E: Perform a manual single cylinder cut-out test.

<table>
<tr><td colspan="3">Condition:
• Turn keyswitch OFF.
• Install the injector leakage isolation tool.
• Turn keyswitch ON.</td></tr>
<tr><th>Action</th><th>Specification/Repair</th><th>Next Step</th></tr>
<tr><td rowspan="2">Perform a manual cut-out test.
• With the engine not operating, disconnect the fuel line routed from the fuel rail to cylinder number 1. Use the following procedure in Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 006-051 in Section 6.
• Install the injector leakage isolation tool

For 3.9L and 5.9L engines, install the injector leakage isolation tool, Part Number 3164325, on the rail where the number 1 cylinder fuel line connects.

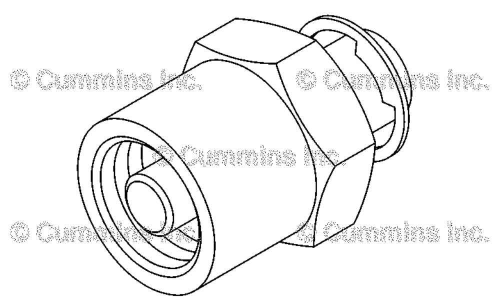
Torque Value: 30 N•m [22 ft-lb]

For 4.5L and 6.7L engines, install the leakage isolation tool, Part Number 4918298, on the rail where the number 1 cylinder fuel line connects.

Torque Value: 35 N•m [26 ft-lb]

Attempt to start the engine or operate the engine at idle.

Repeat the above test, as necessary, with each cylinder blocked off.</td><td>Did the engine start after blocking off a cylinder(s) or can the miss or excessive smoke be attributed to a cylinder(s)?
YES
Repair:
Look for a cause of the complaint, including valve lash and excessive crankcase pressure that can indicate power cylinder damage or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder that was identified using the manual single cylinder cut-out test. Use the following procedure in Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271.Refer to Procedure 006-026 in Section 6</td><td>Repair Complete</td></tr>
<tr><td>Did the engine start after blocking off a cylinder(s) or can the miss or excessive smoke be attributed to a cylinder(s)?
NO</td><td>4F</td></tr>
</table>



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STEP 4F: Measure the injector return fuel drain flow from the cylinder head.

Condition:
- Turn keyswitch OFF.
- Connect appropriate service tools to measure injector fuel drain flow from the cylinder head.

Action	Specification/Repair	Next Step
Measure the injector return fuel drain flow from the cylinder head. Use the following procedure in the ISBe, ISB, and QSB Service Manual, Bulletin 4021271. Refer to Procedure 006-026 in Section 6. Flow Specification: Idle Conditions 4 cylinder engines - 120 ml/minute [4 fl-oz per minute] maximum 6 cylinder engines - 180 ml/minute [6 fl-oz per minute] maximum Cranking Conditions Make sure **not** to overheat the starter. 4 and 6 cylinder engines - 90 ml/minute [3 fl-oz per minute] maximum.	Is injector fuel drain flow from the cylinder head greater than specification? **YES**	4G-1
	Is injector fuel drain flow from the cylinder head greater than specification? **NO**	4H

STEP 4G: Determine which cylinder(s) is causing excessive injector fuel drain flow from the cylinder head.

Condition:
- Turn keyswitch OFF.
- Connect appropriate service tools to measure injector fuel drain flow from the cylinder head.
- Install the injector leakage isolation tool.

Action	Specification/Repair	Next Step
Measure the injector return fuel drain flow from the cylinder head and isolate a cylinder one at a time using the injector leakage isolation tool. Use the following procedure in the ISBe, ISB, and QSB Service Manual, Bulletin 4021271. Refer to Procedure 006-026 in Section 6. The flow rate will decrease below the maximum specified flow when the cylinder with the leak is blocked. If this test is performed and there is **not** a significant change in fuel return flow while cutting out one injector, there can be a problem with more than one injector. Compare the fuel flow difference across all injectors. Is there more than one injector that caused a noticeable decrease in fuel flow? If so, these could be the injectors with the problems. Another cause of this problem could be that the customer is operating on fuels lighter than specified. Fuels with low viscosity will result in higher injector leakage and greater drain flow rates.	Did blocking off a cylinder(s) decrease the flow rate below the maximum specified flow rate? **YES** **Repair:** Remove the fuel connector and inspect for damage. Replace if necessary. Remove the injector and inspect the fuel connector contact surface for damage. Replace if necessary. Use the following procedures in the ISBe, ISB, and QSB Service Manual, Bulletin 4021271. Refer to Procedure 006-052 in Section 6. Refer to Procedure 006-026 in Section 6.	Repair Complete
	Did blocking off a cylinder(s) decrease the flow rate below the maximum specified flow rate? **NO**	4H

STEP 4H: Monitor Commanded Fuel Rail Pressure and Measured Fuel Rail Pressure.

Condition:
- Turn keyswitch ON.
- Electronic service tool connected.
- Engine idling.

Action	Specification/Repair	Next Step
Use an electronic service tool to monitor Commanded Fuel Rail Pressure and Measured Fuel Rail Pressure while the engine is idling. When monitoring, note whether any engine driven accessory (air conditioning compressor, air compressor, fan clutch, etc.) turns on. Also, note whether any accessories that put demand/ load on the alternator (intake air heater, vehicle accessories, etc.). These items can affect the outcome of this check. The load on the engine should be constant.	Does the Measured Fuel Rail Pressure vary more than ± 35 bar [± 500 psi] from the Commanded Fuel Rail Pressure? **YES** **Repair:** Replace the fuel pump actuator. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-007 in Section 5.	Repair complete
	Does the Measured Fuel Rail Pressure vary more than ± 35 bar [± 500 psi] from the Commanded Fuel Rail Pressure? **NO**	4I

STEP 4I: Check the fuel pressure relief valve for excessive leakage.

Condition:
- Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-061 in Section 6.

Action	Specification/Repair	Next Step
Measure the fuel pressure relief valve drain flow. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-061 in Section 6.	Is the fuel pressure relief valve within specification? **YES**	4J
	Is the fuel pressure relief valve within specification? **NO** **Repair:** Replace the fuel pressure relief valve. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-061 in Section 6.	Repair complete

STEP 4J: Measure the high-pressure fuel supply pump fuel drain flow.

Condition:
- Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-016 in Section 5.

Action	Specification/Repair	Next Step
Measure the high-pressure fuel supply pump return flow. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-016 in Section 5.	Is the high-pressure fuel supply pump fuel drain flow greater than specification? **YES** **Repair:** Replace the high-pressure fuel supply pump. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-016 in Section 5.	Repair complete
	Is the high-pressure fuel supply pump fuel drain flow greater than specification? **NO**	4K

STEP 4K: Measure fuel drain line restriction.

Condition:
- Turn keyswitch OFF.
- Connect appropriate service tools to measure fuel drain line restriction.

Action	Specification/Repair	Next Step
Measure the fuel inlet restriction. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-012 in Section 6. Operate the engine at high idle: Maximum fuel drain line restriction: 0.19 bar [2.7 psi].	Is the drain line restriction less than specification? **YES**	Perform next troubleshooting procedure as outlined in Step 2.
	Is the drain line restriction less than specification? **NO** **Repair:** Check OEM fuel drain lines to tank for proper size, leaks, bends, clogs and fuel tank vents for plugging.	Repair Complete

STEP 5: Air handling troubleshooting procedures.

STEP 5A: Check intake manifold pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine OFF.

Action	Specification/Repair	Next Step
Monitor the reading for intake manifold pressure with the engine OFF. Start INSITE™ electronic service tool data monitor/logger and monitor the tool reading for intake manifold pressure with the engine OFF.	Intake manifold pressure reading is less than 102 mm-Hg [4 in-Hg]? **YES** **Repair:** N/A	5B
	Intake manifold pressure reading is less than 102 mm-Hg [4 in-Hg]? **NO** **Repair:** Replace the intake manifold pressure sensor. If equipped with a combination Intake Manifold Pressure/Temperature Sensor, use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-159 in Section 19. Use the following procedure in the ISB, ISBe2, ISBe3, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, ISLe3, ISLe4, and QSL9 CM850 Electronic Control System Troubleshooting and Repair Manual, Bulletin 4021416. Refer to Procedure 019-159 in Section 19.	Repair complete

STEP 5B: Check the Air intake System for Leaks.

Condition:

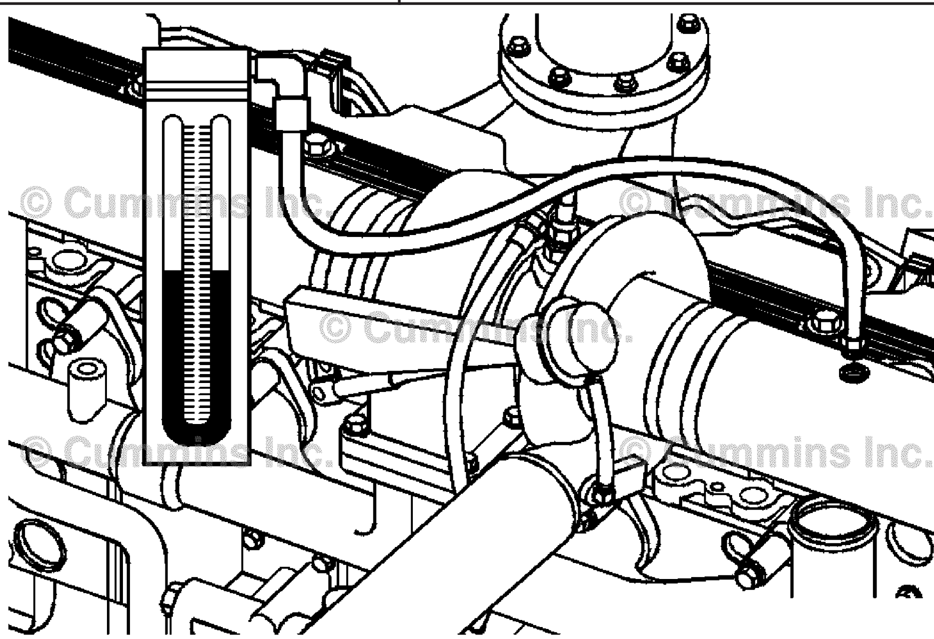
N/A

Action	Specification/Repair	Next Step
Check the air intake system for leaks Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-024 in Section 10. On engines equipped with a turbocharged air compressor, one often overlooked item as a source for air leaks is the air compressor intake line. The intake line supplies intake air from the intake of the engine to the air compressor.	Were any air intake system leaks found? **YES** **Repair:** Repair or replace the damaged component.	Repair complete
	Were any air intake system leaks found? **NO**	5C

STEP 5C: Check air intake restriction.

Condition:
- Turn keyswitch ON.
- Engine operating at rated speed and full load.

Action	Specification/Repair	Next Step
Check the air intake restriction by installing a vacuum gauge (Cummins® Part Number ST-1111-3) into the air intake system. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-031 in Section 10. Maximum Air Intake Restriction: Dirty Filter 635 mm-H_2O; [25 in-H_2O] Clean Filter 254 mm-H_2O; [10 in-H_2O]	Is the air intake restriction greater than the specification? **YES** **Repair:** Correct the cause of high intake air restriction. Check for a plugged air filter or restricted air intake piping.	Repair Complete
	Is the air intake restriction greater than the specification? **NO**	5D



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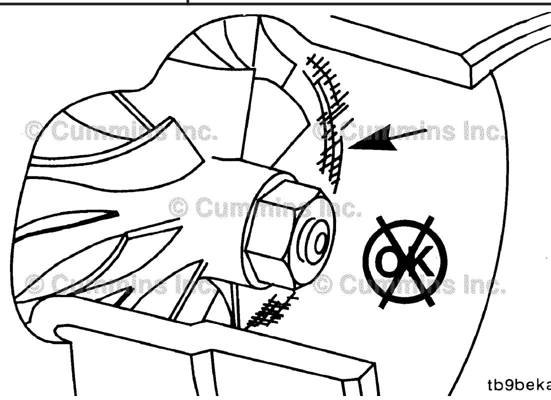
STEP 5D: Inspect the turbocharger compressor blades for damage.

Condition:
- Turn engine OFF.
- Remove the intake piping from the turbocharger.

Action	Specification/Repair	Next Step
Inspect the compressor blades for damage or wear. Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271.	Damage found on turbocharger blades? **YES** **Repair:** Replace the turbocharger assembly. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Repair Complete
	Damage found on turbocharger blades? **NO**	5E



STEP 5E: Determine if the turbocharger is a wastegated turbocharger.

Condition:

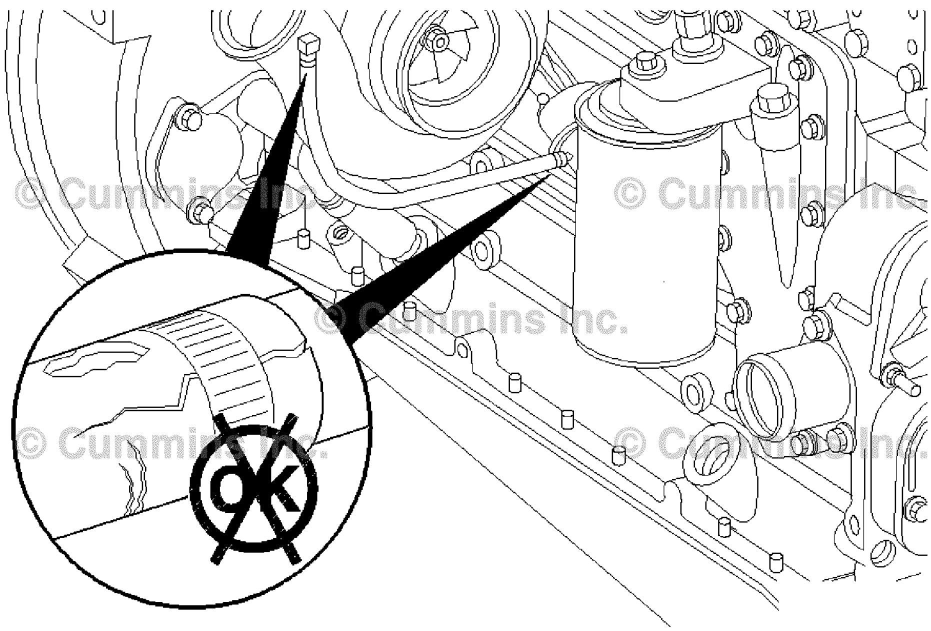
N/A

Action	Specification/Repair	Next Step
Determine if the turbocharger is a wastegated turbocharger. N/A	Is the turbocharger a wastegated turbocharger? **YES**	5F
	Is the turbocharger a wastegated turbocharger? **NO**	5H

STEP 5F: Inspect the wastegate actuator hose.

Condition:
- Turn keyswitch OFF.
- Remove the turbocharger if the wastegate actuator is inaccessible.

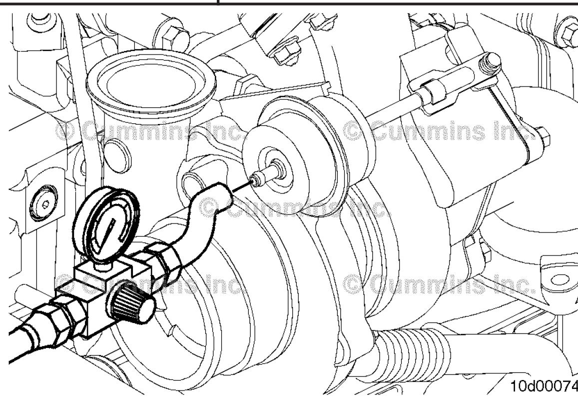
Action	Specification/Repair	Next Step
Inspect the integral wastegate actuator hose for cracks or holes. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10.	Holes or cracks found in the wastegate actuator hose? **YES** **Repair:** Replace the wastegate actuator hose. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10.	Repair complete
	Holes or cracks found in the wastegate actuator hose? **NO**	5G



STEP 5G: Inspect the turbocharger wastegate capsule for air leaks.

Condition:
- Engine OFF.
- Remove the wastegate actuator hose from the wastegate actuator.

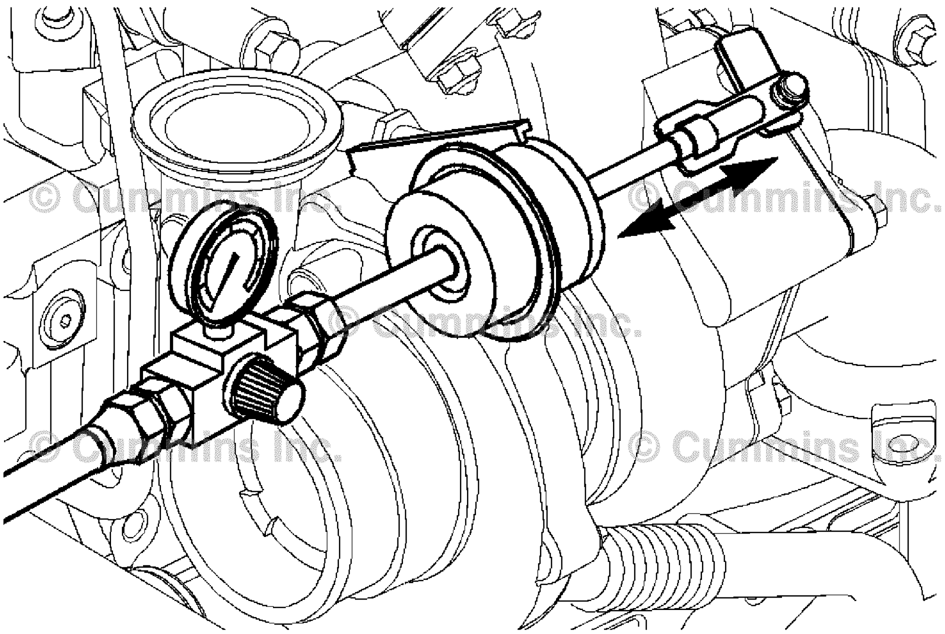
Action	Specification/Repair	Next Step
Perform a leak test on the wastegate actuator capsule. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10. Use Cummins® tool, Part Number 3823799, to apply a regulated air supply of 59 in-Hg (29 psi) to the wastegate actuator capsule. No air should be heard (i.e., leaking noise) through a functional wastegate capsule.	Did the wastegate actuator capsule leak air? **YES** **Repair:** Replace the wastegate actuator. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10.	Repair complete
	Did the wastegate actuator capsule leak air? **NO**	5G-1



STEP 5G-1: Inspect the turbocharger wastegate for proper operation.

Condition:
- Engine OFF.
- Remove the wastegate actuator hose from the wastegate actuator.

Action	Specification/Repair	Next Step
Check for wastegate actuator rod for movement. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10. Use Cummins® tool, Part Number 382379, to apply a regulated air supply of 59 in-Hg (29 psi) to the wastegate actuator capsule. Check for wastegate actuator rod for movement.	Did the wastegate actuator rod move? **YES**	5H
	Did the wastegate actuator rod move? **NO**	5G-2



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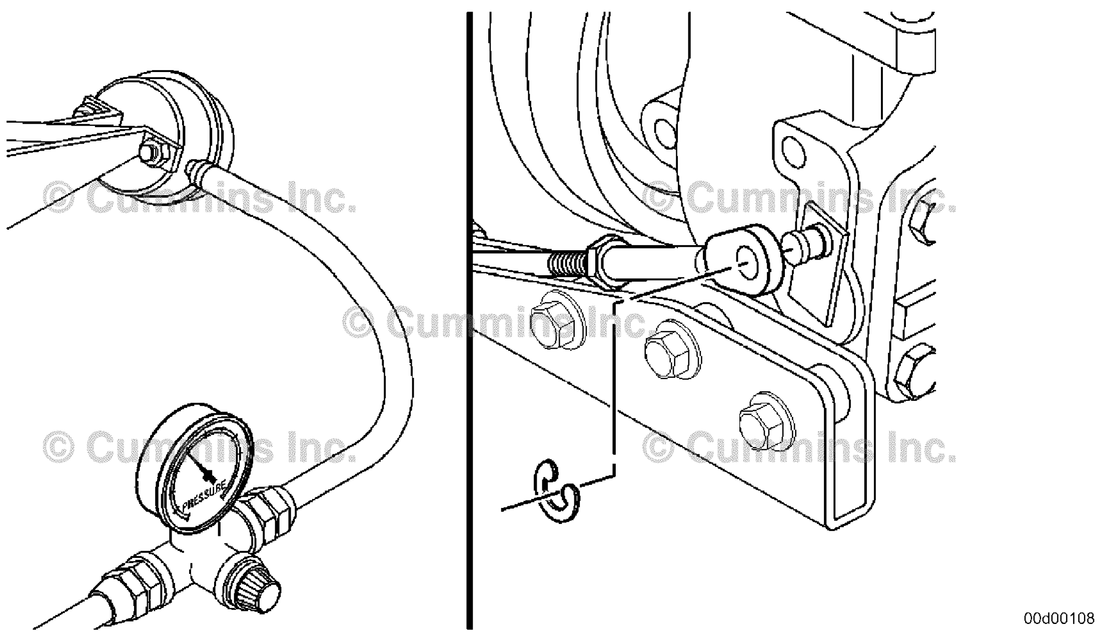
STEP 5G-2: Inspect the turbocharger wastegate for proper operation.

Condition:
- Engine OFF.
- Remove the e-clip from the wastegate pin and disconnect the actuator rod from the wastegate lever.

Action	Specification/Repair	Next Step
Check for wastegate actuator rod for movement with it disconnected from the turbocharger wastegate. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10. Use Cummins® Tool, Part Number 3823799, to apply a regulated air supply of 59 in-Hg (29 psi) to the wastegate actuator capsule. Check for wastegate actuator rod for movement.	Does the wastegate actuator rod move? **YES** **Repair:** Move the wastegate lever back and forth and check for smooth 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, then replace the turbocharger. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Repair Complete
	Does the wastegate actuator rod move? **NO** **Repair:** Replace the wastegate actuator. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10.	Repair Complete



STEP 5H: Measure turbocharger axial and radial clearance.

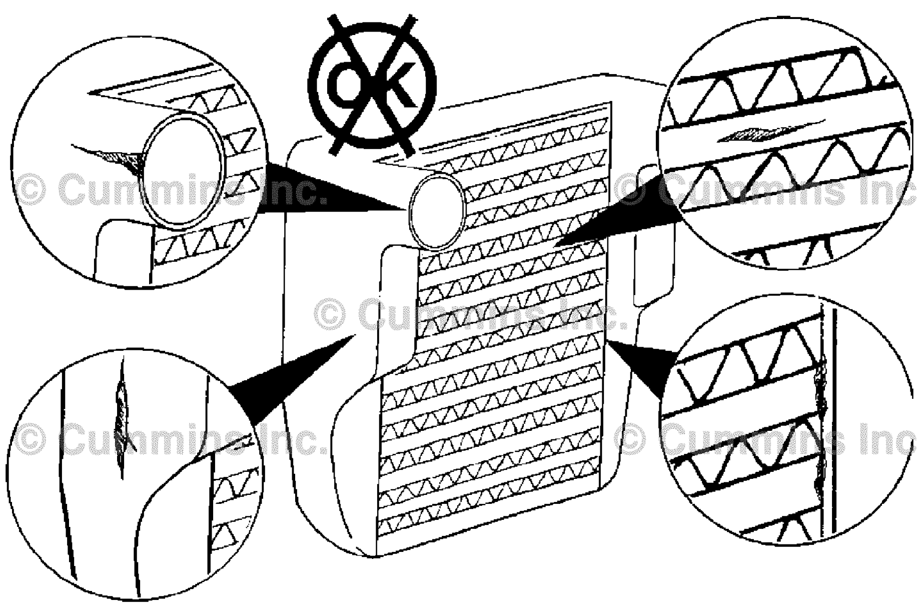
Condition:
- Engine OFF.
- Disconnect the exhaust and intake connections from the turbocharger.

Action	Specification/Repair	Next Step
Follow the procedure for measuring the axial and radial clearances of the turbocharger. Use the following procedure in the Service Manual, ISB, ISBe, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271.Refer to Procedure 010-033 in Section 10. See Clearance Specifications:	Are the axial and radial clearances within specification **YES**	5I
	Are the axial and radial clearances within specification? **NO** **Repair:** Replace the turbocharger assembly. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Repair complete

STEP 5I: Inspect charge-air cooler

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Inspect the charge air cooler for cleanliness, cracks, holes, or other damage. The pressure test and the temperature differential test in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271, can be used to verify charge-air cooler problems. Refer to Procedure 010-027 in Section 10.	Does the charge-air cooler pass the visual inspection as well as the pressure test and temperature differential test? **YES**	Perform the next troubleshooting procedure as outlined in Step 2.
	Does the charge-air cooler pass the visual inspection as well as the pressure test and temperature differential test? **NO** **Repair:** Repair or replace the charge-air cooler assembly. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-027 in Section 10.	Repair complete



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STEP 6: Verify electronic features are operating correctly

STEP 6A: Verify accelerator (throttle) pedal travel.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Monitor accelerator (throttle) position while fully depressing and releasing the throttle pedal Use INSITE™ electronic service tool.	Does the accelerator (throttle) position read 0 percent when the accelerator (throttle) is fully released and 100 percent when the accelerator (throttle) is fully depressed? **YES**	6B
	Does the accelerator (throttle) position read 0 percent when the accelerator (throttle) is fully released and 100 percent when the accelerator (throttle) is fully depressed? **NO** **Repair:** Refer to the OEM service manual for accelerator (throttle) pedal troubleshooting.	Repair Complete

STEP 6B: Monitor the vehicle speed

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Monitor the vehicle speed while the vehicle is not moving • Use INSITE™ electronic service tool.	Does the vehicle speed read zero while the vehicle is not moving? **YES**	6C
	Does the vehicle speed read zero while the vehicle is not moving? **NO** **Repair:** Verify the VSS parameters are adjusted correctly in the ECM. Check the VSS and OEM harness.	Repair complete

STEP 6C: Verify electronic feature settings are correct.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Verify the following adjustable parameters are correctly set: Use INSITE™ electronic service tool to verify: • Maximum vehicle speed • Powertrain protection • Rear axle ratio • Transmission tailshaft teeth • Tire revolutions per mile • Gear-down protection • Cruise control droop settings • Cruise control maximum vehicle speed • Accelerator type • Road speed governor • Vehicle acceleration management • Transmission type.	Are electronic features set correctly? **YES**	6D
	Are electronic features set correctly? **NO** **Repair:** Correct programmable features.	Repair Complete

STEP 6D: Check temperature sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- The engine **must** be turned off long enough for engine coolant temperature to be equal to ambient air temperature.

Action	Specification/Repair	Next Step
Monitor the following temperatures: Use INSITE™ electronic service tool to verify: • Engine coolant temperature sensor • Intake manifold air temperature sensor • If equipped, the turbocharger compressor inlet air temperature sensor	Are all temperature readings within 5.6°C or 10°F of each other? **YES**	6E
	Are all temperature readings within 5.6°C or 10°F of each other? **NO** **Repair:** Check for a short from the signal pin of the temperature sensor in question to all other pins in the harness. Use the following procedure if no short is found, replace the temperature sensor that is reading higher or lower than the other sensors. Refer to Procedure 019-360 in Section 19. See Section 19 for specifications on each temperature sensor.	Repair Complete

STEP 6E: Check ambient air pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

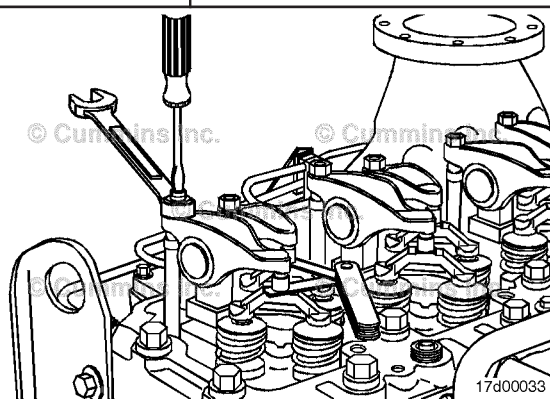
Action	Specification/Repair	Next Step
Start the INSITE™ electronic service tool data monitor/logger. Start INSITE™ electronic service tool data monitor/logger and compare INSITE™ electronic service tool reading for barometric air pressure to the local barometric pressure. Refer to Procedure 018-028 in Section 18.	INSITE™ electronic service tool reading is within 50.8 mm-Hg [2 in-Hg] of local barometric pressure? N/A **YES**	Perform the next troubleshooting procedure as outlined in Step 2.
	INSITE™ electronic service tool reading is within 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **NO** **Repair:** Replace the barometric pressure sensor.	Repair complete

STEP 7: Perform base engine mechanical checks.

STEP 7A: Verify overhead adjustments are correct.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

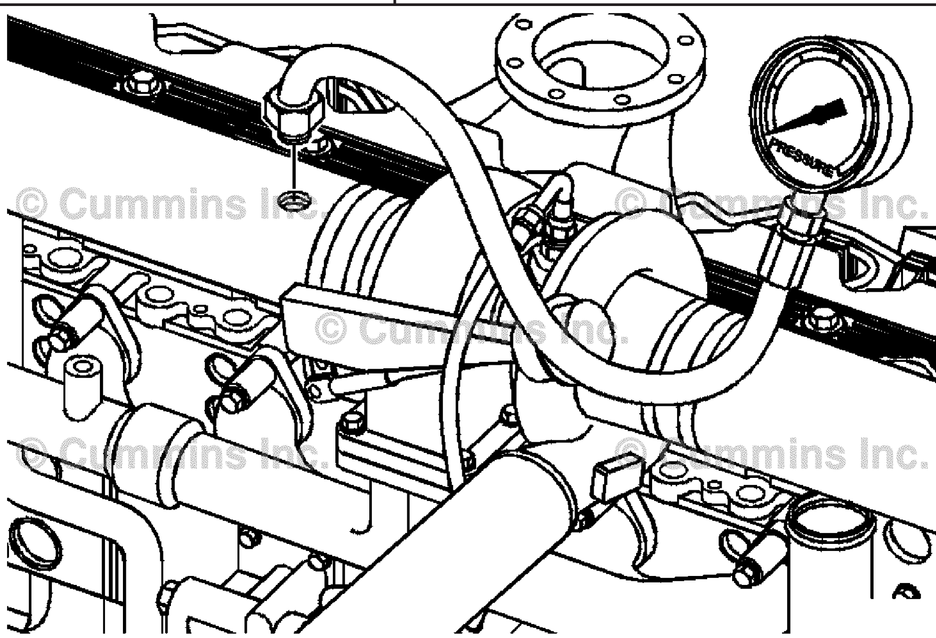
Action	Specification/Repair	Next Step
Measure the overhead settings. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 003-004 in Section 3.	Are the overhead settings within the lash check limits? **YES**	7B
	Are the overhead settings within the lash check limits? **NO** **Repair:** Adjust the overhead settings again. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 003-004 in Section 3.	Repair complete



STEP 7B: Check exhaust restriction.

Condition:
- Turn keyswitch ON.
- Engine operating at rated speed and full load.

Action	Specification/Repair	Next Step
Measure the exhaust system back pressure Measure the exhaust system back pressure by installing a pressure gauge, Part Number ST-1273, into the exhaust system immediately downstream of the turbocharger exhaust outlet. Maximum back pressure measured at the turbocharger outlet (exhaust manifold outlet for naturally aspirated engines) is: • 10 kPa (1.5 psi) • 15 kPa (2.2 psi).	Is the exhaust back pressure greater than the specification? **YES** **Repair:** Correct the cause of high back pressure; look for collapsed or plugged exhaust pipes.	Repair Complete
	Is the exhaust back pressure greater than the specification? **NO**	7C



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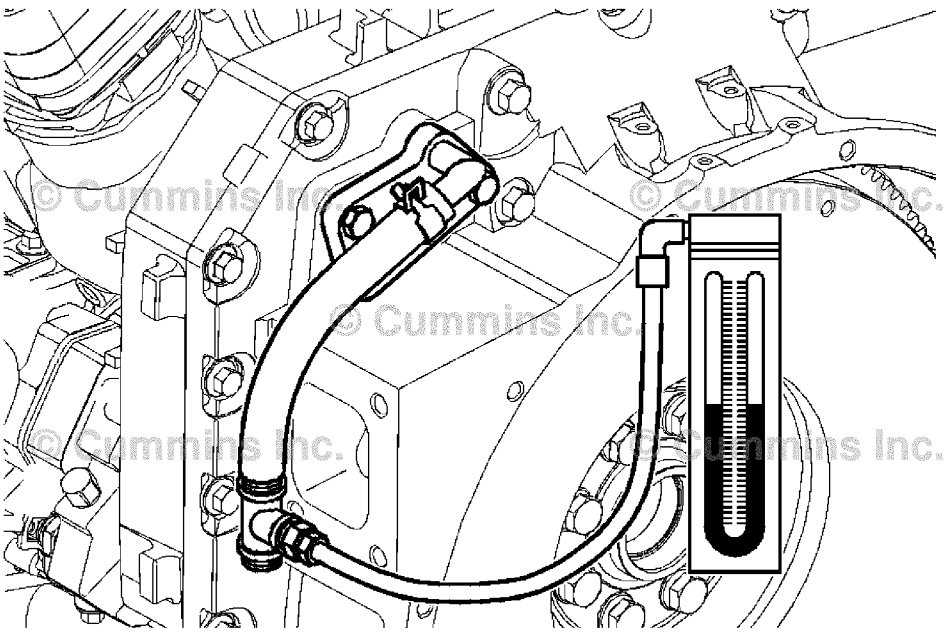
STEP 7C: Verify engine crankcase pressure (blowby) is within specification

Condition:
- Turn keyswitch OFF.
- Connect appropriate service tools to measure blowby.

Action	Specification/Repair	Next Step
Measure engine crankcase pressure (blowby). Use the following procedure in the Troubleshooting and Repair Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 014-010 in Section 14.	Is the engine crankcase pressure (blowby) less than specification? **YES**	7D
	Is the engine crankcase pressure (blowby) less than specification? **NO** **Repair:** See the Crankcase (Blowby) Excessive Troubleshooting Symptom (TS) tree.	See the Crankcase Gases (Blowby) Excessive Troubleshooting Symptom (TS) tree.



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STEP 7D: Check for internal engine damage.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Remove the oil filter. Use the following procedures in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 007-013 in Section 7. Refer to Procedure 007-083 in Section 7. Cut the oil filter open and inspect for debris and area of probable damage.	Did cutting the oil filter open reveal evidence of internal engine damage? **YES** **Repair:** Determine the area of probable damage and repair as necessary. Remove the lubricating oil pan and rocker lever cover, if necessary, to inspect for damage. Use the following procedures in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System), Bulletin 4021271.Refer to Procedure 007-025 in Section 7. Refer to Procedure 003-011 in Section 3.	Repair Complete
	Did cutting the oil filter open reveal evidence of internal engine damage? **NO**	Perform the next troubleshooting procedure as outlined in Step 2.

STEP 8: Excessive vibration checks

STEP 8A: Check engine idle speed

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- INSITE™ Monitor.

Action	Specification/Repair	Next Step
Monitor the engine speed while the engine is idling. Use INSITE™ electronic service tool. See the engine dataplate for idle speed specifications.	Is the engine idle speed within specification? **YES**	8B
	Is the engine idle speed within specification? **NO** **Repair:** Adjust or increase the engine idle speed.	Repair Complete

STEP 8B: Check if the feature Fast Idle Warm Up is available and enabled

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check the features and parameters and check if the feature Fast Idle Warm Up is available and enabled. • Turn keyswitch ON. • Connect INSITE™ electronic service tool. • INSITE™ Monitor.	Is the feature Fast Idle Warm Up available and enabled? **YES**	8B-1
	Is the feature Fast Idle Warm Up available and enabled? **NO**	8C

STEP 8B-1: Monitor the Fast Idle Warm Up Status

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- INSITE™ Monitor.

Action	Specification/Repair	Next Step
Monitor Fast warm-up status Connect INSITE™ electronic service tool.	Is the feature Fast Idle Warm Up becoming active? **YES** **Repair:** Adjust the fast idle warm up idle speed or check with the customer on disabling the feature. Disabling the Fast Idle Warm Up feature can affect warranty.	Repair Complete
	Is the feature Fast Idle Warm Up becoming active? **NO**	8C

STEP 8C: Check front engine driven accessory(s)

Condition:
- Turn keyswitch OFF.
- Isolate front engine driven accessory(s).

Action	Specification/Repair	Next Step
Isolate front engine driven accessory(s) one at a time, including: • Alternator(s) • Refrigerant compressor(s) • Fan hub(s) • Hydraulic/Power steering pump(s) • Water pump • Cooling fan • Crankshaft driven PTO accessories.	Did isolating the front engine driven accessory(s) correct the vibration? **YES** **Repair:** Repair or replace the malfunctioning component.	Repair Complete
	Did isolating the front engine driven accessory(s) correct the vibration? **NO**	8D

STEP 8D: Check the Vibration Damper/Crankshaft speed indicator ring.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Isolate front engine driven accessory(s) one at a time, including: Check the vibration damper/crankshaft speed indicator ring for damage. Use the following procedure for engines equipped with a rubber vibration damper in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 001-051 in Section 1. Use the following procedure for engines equipped with a viscous damper in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 001-052 in Section 1. Use the following procedure for engines equipped with a crankshaft speed indicator ring only in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 001-071 in Section 1.	Is the vibration damper/crankshaft speed indicator ring damaged? **YES** **Repair:** Replace the damaged vibration damper/ crankshaft speed indicator ring.	Repair Complete
	Is the vibration damper/crankshaft speed indicator ring damaged? **NO**	8E

STEP 8E: Check the engine support brackets, mounts and/or isolators.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the engine support brackets, mounts and/or isolators for damage Use the following procedures for front and rear engine supports in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System), Bulletin 4021271. Refer to Procedure 016-002 in Section 16. Refer to Procedure 016-003 in Section 16.	Are the engine support brackets, mounts, and/or isolators or damaged? **YES** **Repair:** Replace the damaged engine support brackets, mounts and/or isolators.	Repair Complete
	Are the engine support brackets, mounts, and/or isolators or damaged? **NO**	8F

STEP 8F: Check engine gear driven accessory(s).

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check if the engine has an engine gear driven / air compressor driven hydraulic pump. N/A	Does the engine have an engine gear driven/ air compressor driven hydraulic pump? **YES**	8F-1
	Does the engine have an engine gear driven/ air compressor driven hydraulic pump? **NO**	8F-2

STEP 8F-1: Isolate engine gear driven accessory(s).

Condition:
- Turn keyswitch OFF.
- Isolate/remove the gear/air compressor driven hydraulic pump.

Action	Specification/Repair	Next Step
Isolate/remove the gear driven air compressor driven hydraulic pump and operate the engine. Use the following procedure for general hydraulic pump remove and install instructions in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 009-016 in Section 9. Some engines require an accessory drive to drive the hydraulic pump. It could be necessary to isolate this as well. Use the following procedure to isolate the accessory drive in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) in Series Engines, Bulletin 4021271.Refer to Procedure 009-001 in Section 9	Did isolating/removing engine gear driven/air compressor driven hydraulic pump correct the vibration? **YES** **Repair:** Repair or replace the damaged component.	Repair Complete
	Did isolating/removing engine gear driven/air compressor driven hydraulic pump correct the vibration? **NO**	8F-2

STEP 8F-2: Check if the engine is equipped with an air compressor.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check if the engine is equipped with an engine gear driven air compressor.	Is the engine equipped with an engine gear driven air compressor? **YES**	8F-3
	Is the engine equipped with an engine gear driven air compressor? **NO**	8G

STEP 8F-3: Unload the air compressor and operate.

Condition:
- Turn keyswitch OFF.
- Unload the air compressor.

Action	Specification/Repair	Next Step
With the air compressor unloaded, operate the engine in the condition in which the vibration complaint occurs. The air compressor can be unloaded by: 1. Disconnecting the air governor signal line and connecting regulated shop air, with a pressure gauge, to the air compressor governor air signal port. Typically 621 kPa (90 psi) of air pressure is the set point for unloading the air compressor. See the OEM service manual. 2. Disconnecting the air compressor discharge line and air intake hose from the air compressor. On turbocharged air compressors, make sure to plug the air intake hose attached to the intake manifold.	Did unloading the air compressor significantly reduce or eliminate the vibration? **YES**	8F-4
	Did unloading the air compressor significantly reduce or eliminate the vibration? **NO**	8G

STEP 8F-4: Check the air compressor timing.

Condition:
- Turn keyswitch OFF.
- Check the timing of the air compressor.

Action	Specification/Repair	Next Step
The air compressor is not required to be timed to the 3.9 L and 5.9 L engines. Check that the air compressor is correctly timed to the engine. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 012-014 in Section 12. When troubleshooting a vibration issue in which it is suspected that the air compressor is the cause of the vibration, it may be necessary to isolate the air compressor from the engine.	Was the air compressor correctly timed to the engine? **YES** **Repair:** Replace the air compressor. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 012-014 in Section 12.	Repair Complete
	Was the air compressor correctly timed to the engine? **NO** **Repair:** Correctly time the air compressor to the engine. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 012-014 in Section 12.	Repair Complete

STEP 8G: Check/isolate the engine driven components.

Condition:
- Turn keyswitch OFF.
- Isolate/remove any engine driven components.

Action	Specification/Repair	Next Step
Isolate/remove any engine driven components and operate the engine. Engine driven components include: • Transmissions (Torque converters/Clutches) • Hydraulic pumps • Direct drive shafts • Flywheels. Refer to Procedure 016-005 in Section 16 of the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. • Flexplates. Refer to Procedure 016-004 in Section 16 of the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271.	Did isolating/removing any engine driven component correct the vibration? **YES** **Repair:** Replace the malfunctioning component. Refer to the OEM service manual.	Repair Complete
	Did isolating/removing any engine driven component correct the vibration? **NO**	8H

STEP 8H: Check the flywheel housing alignment.

Condition:
- Turn keyswitch OFF.
- Engine driven components removed.

Action	Specification/Repair	Next Step
Measure the flywheel housing bore and face runout. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 016-006 in Section 16.	Is the flywheel housing bore and face runout within specification? **YES**	8I
	Is the flywheel housing bore and face runout within specification? **NO** **Repair:** Use the following procedure for flywheel housing repair options in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 016-006 in Section 16.	Repair Complete

STEP 8I: Check if engine is equipped with an internal engine balancer.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check if engine is equipped with an internal engine balancer. Use the engine serial number to look up the engine build history to see if the engine was built with an internal engine balancer option. **Only** 4 cylinder engines can be equipped with an internal engine balancer.	Is the engine equipped with an internal engine balancer? **YES**	8I-1
	Is the engine equipped with an internal engine balancer? **NO**	8A

STEP 8I-1: Check the internal engine balancer.

Condition:
- Turn keyswitch OFF
- Lubricating oil pan removed

Action	Specification/Repair	Next Step
Remove the lubricating oil pan and inspect the internal engine balancer. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 007-025 in Section 7 Check to make sure the internal engine balancer is correctly timed to the engine. Check for any damage to the internal engine balancer. **Only** 4 cylinder engines can be equipped with an internal engine balancer.	Is the internal engine balancer timing incorrect or is the balancer damaged? **YES** **Repair:** Repair or replace the internal engine balancer.	Repair Complete
	Is the internal engine balancer timing incorrect or is the balancer damaged? **NO**	7A

Engine Performance Troubleshooting Tree for QSB5.9 Marine Engines with CM850 Electronic Control System

This troubleshooting procedure should be followed for the following symptoms:

- Engine Acceleration or Response Poor
- Cranking Fuel Pressure is Low
- Engine Operating Fuel Pressure is Low
- Engine Decelerates Slowly
- Engine Difficult to Start or Will Not Start (Exhaust Smoke)
- Engine Difficult to Start or Will Not Start (No Exhaust Smoke)
- Engine Power Output Low
- Engine Runs Rough at Idle
- Engine Runs Rough or Misfires
- Engine Speed Surges at Low or High Idle
- Engine Speed Surges Under Load or in Operating Range
- Smoke, Black - Excessive
- Smoke, White - Excessive
- Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration
- Engine Starts But Will Not Keep Running
- Engine Will Not Reach Rated Speed (rpm)
- Intake Manifold Pressure (Boost) is Below Normal
- Excessive Vibration in Marine Applications

How to Use This Troubleshooting Procedure:

This symptom tree can be used to troubleshoot all performance based symptoms listed above. Start by performing Step 1 troubleshooting. Step 2 will ask a series of questions and will provide a list of troubleshooting steps to perform, depending on the symptom. Perform the list of troubleshooting in the sequence shown in the Specifications/Repair section of the tree.

Shop Talk:

Operational is a term that in general describes vessel performance on the water. Operational problems for an engine can be caused by several different factors. Some of the factors are engine-related and some are **not**. Before troubleshooting, it is important to determine the exact complaint and whether the engine has a real operational problem or if it simply does **not** meet owner expectations.

Low power is a term that is used in the field to describe many different performance problems. Low power is defined as the inability of the engine to produce the power necessary to move the vessel at a speed that can be reasonably expected under the given environment.

Poor acceleration or response is described as the inability of the vessel to accelerate satisfactorily from a stop. It can also be the lag in acceleration at conditions less than rated speed and load. Poor acceleration or response is difficult to troubleshoot, since it can be caused by several factors.

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Perform basic troubleshooting procedures.**		
STEP 1A:	Check for active fault codes or high counts of inactive fault codes.	Active fault codes or high counts of inactive fault codes?	
STEP 1B:	Perform basic troubleshooting checks.	Can the problem be verified?	
STEP 1C:	Perform basic troubleshooting checks.	All steps have been verified to be correct?	
STEP 2:	**Determination of engine symptom.**		
STEP 2A:	Low power, poor acceleration, or poor response.	Is the engine symptom low power, poor acceleration, or poor response?	
STEP 2B:	Engine misfire, engine speed surge, or engine speed unstable.	Is the engine symptom engine misfire, engine speed surge, or engine speed unstable?	
STEP 2C:	Excessive white or black smoke.	Is the engine symptom excessive white or black smoke?	
STEP 2D:	Low intake manifold pressure.	Is the engine symptom low boost pressure?	
STEP 2E:	Engine will not start or difficult to start, engine shuts off unexpectedly.	Is the engine symptom engine will not start or difficult to start, engine shuts off unexpectedly?	
STEP 2F:	Engine vibration excessive.	Is the symptom engine vibration is excessive occurring when the engine is in or out of gear?	
STEP 3:	**Engine starting and running troubleshooting procedures.**		
STEP 3A:	Verify the fuel supply and return valves are open.	Are the fuel supply and return valves in the open position?	
STEP 3A-1:	Check the fuel cooler for damage due to high fuel return back pressure.	Is the fuel cooler damaged or collapsed internally?	
STEP 3B:	Verify the low pressure fuel lines are routed correctly.	Are the low pressure fuel lines connected properly to the engine control module (ECM) cooling plate?	
STEP 3C:	Check the engine speed during cranking.	Is the engine cranking speed greater than 150 rpm?	
STEP 3D:	Check the ECM keyswitch voltage.	Is the keyswitch voltage equal to the battery voltage?	
STEP 3E:	Check the ECM battery supply voltage.	Is the ECM battery supply voltage equal to the battery voltage?	
STEP 3F:	Verify the rail fuel pressure sensor accuracy.	Is the rail fuel pressure sensor (measured) value less than 30 bar [435 psi]?	

STEP 3G:	Check for fuel rail pressure while cranking the engine.	Did Fault Code 2215 or Fault Code 559 become active during the failed start attempt?
STEP 3H:	Check the fuel lift pump pressure.	Is the fuel lift pump pressure greater than the specifications outlined in Procedure 005-045?

STEP 4: Fuel system troubleshooting procedures.

STEP 4A:	Check for fault codes that pertain to the fuel system.	Did Fault Code 2215 or Fault Code 559 become active during the failed start attempt?
STEP 4B:	Check for air in the high pressure pump fuel supply.	Is air present in the fuel supply?
STEP 4C:	Measure the fuel inlet restriction.	Is the fuel inlet restriction above specification?
STEP 4D:	Perform the single cylinder cutout test.	Can the miss or excessive smoke be attributed to a single cylinder?
STEP 4E:	Perform the cylinder balance diagnostic test.	Does the cylinder performance test identify any cylinder that is contributing to a power imbalance?
STEP 4F:	Measure the fuel drain line restriction.	Is the fuel drain line restriction within specification?

STEP 5: Air handling troubleshooting procedures.

STEP 5A:	Check the intake manifold pressure sensor accuracy.	Is the reading within 50.8 mm-Hg [2 in-Hg] of local barometric pressure?
STEP 5B:	Check the air intake system for leaks.	Were any air intake system leaks found?
STEP 5C:	Check the air intake restriction.	Is the air intake restriction greater than the specification?
STEP 5D:	Inspect the turbocharger blades for damage.	Are the turbocharger blades damaged?
STEP 5E:	Determine if the turbocharger is a wastegated turbocharger.	Is the turbocharger a wastegated turbocharger?
STEP 5F:	Inspect the wastegate actuator hose.	Are holes or cracks found in the wastegate actuator hose?
STEP 5G:	Inspect the turbocharger wastegate capsule for air leaks.	Did the wastegate actuator rod move?
STEP 5G-1:	Inspect the turbocharger wastegate for proper operation.	Did the wastegate actuator rod move?
STEP 5G-2:	Inspect the turbocharger wastegate for proper operation.	Does the wastegate actuator rod move?
STEP 5H:	Measure turbocharger axial and radial clearance.	Are the axial and radial clearances within specification?
STEP 5I:	Inspect the aftercooler.	Is the aftercooler free of cracks or other damage?

STEP 6: Electronic feature troubleshooting procedures.

STEP 6A:	**Verify the throttle travel.**	**Does the throttle position read 0 when the throttle is released and 100 percent when the throttle is actuated?**
STEP 6B:	**Check the ambient air pressure sensor accuracy.**	**Is the reading within 101.6 mm-Hg [4 in-Hg] of local barometric pressure?**
STEP 6C:	**Check the intake manifold pressure sensor accuracy.**	**Is the reading within 101.6 mm-Hg [4 in-Hg] of local barometric pressure?**

STEP 7: Base engine troubleshooting procedures.

STEP 7A:	**Verify the overhead adjustments are correct.**	**Are the overhead settings within the reset limits?**
STEP 7B:	**Check the exhaust restriction.**	**Is the exhaust system back pressure less than 127 mm-Hg [5 in-Hg] or 1763 mm-H_2O [68 in-H_2O] or 17 kPa [2.5 psi]?**
STEP 7C:	**Check the engine blowby.**	**Are the engine blowby measurements within specification?**
STEP 7C-1:	**Verify turbocharger contribution to engine blowby.**	**Has the total engine blowby dropped more than 30 percent of the total?**

STEP 8: Excessive vibration troubleshooting procedures.

STEP 8A:	**Check the gear ratio and propeller configuration.**	**Are the gear ratio and the propeller incorrectly matched to the engine power?**
STEP 8B:	**Check for correct engine mounting isolators and for proper installation requirements.**	**Are the engine mount isolators correct and installed correctly?**
STEP 8C:	**Check for damaged engine mounts and isolators.**	**Are the engine mounts and isolators in good condition?**
STEP 8D:	**Check the exhaust system.**	**Is the exhaust system deficient?**
STEP 8E:	**Check the engine driven accessories.**	**Is an engine driven accessory malfunctioning?**
STEP 8F:	**Check the shaft coupling to gear coupling alignment.**	**Is the shaft coupling to gear coupling misaligned?**
STEP 8G:	**Check the propeller shaft for proper installation.**	**Is the propeller shaft installed correctly?**
STEP 8H:	**Check the propeller shaft for straightness.**	**Is the propeller shaft straightness within the OEM specification?**
STEP 8I:	**Isolate the engine.**	**Does the engine vibration persist?**
STEP 8J:	**Check for strut/cutlass bearing misalignment.**	**Is the strut/cutlass bearing misaligned or strut mounting not secure?**
STEP 8K:	**Check the propeller.**	**Is the propeller out of balance or not fitted properly to the shaft?**

STEP 8L:	**Check the V-angle on the V-strut.**	**Does the V-angle on the V-strut match the angle of the blade on the prop?**
STEP 8M:	**Check the propeller tunnels.**	**Does the entry and exit of the propeller tunnel match with the propeller blades?**
STEP 8N:	**Check the engine to transmission torsional coupling.**	**Is the torsional coupling incorrect or worn?**
STEP 8O:	**Check the rudder.**	**Does the rudder have excessive in the rudder post?**
STEP 8P:	**Check the engine flywheel housing to cylinder block alignment.**	**Is the flywheel housing alignment incorrect?**

TROUBLESHOOTING STEP

STEP 1: Perform basic troubleshooting procedures.

STEP 1A: Check for active fault codes or high counts of inactive fault codes.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for any active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Active fault codes or high counts of inactive fault codes? **YES** **Repair:** Reference Section TF in the ISB, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, ISLe3 and QSL9 (Common Rail Fuel System) Series Engines, CM850 Electronic Control System Troubleshooting and Repair Manual, Bulletin 4021416 for fault code troubleshooting.	Repair complete
	Active fault codes or high counts of inactive fault codes? **NO**	1B

STEP 1B: Perform basic troubleshooting checks.

Condition:

None

Action	Specification/Repair	Next Step
Verify the following items. • Is the engine operating within the conditions it was intended to perform? For example, wide open throttle rpm, ambient versus engine room temperatures, load on the vessel, sea conditions, etc. • Are the customer's expectations in line with the engine capability? • Is the engine performing according to the OEM sea trial?	Can the problem be verified? **YES**	1C
	Can the problem be verified? **NO** **Repair:** The problem can **not** be verified and **no** repair is possible.	Repair complete

STEP 1C: Perform the basic troubleshooting checks.

Condition:

None

Action	Specification/Repair	Next Step
The following items must be checked or verified before continuing. • Verify the fuel level in the tanks. • Verify there have **not** been any changes to the control parts list (turbocharger, injectors, pistons, fuel pump, camshaft, etc.) components on the engine. • Verify the fuel grade is correct for the application. • Verify the engine is operating within the recommended altitude. • Verify the engine oil is at the correct level. • Verify none of the air vents are restricted or obstructed. • Verify the engine parasitics have **not** changed. • Verify the engine duty cycle has **not** changed. • Verify the engine cranking speed is greater than 150 rpm. • Verify the battery voltage is adequate. • Verify the drive train is correctly matched to the engine. • Verify the transmission is correct and is **not** malfunctioning. • Verify the propeller is at the correct pitch and is **not** damaged. • Verify the fuel inlet temperature to the fuel pump is within specification. • Verify the engine throttle and throttle wiring is correct for the engine response issues. • Verify the condition of the hull (clean and **no** damage).	All steps have been verified to be correct? **YES**	2A
	All steps have been verified to be correct? **NO** **Repair:** Correct the condition and verify the complaint is **no** longer present after the repair.	Repair complete

STEP 2: Determination of engine symptom.

STEP 2A: Low power, poor acceleration, or poor response.

Condition:

None

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance. N/A	Is the engine symptom low power, poor acceleration, or poor response? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Fuel System Checks • Air Handling Checks • Electronics Checks • Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom low power, poor acceleration, or poor response? **NO**	2B

STEP 2B: Engine misfire, engine speed surge, or engine speed unstable.

Condition:

None

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance. N/A	Is the engine symptom engine misfire, engine speed surge, or engine speed unstable? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Fuel System Checks • Air Handling Checks • Electronics Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom engine misfire, engine speed surge, or engine speed unstable? **NO**	2C

STEP 2C: Excessive white or black smoke.

Condition:

None

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance. N/A	Is the engine symptom excessive white or black smoke? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Air Handling Checks • Fuel System Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom excessive white or black smoke? **NO**	2D

STEP 2D: Low intake manifold pressure.

Condition:

None

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance. N/A	Is the engine symptom low boost pressure? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Air Handling Checks • Fuel System Checks • Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom low boost pressure? **NO**	2E

STEP 2E: Engine will not start or difficult to start, engine shuts off unexpectedly.

Condition:

None

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance. N/A	Is the engine symptom engine will **not** start or difficult to start, engine shuts off unexpectedly? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • No Start Checks • Fuel System checks • Air Handling Checks • Electronics Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom engine will **not** start or difficult to start, engine shuts off unexpectedly? **NO**	2F

STEP 2F: Engine vibration excessive.

Condition:

None

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance. N/A	Is the symptom engine vibration is excessive occurring when the engine is in or out of gear? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Fuel System Checks • Air Handling Checks • Electronics Checks • Base Engine Checks • Excessive Vibration Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the symptom engine vibration is excessive occurring when the engine is in or out of gear? **NO**	Return to the correct symptom tree.

STEP 3: Engine starting and running troubleshooting procedures.

STEP 3A: Verify the fuel supply and return valves are open.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Verify the fuel supply and return valves are in the open position. If the vessel is new or work has been completed on the vessel, the fuel valves could have been left in the OFF position.	Is the fuel supply and return valves in the open position? **YES**	3B
	Is the fuel supply and return valves in the open position? **NO** **Repair:** Turn the fuel supply and return valve to the OPEN position and verify that **no** engine damage has occurred.	3A-1

STEP 3A-1: Check the fuel cooler for damage due to high fuel return back pressure.

Condition:

None

Action	Specification/Repair	Next Step
Remove and inspect the fuel cooler. Check the fuel cooler for internal damage, or collapse. Refer to Procedure 006-062 in Section 6 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Is the fuel cooler damaged or collapsed internally? **YES** **Repair:** Remove and replace the fuel cooler. Refer to Procedure 006-062 in Section 6 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Is the fuel cooler damaged or collapsed internally? **NO**	3B

STEP 3B: Verify the low pressure fuel lines are routed correctly.

Condition:

None

Action	Specification/Repair	Next Step
It is sometimes possible to get the low pressure fuel lines connected to the ECM cooling plate installed improperly. The top connection to the ECM cooling plate is the inlet and the bottom connection is the outlet. Verify these connections are correct if the low pressure fuel lines have been removed and reinstalled on the engine.	Are the low pressure fuel lines connected properly to the ECM cooling plate? **YES**	3C
	Are the low pressure fuel lines connected properly to the ECM cooling plate? **NO** **Repair:** Properly connect the low pressure fuel lines to the ECM cooling plate. The fuel inlet is the top connection.	Repair complete

STEP 3C: Check the engine speed during cranking.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to monitor Engine Speed while cranking the engine. If the engine does **not** crank at all, see the troubleshooting symptom tree Engine Will Not Crank or Cranks Slowly.	Is the engine cranking speed greater than 150 rpm? **YES**	3D
	Is the engine cranking speed greater than 150 rpm? **NO** **Repair:** Find and correct the cause for low cranking speed. Check the batteries, engine starting motor and accessory loads. See the troubleshooting symptom tree Engine Will Not Crank or Cranks Slowly.	Repair complete

STEP 3D: Check the engine control module (ECM) keyswitch voltage.

Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Measure the signal voltage. • Measure the signal voltage from the keyswitch input SIGNAL wire of the OEM harness to the engine block ground. Measure the keyswitch voltage with the keyswitch in the ON position and also with the keyswitch in the Cranking position. Refer to the wiring diagram for connector pin identification.	Is the keyswitch voltage equal to the battery voltage? **YES**	3E
	Is the keyswitch voltage equal to the battery voltage? **NO** **Repair:** Repair or replace the keyswitch harness, keyswitch, or check the battery connections. The keyswitch harness can be supplied by the OEM.	Repair complete

STEP 3E: Check the ECM battery supply voltage.

Condition:
- Turn the keyswitch OFF.
- Disconnect the ECM power harness from the ECM.

Action	Specification/Repair	Next Step
Measure the voltage. • Measure the voltage from the ECM battery supply (-) to the ECM battery supply (+) pins in the ECM power harness connector. Measure the ECM voltage with the keyswitch in the ON position and also with the keyswitch in the Cranking position. Refer to the wiring diagram for connector pin identification.	Is the ECM battery supply voltage equal to the battery voltage? **YES**	3F
	Is the ECM battery supply voltage equal to the battery voltage? **NO** **Repair:** Repair or replace the ECM power harness. Check the battery connections and fuse terminals.	Repair complete

STEP 3F: Verify the rail fuel pressure sensor accuracy.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Monitor the rail fuel pressure sensor. Use INSITE™ electronic service tool, to monitor the rail fuel pressure sensor (measured) with the keyswitch ON and the engine OFF (**not** operating).	Is the rail fuel pressure sensor (measured) value less than 30 bar [435 psi]? **YES**	3G
	Is the rail fuel pressure sensor (measured) value less than 30 bar [435 psi]? **NO** **Repair:** Replace the rail fuel pressure sensor. Refer to Procedure 019-115 in Section 19 in the ISB, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, ISLe3 and QSL9 (Common Rail Fuel System) Series Engines, CM850 Electronic Control System Troubleshooting and Repair Manual, Bulletin 4021416.	Repair complete

STEP 3G: Check for fuel rail pressure while cranking the engine.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for fuel rail pressure. • Attempt to start the engine by engaging the engine starter for at lease 30 continuous seconds. • Use INSITE™ electronic service tool to monitor the Fuel Rail pressure (Measured) and Fuel Rail Pressure (Commanded). • Use INSITE™ electronic service tool to read the fault codes. Attempting to start the engine for 30 continuous seconds allows the fault code logic time to perform. If Fault Code 2215 or Fault Code 559 becomes active, then fuel rail pressure is **not** being developed. If the engine starts during this attempt, it is possible that fuel prime to the high pressure pump has been lost. Look for loose fuel lines or filters that allow for loss of fuel prime.	Did Fault Code 2215 or Fault Code 559 become active during the failed start attempt? **YES** **Repair:** Follow troubleshooting Fault Codes 2215 or 559 Fuel Pump Delivery Pressure Low Choice.	Repair complete
	Did Fault Code 2215 or Fault Code 559 become active during the failed start attempt? **NO**	4A

STEP 3H: Check the fuel lift pump pressure.

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Install a pressure gauge at the inlet port of the fuel pump. • Measure the fuel lift pump output pressure. Refer to Procedure 005-045 in Section 5 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271. At initial key ON, the lift pump will run for 60 seconds then stop if the engine is **not** started and **not** operating. The lift pump will operate continuously once the engine is operating.	Is the fuel lift pump pressure greater than the specifications? **YES** **Repair:** Replace the fuel pump. Refer to Procedure 005-016 in Section 5 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Is the fuel lift pump pressure greater than the specifications? **NO** **Repair:** Replace the fuel lift pump. Refer to Procedure 005-045 in Section 5 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete

STEP 4: Fuel system troubleshooting procedures.

STEP 4A: Check for fault codes that pertain to the fuel system.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for fault codes. • Attempt to start the engine by engaging the starter for at least 30 continuous seconds. • Use INSITE™ electronic service tool to monitor Fuel Rail Pressure (Measured) and Fuel Rail Pressure (Commanded). • Use INSITE™ electronic service tool to read the fault codes. Attempting to start the engine for 30 continuous seconds allows the fault code logic time to perform. If Fault Code 2215 or Fault Code 559 becomes active, then fuel rail pressure is **not** being developed.	Did Fault Code 2215 or Fault Code 559 become active during the failed start attempt? **YES** **Repair:** Follow troubleshooting Fault Code 559 Fuel Pump Delivery Pressure Low choice.	Repair complete
	Did Fault Code 2215 or Fault Code 559 become active during the failed start attempt? **NO**	4B

STEP 4B: Check for air in the high pressure pump fuel supply.

Condition:

None

Action	Specification/Repair	Next Step
Check for air in the fuel. Refer to Procedure 006-003 in Section 6 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Is air present in the fuel supply? **YES** **Repair:** Locate and correct the cause of air ingestion in the fuel supply system. Sources of air ingestion include loose fuel filters, loose fuel line fittings, loose or cracked fuel tank stand-pipes, or severe restrictions in the fuel supply lines and filters.	Repair complete
	Is air present in the fuel supply? **NO**	4C

STEP 4C: Measure the fuel inlet restriction.

Condition:

None

Action	Specification/Repair	Next Step
Measure the fuel inlet restriction at the customer connection. Refer to Procedure 006-020 in Section 6 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271. Maximum fuel inlet restriction at the customer connection • New Filter: 63.5 mm-Hg [2.5 in-Hg] • Dirty Filter: 101.6 mm-Hg [4.0 in-Hg]	Is the fuel inlet restriction above specification? **YES** **Repair:** Find and correct the cause of high fuel inlet restriction. Look for plugged OEM fuel filters or screens, a restricted ECM cooler, pinched OEM fuel lines, or a restricted stand pipe in the OEM fuel tank.	Repair complete
	Is the fuel inlet restriction above specification? **NO**	4D

STEP 4D: Perform the single cylinder cutout test.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.
- Start the engine and run at low idle.

Action	Specification/Repair	Next Step
Perform the single cylinder cutout test. • Operate the engine at load. • Use INSITE™ electronic service tool to perform the Cylinder Cutout test. Disable individual injectors.	Can the miss or excessive smoke be attributed to a single cylinder? **YES** **Repair:** Look for a cause of the complaint, including valve lash and excessive crankcase pressure that can indicate power cylinder damage, or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder that was identified using the single cylinder cutout test. Refer to Procedure 006-026 in Section 6 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Can the miss or excessive smoke be attributed to a single cylinder? **NO**	4E

STEP 4E: Perform the cylinder balance diagnostic test.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Perform the cylinder balance diagnostic test. • Use INSITE™ electronic service tool to perform the Cylinder Performance Test. Determine if a single cylinder is contributing to the engine symptom.	Does the Cylinder Performance Test identify any cylinder that is contributing to a power imbalance? **YES** **Repair:** Look for a cause of the power imbalance, including valve lash and excessive crankcase pressure that may indicate power cylinder damage or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder contributing to the power imbalance. Refer to Procedure 006-026 in Section 6 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Does the Cylinder Performance Test identify any cylinder that is contributing to a power imbalance? **NO**	4F

STEP 4F: Measure the fuel drain line restriction.

Condition:

None

Action	Specification/Repair	Next Step
Measure the fuel drain line restriction. Refer to Procedure 006-012 in Section 6 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Is the fuel drain line restriction within specification? **YES**	2A
	Is the fuel drain line restriction within specification? **NO** **Repair:** Look for causes of high drain line restriction, such as kinked or blocked fuel lines.	Repair complete

STEP 5: Air handling troubleshooting procedures.

STEP 5A: Check the intake manifold pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine OFF.

Action	Specification/Repair	Next Step
Monitor the reading for intake manifold pressure with the engine off. • Start INSITE™ electronic service tool data/logger and monitor the INSITE™ electronic service tool reading for intake manifold pressure with the engine off. Compare the pressure readings in INSITE™ to the local barometric pressure. Refer to Procedure 018-028 in Section V.	Is the intake manifold pressure reading less than 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **YES**	5B
	Is the intake manifold pressure reading less than 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **NO** **Repair:** Replace the intake manifold pressure sensor. Refer to Procedure 019-159 in Section 19 in Troubleshooting and Repair Manual, ISB, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, and QSL9 Engines, CM850 Electronic Control System, Bulletin 4021416.	Repair complete

STEP 5B: Check the air intake system for leaks.

Condition:

None

Action	Specification/Repair	Next Step
Check the air intake system for leaks. Refer to Procedure 010-024 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Were any air intake system leaks found? **YES** **Repair:** Repair or replace the damaged component.	Repair complete
	Were any air intake system leaks found? **NO**	5C

STEP 5C: Check the air intake restriction.

Condition:
- Install vacuum gauge Part Number ST1111-3 into the air intake system.
- Turn keyswitch ON.
- Engine operating at rated speed and full load.

Action	Specification/Repair	Next Step
Measure the intake system restriction. Refer to Procedure 010-031 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271. Maximum air intake restriction: Clean filter: 381 mm-H_2O [15 in-H_2O] Dirty filter: 635 mm-H_2O [25 in-H_2O]	Is the air intake restriction greater than the specification? **YES** **Repair:** Correct the cause of high intake air restriction. Check for plugged air filter or restricted air intake piping.	Repair complete
	Is the air intake restriction greater than the specification? **NO**	5D

STEP 5D: Inspect the turbocharger blades for damage.

Condition:
- Turn keyswitch OFF.
- Remove the intake and exhaust pipes from the turbocharger.

Action	Specification/Repair	Next Step
Inspect the turbocharger. • Inspect the compressor blades for damage or wear. Refer to Procedure 010-033 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Are the turbocharger blades damaged? **YES** **Repair:** Replace the turbocharger assembly. Refer to Procedure 010-033 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Are the turbocharger blades damaged? **NO**	5E

STEP 5E: Determine if the turbocharger is a wastegated turbocharger.

Condition:

None

Action	Specification/Repair	Next Step
Determine if the turbocharger is a wastegated turbocharger. N/A	Is the turbocharger a wastegated turbocharger? **YES**	5F
	Is the turbocharger a wastegated turbocharger? **NO**	5H

STEP 5F: Inspect the wastegate actuator hose.

Condition:
- Turn keyswitch OFF.
- Remove the turbocharger if the wastegate actuator is inaccessible.

Action	Specification/Repair	Next Step
Inspect the integral wastegate actuator hose for cracks or holes. Refer to Procedure 010-050 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Are holes or cracks found in the wastegate actuator hose? **YES** **Repair:** Replace the wastegate actuator hose. Refer to Procedure 010-050 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Are holes or cracks found in the wastegate actuator hose? **NO**	5G

STEP 5G: Inspect the turbocharger wastegate capsule for air leaks

Condition:
- Engine OFF.
- Remove the wastegate actuator hose from the wastegate actuator.

Action	Specification/Repair	Next Step
Perform a leak test on the wastegate actuator capsule. Use Wastegate Pressure Test Kit, Part Number 3823799, to apply a regulated air supply of 59 in-Hg to the wastegate actuator capsule. No air should be heard (a leaking noise) through a functional wastegate capsule. Refer to Procedure 010-050 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Did the wastegate actuator capsule leak air? **YES** **Repair:** Replace the wastegate actuator. Refer to Procedure 010-050 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Did the wastegate actuator capsule leak air? **NO**	5G-1

STEP 5G-1: Inspect the turbocharger wastegate for proper operation.

Condition:
- Engine OFF.
- Remove the wastegate actuator hose from the wastegate actuator.

Action	Specification/Repair	Next Step
Check for wastegate actuator rod for movement. Use Wastegate Pressure Test Kit, Part Number 3823799, to apply a regulated air supply of [29 psi] to the wastegate actuator capsule. Check for wastegate actuator rod for movement. Refer to Procedure 010-050 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Did the wastegate actuator rod move? **YES**	5H
	Did the wastegate actuator rod move? **NO**	5G-2

STEP 5G-2: Inspect the turbocharger wastegate for proper operation.

Condition:
- Engine OFF.
- Remove the e-clip from the wastegate pin and disconnect the actuator rod from the wastegate lever.

Action	Specification/Repair	Next Step
Check for wastegate actuator rod movement with it disconnected from the turbocharger wastegate. Use Wastegate Pressure Test Kit, Part Number 3823799, to apply a regulated air supply of [29 psi] to the wastegate actuator capsule. Check for wastegate actuator rod for movement. Refer to Procedure 010-050 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Does the wastegate actuator rod move? **YES** **Repair:** Move the wastegate lever back and forth and check for smooth 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, then replace the turbocharger. Refer to Procedure 010-033 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Does the wastegate actuator rod move? **NO** **Repair:** Replace the wastegate actuator. Refer to Procedure 010-050 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete

STEP 5H: Measure turbocharger axial and radial clearance.

Condition:
- Engine OFF.
- Disconnect the exhaust and intake connections from the turbocharger.

Action	Specification/Repair	Next Step
Follow the procedure for measuring the axial and radial clearances of the turbocharger. Refer to Procedure 010-033 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Are the axial and radial clearances within specification? **YES**	5I
	Are the axial and radial clearances within specification? **NO** **Repair:** Replace the turbocharger assembly. Refer to Procedure 010-033 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete

STEP 5I: Inspect the aftercooler.

Condition:

None

Action	Specification/Repair	Next Step
Inspect the aftercooler. N/A	Is the aftercooler free of cracks or other damage? **YES**	2A
	Is the aftercooler free of cracks or other damage? **NO** **Repair:** Repair or replace the aftercooler assembly. Refer to Procedure 010-005 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete

STEP 6: Electronic feature troubleshooting procedures.

STEP 6A: Verify the throttle travel.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Verify the throttle travel. • Use INSITE™ electronic service tool to monitor throttle position while fully depressing and releasing the throttle lever.	Does the throttle position read 0 when the throttle is released and 100 percent when the throttle is actuated? **YES**	2A
	Does the throttle position read 0 when the throttle is released and 100 percent when the throttle is actuated? **NO** **Repair:** Determine and correct the cause of the throttle lever restriction.	Repair complete

STEP 7: Base engine troubleshooting procedures

STEP 7A: Verify the overhead adjustments are correct.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Measure the overhead settings. • Remove the rocker lever cover. Refer to Procedure 003-011 in Section 3 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271. • Measure the overhead settings. Refer to Procedure 003-004 in Section 3 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Are the overhead settings within the reset limits? **YES**	7B
	Are the overhead settings within the reset limits? **NO** **Repair:** Adjust the overhead settings. Refer to Procedure 003-004 in Section 3 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete

STEP 7B: Check the exhaust restriction.

Condition:

None

Action	Specification/Repair	Next Step
Install a pressure gauge into the exhaust system just past the turbocharger outlet to check the exhaust system back pressure. Refer to Procedure 011-009 in Section 11 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Is the exhaust system back pressure less than 127 mm-Hg [5 in-Hg] or 1763 mm-H_2O [68 in-H_2O] or 17 kPa [2.5 psi]? **YES**	7C
	Is the exhaust system back pressure less than 127 mm-Hg [5 in-Hg] or 1763 mm-H_2O [68 in-H_2O] or 17 kPa [2.5 psi]? **NO** **Repair:** Fix or clear the source of high exhaust system restriction.	Repair complete

STEP 7C: Check the engine blowby.

Condition:

None

Action	Specification/Repair	Next Step
Measure the engine blowby. Refer to Procedure 014-005 in Section 14 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Are the engine blowby measurements within specification? **YES**	Return to step 2, or contact a local Cummins® Authorized Repair Location for further diagnostic and troubleshooting instructions.
	Are the engine blowby measurements within specification? **NO**	7C-1

STEP 7C-1: Verify the turbocharger contribution to the engine blowby.

Condition:
- Turn keyswitch OFF.
- Start the engine.

Action	Specification/Repair	Next Step
Verify the turbocharger contribution. • Connect the appropriate orifice to the end of the blowby draft tube. • Remove the turbocharger oil drain line from the block and drain into a bucket. • Load the engine to rated rpm. • Measure the engine blowby. Refer to Procedure 014-005 in Section 14 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Has the total engine blowby dropped more than 30 percent of the total? **YES** **Repair:** Replace the turbocharger assembly. Refer to Procedure 010-033 in Section 10 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Has the total engine blowby dropped more than 30 percent of the total? **NO** **Repair:** The engine may need to be rebuilt. Refer to Procedure 000-001 in Section 0 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271 and the engine rebuild specifications.	Repair complete

STEP 8: Excessive vibration troubleshooting procedures.

STEP 8A: Check the gear ratio and propeller configuration.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for an incorrect matching of the gear ratio and propeller to the engine power. N/A	Are the gear ratio and the propeller incorrectly matched to the engine power? **YES** **Repair:** Contact a Cummins® Distributor or Marine District Field Service Manager.	Repair complete
	Are the gear ratio and the propeller incorrectly matched to the engine power? **NO**	8B

STEP 8B: Check for the correct engine mounting isolators and for proper installation requirements.

Condition:

None

Action	Specification/Repair	Next Step
Check for the correct engine mount isolators and for propeller installation requirements. N/A	Are the engine mount isolators correct and installed correctly? **YES**	8C
	Are the engine mount isolators correct and installed correctly? **NO** **Repair:** Check for proper isolator installation requirements. Replace and repair vibration isolators as needed. Refer to Procedure 016-026 in Section 16 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271 and Engine Mounting/Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649. If the isolators are not manufactured by Cummins Inc., refer to the OEM service manual.	Repair complete

STEP 8C: Check for damaged engine mounts and isolators.

Condition:

None

Action	Specification/Repair	Next Step
Inspect the engine mount and isolators for failure. N/A	Are the engine mounts and isolators in good condition? **YES**	8D
	Are the engine mounts and isolators in good condition? **NO** **Repair:** Remove and replace the engine mount isolators. Refer to Procedure 016-026 in Section 16 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271 and Engine Mounting/Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649. If the isolators are not manufactured by Cummins Inc., refer to the OEM service manual.	Repair complete

STEP 8D: Check the exhaust system.

Condition:

None

Action	Specification/Repair	Next Step
Check for exhaust system deficiencies. N/A	Is the exhaust system deficient? **YES** **Repair:** Repair or replace as needed. See the Exhaust System section in the Marine Recreational Installation Directions, Bulletin 3884649 and the OEM service manual and instructions.	Repair complete
	Is the exhaust system deficient? **NO**	8E

STEP 8E: Check the engine driven accessories.

Condition:
- Turn keyswitch ON.
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for engine driven accessories malfunctions. Isolate or disconnect the accessories and check for vibration. Do **not** operate the engine if the sea water pump is disconnected.	Is an engine driven accessory malfunctioning? **YES** **Repair:** Determine the cause of the malfunctioning accessories and correct the problem. See the Engine Driven Accessories section in the Marine Recreational Installation Directions, Bulletin 3884649. If the accessory is **not** installed by Cummins Inc., refer to the OEM service manual.	Repair complete
	Is an engine driven accessory malfunctioning? **NO**	8F

STEP 8F: Check the shaft coupling to gear coupling alignment.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the shaft coupling to gear coupling alignment. N/A	Is the shaft coupling to gear coupling misaligned? **YES** **Repair:** Repair or replace as needed. Refer to Procedure 016-025 in Section 16 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271 and Engine Mounting/Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649, and the gear manufacturer's recommendations.	Repair complete
	Is the shaft coupling to gear coupling misaligned? **NO**	8G

STEP 8G: Check the propeller shaft for proper installation.

Condition:

None

Action	Specification/Repair	Next Step
Check the propeller shaft for proper installation. N/A	Is the propeller shaft installed correctly? **YES**	8H
	Is the propeller shaft installed correctly? **NO** **Repair:** Repair or replace as needed. Refer to Procedure 016-025 in Section 16 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271 and Engine Mounting/Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649, and the gear manufacturer's recommendations.	Repair complete

STEP 8H: Check the propeller shaft for straightness.

Condition:

None

Action	Specification/Repair	Next Step
Check the propeller shaft for straightness. N/A	Is the propeller shaft straightness within the OEM specification? **YES**	8I
	Is the propeller shaft straightness within the OEM specification? **NO** **Repair:** Repair or replace the propeller shaft as needed. Contact a Cummins® Authorized Repair Location.	Repair complete

STEP 8I: Isolate the engine.

Condition:
- Turn keyswitch ON.
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Operate the engine without the drive shaft attached at the coupler. N/A	Does the engine vibration persist? **YES** **Repair:** Check the engine vibration damper for damage. Repair or replace as needed. Refer to Procedure 001-052 in Section 1 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Does the engine vibration persist? **NO**	8J

STEP 8J: Check for strut/cutlass bearing misalignment.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for strut/cutlass bearing misalignment or strut mounting is **not** secure. N/A	Is the strut/cutlass bearing misaligned or strut mounting **not** secure? **YES** **Repair:** Check the strut for mounting stiffness. Repair or replace as needed. Contact a Authorized Cummins® Repair Location.	Repair complete
	Is the strut/cutlass bearing misaligned or strut mounting **not** secure? **NO**	8K

STEP 8K: Check the propeller.

Condition:

None

Action	Specification/Repair	Next Step
Check for propeller out-of-balance or propeller **not** fitted properly to shaft. N/A	Is the propeller out of balance or **not** fitted properly to the shaft? **YES** **Repair:** Check the propeller for accuracy. Repair or replace as needed. Contact a Cummins® Authorized Repair Location	Repair complete
	Is the propeller out of balance or **not** fitted properly to the shaft? **NO**	8L

STEP 8L: Check the V-angle on the V-strut.

Condition:

None

Action	Specification/Repair	Next Step
Check to see if the V-angle on the V-strut does **not** match the angle of the blade on the prop. N/A	Does the V-angle on the V-strut match the angle of the blade on the prop? **YES**	8M
	Does the V-angle on the V-strut match the angle of the blade on the prop? **NO** **Repair:** Repair or replace as needed. Contact a Cummins® Authorized Repair Location	Repair complete

STEP 8M: Check the propeller tunnels.

Condition:

None

Action	Specification/Repair	Next Step
Check if the propeller tunnels are properly matched with the propellers. N/A	Does the entry and exit of the propeller tunnel match with the propeller blades? **YES**	8N
	Does the entry and exit of the propeller tunnel match with the propeller blades? **NO** **Repair:** Repair or replace as needed. Contact a Cummins® Authorized Repair Location	Repair complete

STEP 8N: Check the engine to transmission torsional coupling.

Condition:

None

Action	Specification/Repair	Next Step
Check for incorrect or worn torsional coupling. N/A	Is the torsional coupling incorrect or worn? **YES** **Repair:** Replace the coupling. Refer to the OEM service manual.	Repair complete
	Is the torsional coupling incorrect or worn? **NO**	8O

STEP 8O: Check the rudder.

Condition:

None

Action	Specification/Repair	Next Step
Check the rudder for excessive play in the rudder post. N/A	Does the rudder have excessive play in the rudder post? **YES** **Repair:** Repair or replace as needed. Contact a Cummins® Authorized Repair Location	Repair complete
	Does the rudder have excessive play in the rudder post? **NO**	8P

STEP 8P: Check the engine flywheel housing to cylinder block alignment.

Condition:

None

Action	Specification/Repair	Next Step
Check the engine flywheel housing to cylinder block alignment. N/A	Is the flywheel housing alignment incorrect? **YES** **Repair:** Realign the flywheel housing to cylinder block. Refer to Procedure 016-006 in Section 16 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271.	Repair complete
	Is the flywheel housing alignment incorrect? **NO** **Repair:** The engine might have internal damage that has **not** been detected. Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-083 in Section 7 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271. The engine might need to be rebuilt. Refer to Procedure 000-001 in Section 0 in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Series Engines Service Manual, Bulletin 4021271 and the engine rebuild specifications. If the engine is **not** damaged, the problem might be the vessel design. Contact a Cummins Authorized Repair Location	Repair complete

Engine Performance Troubleshooting Tree for QSC and QSL Marine Engines with CM850 ECM

This troubleshooting procedure should be followed for the following symptoms:

- Engine Acceleration or Response Poor
- Cranking Fuel Pressure is Low
- Engine Operating Fuel Pressure is Low
- Engine Decelerates Slowly
- Engine Difficult to Start or Will Not Start (Exhaust Smoke)
- Engine Difficult to Start or Will Not Start (No Exhaust Smoke)
- Engine Power Output Low
- Engine Runs Rough at Idle
- Engine Runs Rough or Misfires
- Engine Speed Surges at Low or High Idle
- Engine Speed Surges Under Load or in Operating Range
- Smoke, Black - Excessive
- Smoke, White - Excessive
- Engine Shuts Off or Dies Unexpectedly or Dies During Deceleration
- Engine Starts But Will Not Keep Running
- Engine Will Not Reach Rated Speed (rpm)
- Intake Manifold Pressure (Boost) is Below Normal
- Excessive Vibration in Marine Applications

How to Use This Troubleshooting Procedure:

This symptom tree can be used to troubleshoot all performance based symptoms listed above. Start by performing Step 1 troubleshooting. Step 2 will ask a series of questions and will provide a list of troubleshooting steps to perform depending on the symptom. Perform the list of troubleshooting in the sequence shown in the Specifications/Repair section of the tree.

Shop Talk:

Operational is a term that in general describes vessel performance on the water. Operational problems for an engine can be caused by several different factors. Some of the factors are engine-related and some are **not**. Before troubleshooting, it is important to determine the exact complaint and whether the engine has a real operational problem or if it simply does **not** meet owner expectations.

Low power is a term that is used in the field to describe many different performance problems. Low power is defined as the inability of the engine to produce the power necessary to move the vessel at a speed that can be reasonably expected under the given environment.

Poor acceleration or response is described as the inability of the vessel to accelerate satisfactorily from a stop. It can also be the lag in acceleration at conditions less than rated speed and load. Poor acceleration or response is difficult to troubleshoot, since it can be caused by several factors.

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Perform basic troubleshooting procedures.**		
STEP 1A:	Check for active fault codes or high counts of inactive fault codes.	Active fault codes or high counts of inactive fault codes?	
STEP 1B:	Perform basic troubleshooting checks.	Can the problem be verified?	
STEP 1C:	Perform basic troubleshooting checks.	All steps have been verified to be correct?	
STEP 2:	**Determination of engine symptom.**		
STEP 2A:	Low power, poor acceleration, or poor response.	Is the engine symptom low power, poor acceleration, or poor response?	
STEP 2B:	Engine misfire, engine speed surge, or engine speed unstable.	Is the engine symptom engine misfire, engine speed surge, or engine speed unstable?	
STEP 2C:	Excessive white or black smoke.	Is the engine symptom excessive white or black smoke?	
STEP 2D:	Low intake manifold pressure.	Is the engine symptom low boost pressure	
STEP 2E:	Engine will not start or difficult to start, engine shuts off unexpectedly.	Is the engine symptom engine will not start or difficult to start or engine shuts off unexpectedly?	
STEP 2F:	Engine vibration excessive.	Is the engine symptom Engine Vibration Excessive occurring when the engine is in or out of gear?	
STEP 3:	**Engine starting and running troubleshooting procedures.**		
STEP 3A:	Verify the fuel supply and return valves are open.	Are the fuel supply and return valves in the open position?	
STEP 3A-1:	Check the fuel cooler for damage due to high fuel return back pressure.	Is the fuel cooler damaged or collapsed internally?	
STEP 3B:	Verify the low pressure fuel lines are routed correctly.	Are the low pressure fuel lines connected properly to the ECM cooling plate?	
STEP 3C:	Check the engine speed during cranking.	Is the engine cranking speed greater than 150 rpm?	
STEP 3D:	Check the electronic control module (ECM) keyswitch voltage.	Is the keyswitch voltage equal to battery voltage?	
STEP 3E:	Check the ECM battery supply voltage.	Is the ECM battery supply voltage equal to the battery voltage?	
STEP 3F:	Verify the rail fuel pressure sensor accuracy.	Is the rail fuel pressure sensor (measured) value less than 30 bar [435 psi]?	

STEP 3G:	Check for fuel rail pressure while cranking the engine.	Did Fault Code 2215 or 559 become active during the failed start attempt?
STEP 3G-1:	Check the fuel gear pump pressure.	Is the fuel gear pump pressure greater than 69 kPa [10 psi]?
STEP 3G-2:	Check the fuel lift pump pressure.	Is the fuel lift pump pressure greater than the specifications?

STEP 4: Fuel system troubleshooting procedures.

STEP 4A:	Check for air in the high-pressure pump fuel supply	Is air present in the fuel supply?
STEP 4B:	Measure the fuel inlet restriction	Is the fuel inlet restriction above specification?
STEP 4C:	Perform the single cylinder cutout test.	Can the miss or excessive smoke be attributed to a single cylinder?
STEP 4D:	Perform the cylinder balance diagnostic test.	Does the Cylinder Performance Test identify any cylinder that is contributing to a power imbalance?
STEP 4E:	Measure the fuel drain line restriction.	Is the drain line restriction within specification?

STEP 5: Air handling troubleshooting procedures.

STEP 5A:	Check the intake manifold pressure sensor accuracy.	Is the reading within 101.6 mm-Hg [4 in-Hg] of local barometric pressure?
STEP 5B:	Check the air intake system for leaks.	Were any air intake system leaks found?
STEP 5C:	Check the air intake restriction.	Is the air intake restriction greater than the specification?
STEP 5D:	Inspect the turbocharger blades for damage.	Are the turbocharger blades damaged?
STEP 5E:	Determine if the turbocharger is a waste gated turbocharger.	Is the turbocharger a waste gated turbocharger?
STEP 5F:	Inspect the wastegate actuator hose.	Are holes or cracks found in the wastegate actuator hose?
STEP 5G:	Inspect the turbocharger wastegate capsule for air leaks.	Did the wastegate actuator rod move?
STEP 5G-1:	Inspect the turbocharger wastegate for proper operation.	Did the wastegate actuator rod move?
STEP 5G-2:	Inspect the turbocharger wastegate for proper operation.	Does the wastegate actuator rod move?
STEP 5H:	Measure turbocharger axial and radial clearance.	Are the axial and radial clearances within specification?
STEP 5I:	Inspect the aftercooler.	Is the aftercooler free of cracks or damage?

STEP 6: Electronic feature troubleshooting procedures.

STEP 6A:	Verify the throttle travel.	Does the throttle position read 0 when the throttle is released and

100 percent when the throttle is actuated?

STEP 7: Base engine troubleshooting procedures.

STEP 7A:	Verify the overhead adjustments are correct.	Are the overhead settings within the reset limits?
STEP 7B:	Check the exhaust restriction.	Is the exhaust back pressure less than 75 mm-Hg [3 in-Hg] or 1016 mm-H_2O [40 in-H_2O]?
STEP 7C:	Check the engine blowby.	Are the engine blowby measurements within specification?
STEP 7C-1:	Verify turbocharger contribution to engine blowby.	Has the total engine blowby dropped more than 30% of the total?

STEP 8: Excessive vibration troubleshooting procedures.

STEP 8A:	Check the gear ratio and propeller configuration.	Are the gear ratio and the propeller incorrectly matched to the engine power?
STEP 8B:	Check for correct engine mount isolators and for proper installation requirements.	Are the engine mount isolators correct and installed correctly?
STEP 8C:	Check for damaged engine mounts and isolators.	Are the engine mounts and isolators in good condition?
STEP 8D:	Check the exhaust system.	Is the exhaust system deficient?
STEP 8E:	Check the engine driven accessories.	Is an engine driven accessory malfunctioning?
STEP 8F:	Check the shaft coupling to gear coupling alignment.	Is the shaft coupling to gear coupling misaligned?
STEP 8G:	Check the propeller shaft for proper installation.	Is the propeller shaft installed correctly?
STEP 8H:	Check the propeller shaft for straightness.	Is the propeller shaft straightness within the OEM specification?
STEP 8I:	Isolate the engine.	Does the engine vibration persist?
STEP 8J:	Check for strut/cutlass bearing misalignment.	Is the strut/cutlass bearing misaligned or strut mounting not secure?
STEP 8K:	Check the propeller.	Is the propeller out of balance or propeller not fitted properly to shaft?
STEP 8L:	Check the V-angle on the V-strut.	Does the V-angle on the V-strut match the angle of the blade on the propeller?
STEP 8M:	Check the propeller tunnels.	Does the entry and exit of the propeller tunnel match with the propeller blades?
STEP 8N:	Check the engine to transmission torsional coupling.	Is the torsional coupling incorrect or worn?
STEP 8O:	Check the rudder.	Does the rudder have excessive play in the rudder post?

STEP 8P: **Check the engine flywheel housing to cylinder block alignment.** **Is the flywheel housing alignment incorrect?**

TROUBLESHOOTING STEP

STEP 1: Perform basic troubleshooting procedures.

STEP 1A: Check for active fault codes or high counts of inactive fault codes.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for any active fault codes. • Use INSITE™ electronic service tool to read the fault codes.	Active fault codes or high counts of inactive fault codes? **YES** **Repair:** Reference Section TF in the Troubleshooting and Repair Manual, ISB, ISBe [4], QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, and QSL9 Engines, CM850 Electronic Control System, Bulletin 4021416 for fault code troubleshooting.	Repair complete
	Active fault codes or high counts of inactive fault codes? **NO**	1B

STEP 1B: Perform basic troubleshooting checks.

Condition:

None.

Action	Specification/Repair	Next Step
Verify the following items. • Is the engine operating within the conditions it was intended to perform? For example, wide open throttle rpm, ambient versus engine room temperatures, load on the vessel, sea conditions, etc. • Are the customer's expectations in line with the engine capability? • Is the engine performing according to the OEM sea trial?	Can the problem be verified? **YES**	1C
	Can the problem be verified? **NO** **Repair:** The problem can **not** be verified and no repair is possible.	Repair complete

STEP 1C: Perform the basic troubleshooting checks.

Condition:

None.

Action	Specification/Repair	Next Step
The following items must be checked or verified before continuing. • Verify the fuel level in the tanks. • Verify there have **not** been any changes to the CPL (turbocharger, injectors, pistons, fuel pump, camshaft, etc.) components on the engine. • Verify the fuel grade is correct for the application. • Verify the engine is operating within the recommended altitude. • Verify the engine oil is at the correct level. • Verify none of the air vents are restricted or obstructed. • Verify the engine parasitics have **not** changed. • Verify the engine duty cycle has **not** changed. • Verify the engine cranking speed is greater than 150 rpm. • Verify the battery voltage is adequate. • Verify the drive train is correctly matched to the engine. • Verify the transmission is correct and is **not** malfunctioning. • Verify the propeller is at the correct pitch and is **not** damaged. • Verify the fuel inlet temperature to the fuel pump is within specification. • Verify the engine throttle and throttle wiring is correct for the engine response issues. • Verify the condition of the hull (clean and no damage).	All steps have been verified to be correct? **YES**	2A
	All steps have been verified to be correct? **NO** **Repair:** Correct the condition and verify the complaint is no longer present after the repair.	Repair complete

STEP 2: Determination of engine symptom.

STEP 2A: Low power, poor acceleration, or poor response.

Condition:

None.

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance.	Is the engine symptom low power, poor acceleration, or poor response? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Step 4 - Fuel System Checks • Step 5 - Air Handling Checks • Step 6 - Electronics Checks • Step 7 - Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom low power, poor acceleration, or poor response? **NO**	2B

STEP 2B: Engine misfire, engine speed surge, or engine speed unstable.

Condition:

None.

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance.	Is the engine symptom engine misfire, engine speed surge, or engine speed unstable? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Step 4 - Fuel System Checks • Step 5 - Air Handling Checks • Step 6 - Electronics Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom engine misfire, engine speed surge, or engine speed unstable? **NO**	2C

STEP 2C: Excessive white or black smoke.

Condition:

None.

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance.	Is the engine symptom excessive white or black smoke? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Step 5 - Air Handling Checks • Step 4 - Fuel System Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom excessive white or black smoke? **NO**	2D

STEP 2D: Low intake manifold pressure.

Condition:

None.

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance.	Is the engine symptom low boost pressure? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Step 5 - Air Handling Checks • Step 4 - Fuel System Checks • Step 7 - Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom low boost pressure? **NO**	2E

STEP 2E: Engine will not start or difficult to start, engine shuts off unexpectedly.

Condition:

None.

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance.	Is the engine symptom engine will **not** start or difficult to start, engine shuts off unexpectedly? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Step 3 - No Start Checks • Step 4 - Fuel System checks • Step 5 - Air Handling Checks • Step 6 - Electronics Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom engine will **not** start or difficult to start, engine shuts off unexpectedly? **NO**	Return to the correct symptom tree.

STEP 2F: Engine vibration excessive.

Condition:

None.

Action	Specification/Repair	Next Step
Determine the engine symptom according to the engine performance.	Is the symptom Engine Vibration is Excessive occurring when the engine is in or out of gear? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below. • Step 4 - Fuel System Checks • Step 5 - Air Handling Checks • Step 6 - Electronics Checks • Step 7 - Base Engine Checks • Step 8 - Excessive Vibration Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the symptom Engine Vibration is Excessive occurring when the engine is in or out of gear? **NO**	Return to the correct symptom tree.

STEP 3: Engine starting and running troubleshooting procedures.

STEP 3A: Verify the fuel supply and return valves are open.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Verify the fuel supply and return valves are in the open position. If the vessel is new or work has been completed on the vessel, the fuel valves could have been left in the closed position.	Are the fuel supply and return valves in the open position? **YES**	3B
	Are the fuel supply and return valves in the open position? **NO** **Repair:** Turn the fuel supply and return valve to the open position and verify that no engine damage has occurred.	3A-1

STEP 3A-1: Check the fuel cooler for damage due to high fuel return back pressure.

Condition:

None.

Action	Specification/Repair	Next Step
Remove and inspect the fuel cooler. Check for internal damage, or collapsed internally. For QSL9 engines, refer to Procedure 006-062 (Fuel Cooler) in Section 6 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. For QSC8.3 engines, refer to Procedure 008-129 (Marine Gear Oil and Fuel Cooler Assembly) in Section 8 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Is the fuel cooler damaged or collapsed internally? **YES** **Repair:** Remove and replace the fuel cooler. For QSL9 engines, refer to Procedure 006-062 (Fuel Cooler) in Section 6 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. For QSC8.3 engines, refer to Procedure 008-129 (Marine Gear Oil and Fuel Cooler Assembly) in Section 8 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Is the fuel cooler damaged or collapsed internally? **NO**	3B

STEP 3B: Verify the low pressure fuel lines are routed correctly.

Condition:

None.

Action	Specification/Repair	Next Step
It is sometimes possible to get the low pressure fuel lines connected to the ECM cooling plate installed improperly. The top connection to the ECM cooling plate is the inlet and the bottom connection is the outlet. Verify these connections are correct if the low pressure fuel lines have been removed and installed on the engine.	Are the low pressure fuel lines connected properly to the ECM cooling plate? **YES**	3C
	Are the low pressure fuel lines connected properly to the ECM cooling plate? **NO** **Repair:** Properly connect the low pressure fuel lines to the ECM cooling plate. The fuel inlet is the top connection.	Repair complete

STEP 3C: Check the engine speed during cranking.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to monitor Engine Speed while cranking the engine. If the engine does **not** crank at all, reference the Engine Will Not Crank or Cranks Slowly troubleshooting symptom tree in the Troubleshooting and Repair Manual, ISB, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, and QSL9 Engines, CM850 Electronic Control System, Bulletin 4021416.	Is the engine cranking speed greater than 150 rpm? **YES**	3D
	Is the engine cranking speed greater than 150 rpm? **NO** **Repair:** Find and correct the cause for low cranking speed. Check the batteries, engine starting motor and accessory loads. Reference the Engine Will Not Crank or Cranks Slowly troubleshooting symptom tree.	Repair complete

STEP 3D: Check the ECM keyswitch voltage.

Condition:
- Turn keyswitch OFF.
- Disconnect the OEM harness from the ECM.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Measure the signal voltage. • Measure the signal voltage from the keyswitch input SIGNAL wire of the OEM harness to the engine block ground. Measure the keyswitch voltage with the keyswitch in the “ON” position and also with the keyswitch in the “Cranking” position. Refer to the wiring diagram for connector pin identification.	Is the keyswitch voltage equal to the battery voltage? **YES**	3E
	Is the keyswitch voltage equal to the battery voltage? **NO** **Repair:** Repair or replace the keyswitch harness and/or keyswitch. Check the battery connections. The keyswitch harness can be supplied by the OEM.	Repair complete

STEP 3E: Check the ECM battery supply voltage.

Condition:
- Turn the keyswitch OFF.
- Disconnect the ECM power harness from the ECM.

Action	Specification/Repair	Next Step
Measure the voltage. • Measure the voltage from the ECM battery supply (-) to the ECM battery supply (+) pins in the ECM power harness connector. Measure the ECM voltage with the keyswitch in the ON position and also with the keyswitch in the “Cranking” position. Refer to the wiring diagram for connector pin identification.	Is the ECM battery supply voltage equal to the battery voltage? **YES**	3F
	Is the ECM battery supply voltage equal to the battery voltage? **NO** **Repair:** Repair or replace the ECM power harness. Check the battery connections and fuse terminals.	Repair complete

STEP 3F: Verify the rail fuel pressure sensor accuracy.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Monitor the rail fuel pressure sensor. Use INSITE™ electronic service tool to monitor the rail fuel pressure sensor (measured) with the keyswitch ON and the engine **not** running.	Is the rail fuel pressure sensor (measured) value less than 30 bar [435 psi]? **YES**	3G
	Is the rail fuel pressure sensor (measured) value less than 30 bar [435 psi]? **NO** **Repair:** Replace the rail fuel pressure sensor. Refer to Procedure 019-115 (Rail Fuel Pressure Sensor) in Section 19 in the Troubleshooting and Repair Manual, ISB, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, and QSL9 Engines, CM850 Electronic Control System, Bulletin 4021416.	Repair complete

STEP 3G: Check for fuel rail pressure while cranking the engine.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Check for fuel rail pressure. • Attempt to start the engine by engaging the engine starter for at lease 30 continuous seconds. • Use INSITE™ electronic service tool to monitor the Fuel Rail pressure (Measured) and Fuel Rail Pressure (Commanded). • Use INSITE™ electronic service tool to read the fault codes. Attempting to start the engine for 30 continuous seconds allows the fault code logic time to run. If either Fault Code 2215 or 559 becomes active, then fuel rail pressure is **not** being developed. Refer to Bulletin 4021416 Troubleshooting and Repair Manual, ISB, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, and QSL9 Engines, CM850 Electronic Control System. If the engine starts during this attempt, it is possible that fuel prime to the high pressure pump has been lost. Look for loose fuel lines or filters that allow for loss of fuel prime.	Did either Fault Code 2215 or 559 become active during the failed start attempt? **YES**	3G-1
	Did either Fault Code 2215 or 559 become active during the failed start attempt? **NO**	4A

STEP 3G-1: Check the fuel gear pump pressure.

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Install a pressure gauge at the pressure side fuel filter head. • Measure the fuel gear pump output pressure while cranking the engine. Refer to Procedure 005-025 (Fuel Pump Gear Pump) in Section 5 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Cranking speed **must** be greater than 150 rpm.	Is the fuel gear pump pressure greater than 69 kPa [10 psi] while cranking? **YES** **Repair:** Follow Fault Code 2215 troubleshooting tree. Refer to Bulletin 4021416 Troubleshooting and Repair Manual, ISB, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, and QSL9 Engines, CM850 Electronic Control System.	Repair complete
	Is the fuel gear pump pressure greater than 69 kPa [10 psi] while cranking? **NO**	3G-2

STEP 3G-2: Check the fuel lift pump pressure.

Condition:
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Install a pressure gauge at the inlet port of the fuel pump. • Measure the fuel lift pump output pressure. Refer to Procedure 005-045 (Fuel Lift Pump) in Section 5 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. At initial key-on, the lift pump will run for 60 seconds then stop. The lift pump will run for 30 seconds at key-on and 30 seconds after starting the engine.	Is the fuel lift pump pressure greater than the specifications? **YES** **Repair:** Replace the fuel pump. Refer to Procedure 005-025 (Fuel Pump Gear Pump) in Section 5 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Is the fuel lift pump pressure greater than the specifications? **NO** **Repair:** Replace the fuel lift pump. Refer to Procedure 005-045 (Fuel Lift Pump) in Section 5 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete

STEP 4: Fuel system troubleshooting procedures.

STEP 4A: Check for air in the high pressure pump fuel supply.

Condition:

None.

Action	Specification/Repair	Next Step
Check for air in the fuel. Refer to Procedure 006-003 (Air in Fuel) in Section 6 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Is air present in the fuel supply? **YES** **Repair:** Locate and correct the cause of air ingestion in the fuel supply system. Sources of air ingestion include loose fuel filters, loose fuel line fittings, loose or cracked fuel tank stand-pipes, or severe restrictions in the fuel supply lines and filters.	Repair complete
	Is air present in the fuel supply? **NO**	4B

STEP 4B: Measure the fuel inlet restriction.

Condition:

None.

Action	Specification/Repair	Next Step
Measure the fuel inlet restriction at the customer connection. Refer to Procedure 006-020 (Fuel Inlet Restriction) in Section 6 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Maximum fuel inlet restriction at the customer connection. • New filter: 63.5 mm-Hg [2.5 in-Hg] • Dirty Filter: 101.6 mm-Hg [4.0 in-Hg]	Is the fuel inlet restriction above specification? **YES** **Repair:** Find and correct the cause of high fuel inlet restriction. Look for plugged OEM fuel filters or screens, a restricted ECM cooler, restricted lift pump bypass check valve (in the ECM cooler), pinched OEM fuel lines, or a restricted stand pipe in the OEM fuel tank.	Repair complete
	Is the fuel inlet restriction above specification? **NO** **Repair:** Replace the fuel gear pump. Refer to Procedure 005-025 (Fuel Pump Gear Pump) in Section 5 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete

STEP 4C: Perform the single cylinder cutout test.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.
- Start the engine and run at low idle.

Action	Specification/Repair	Next Step
Perform the single cylinder cutout test. • Operate the engine at load. • Use INSITE™ electronic service tool to perform the Cylinder Cutout test. Disable individual injectors.	Can the miss or excessive smoke be attributed to a single cylinder? **YES** **Repair:** Look for a cause of the complaint including valve lash and excessive crankcase pressure that can indicate power cylinder damage, or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder that was identified using the single cylinder cutout test. Refer to Procedure 006-026 (Injector) in Section 6 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Can the miss or excessive smoke be attributed to a single cylinder? **NO**	4D

STEP 4D: Perform the cylinder balance diagnostic test.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Perform the cylinder balance diagnostic test. • Use INSITE™ electronic service tool to perform the Cylinder Performance Test. Determine if a single cylinder is contributing to the engine symptom.	Does the Cylinder Performance Test identify any cylinder that is contributing to a power imbalance? **YES** **Repair:** Look for a cause of the power imbalance including valve lash and excessive crankcase pressure that can indicate power cylinder damage or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder contributing to the power imbalance. Refer to Procedure 006-026 (Injector) in Section 6 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Does the Cylinder Performance Test identify any cylinder that is contributing to a power imbalance? **NO**	4E

STEP 4E: Measure the fuel drain line restriction.

Condition:

None.

Action	Specification/Repair	Next Step
Measure the fuel drain line restriction. Refer to Procedure 006-012 (Fuel Drain Line Restriction) in Section 6 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Is the fuel drain line restriction within specification? **YES**	2A
	Is the fuel drain line restriction within specification? **NO** **Repair:** Look for causes of high drain line restriction, such as kinked or blocked fuel lines.	Repair complete

STEP 5: Air handling troubleshooting procedures.

STEP 5A: Check the intake manifold pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine OFF.

Action	Specification/Repair	Next Step
Monitor the reading for intake manifold pressure with the engine off. • Start INSITE™ electronic service tool data/ logger and monitor the INSITE™ electronic service tool reading for intake manifold pressure with the engine off. • Compare the pressure readings observed in INSITE™ electronic service tool to the local barometric pressure. Refer to Procedure 018-028 (Barometric Pressure at Altitude) in Section V.	Is the intake manifold pressure reading less than 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **YES**	5B
	Is the intake manifold pressure reading less than 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **NO** **Repair:** Replace the intake manifold pressure sensor. Refer to Procedure 019-061 (Intake Manifold Pressure Sensor) in Section 19 in the Troubleshooting and Repair Manual, ISB, ISBe4, QSB4.5, QSB5.9, QSB6.7, ISC, QSC8.3, ISL, and QSL9 Engines, CM850 Electronic Control System, Bulletin 4021416.	Repair complete

STEP 5B: Check the air intake system for leaks.

Condition:

None.

Action	Specification/Repair	Next Step
Check the air intake system for leaks. Refer to Procedure 010-024 (Air Leaks, Air Intake and Exhaust Systems) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Were any air intake system leaks found? **YES** **Repair:** Repair or replace the damaged component.	Repair complete
	Were any air intake system leaks found? **NO**	5C

STEP 5C: Check the air intake restriction.

Condition:
- Install vacuum gauge Part Number ST-1111-3 into the air intake system.
- Turn keyswitch ON.
- Engine operating at rated speed and full load.

Action	Specification/Repair	Next Step
Measure the intake system restriction. Refer to Procedure 010-031 (Intake Air Restriction) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Maximum air intake restriction: Clean filter: 381 mm-H_2O [15 in-H_2O] Dirty filter: 635 mm-H_2O [25 in-H_2O]	Is the air intake restriction greater than the specification? **YES** **Repair:** Correct the cause of high intake air restriction. Check for plugged air filter or restricted air intake piping.	Repair complete
	Is the air intake restriction greater than the specification? **NO**	5C

STEP 5D: Inspect the turbocharger blades for damage.

Condition:
- Turn keyswitch OFF.
- Remove the intake and exhaust pipes from the turbocharger.

Action	Specification/Repair	Next Step
Inspect the turbocharger. • Inspect the compressor blades and turbine for damage or wear. Refer to Procedure 010-033 (Turbocharger) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Are the turbocharger blades damaged? **YES** **Repair:** Replace the turbocharger assembly. Refer to Procedure 010-033 (Turbocharger) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Are the turbocharger blades damaged? **NO**	5E

STEP 5E: Determine if the turbocharger is a wastegated turbocharger.

Condition:

None.

Action	Specification/Repair	Next Step
Determine if the turbocharger is a wastegated turbocharger.	Is the turbocharger a wastegated turbocharger? **YES**	5F
	Is the turbocharger a wastegated turbocharger? **NO**	5H

STEP 5F: Inspect the wastegate actuator hose.

Condition:
- Turn keyswitch OFF.
- Remove the turbocharger if the wastegate actuator is inaccessible.

Action	Specification/Repair	Next Step
Inspect the integral wastegate actuator hose for cracks or holes. Refer to Procedure 010-050 (Turbocharger Wastegate Actuator) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Are holes or cracks found in the wastegate actuator hose? **YES** **Repair:** Replace the wastegate actuator hose. Refer to Procedure 010-050 (Turbocharger Wastegate Actuator) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Are holes or cracks found in the wastegate actuator hose? **NO**	5G

STEP 5G: Inspect the turbocharger wastegate capsule for air leaks

Condition:
- Engine OFF.
- Remove the wastegate actuator hose from the wastegate actuator.

Action	Specification/Repair	Next Step
Perform a leak test on the wastegate actuator capsule. Use Wastegate Pressure Test Kit, Part Number 3823799, to apply a regulated air supply of 59 in-Hg to the wastegate actuator capsule. No air should be heard (a leaking noise) through a functional wastegate capsule. Refer to Procedure 010-050 (Turbocharger Wastegate Actuator) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Did the wastegate actuator capsule leak air? **YES** **Repair:** Replace the wastegate actuator. Refer to Procedure 010-050 (Turbocharger Wastegate Actuator) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Did the wastegate actuator capsule leak air? **NO**	5G-1

STEP 5G-1: Inspect the turbocharger wastegate for proper operation.

Condition:
- Engine OFF.
- Remove the wastegate actuator hose from the wastegate actuator.

Action	Specification/Repair	Next Step
Check for wastegate actuator rod for movement. Use Wastegate Pressure Test Kit, Part Number 3823799, to apply a regulated air supply of [29 psi] to the wastegate actuator capsule. Check for wastegate actuator rod for movement. Refer to Procedure 010-050 (Turbocharger Wastegate Actuator) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Did the wastegate actuator rod move? **YES**	5H
	Did the wastegate actuator rod move? **NO**	5G-2

STEP 5G-2: Inspect the turbocharger wastegate for proper operation.

Condition:
- Engine OFF.
- Remove the e-clip from the wastegate pin and disconnect the actuator rod from the wastegate lever.

Action	Specification/Repair	Next Step
Check for wastegate actuator rod movement with it disconnected from the turbocharger wastegate. Use Wastegate Pressure Test Kit, Part Number 3823799, to apply a regulated air supply of [29 psi] to the wastegate actuator capsule. Check for wastegate actuator rod for movement. Refer to Procedure 010-050 (Turbocharger Wastegate Actuator) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Does the wastegate actuator rod move? **YES** **Repair:** Move the wastegate lever back and forth and check for smooth 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, then replace the turbocharger. Refer to Procedure 010-033 (Turbocharger) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Does the wastegate actuator rod move? **NO** **Repair:** Replace the wastegate actuator. Refer to Procedure 010-050 (Turbocharger Wastegate Actuator) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete

STEP 5H: Measure turbocharger axial and radial clearance.

Condition:
- Engine OFF.
- Disconnect the exhaust and intake connections from the turbocharger.

Action	Specification/Repair	Next Step
Follow the procedure for measuring the axial and radial clearances of the turbocharger. Refer to Procedure 010-033 (Turbocharger) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Are the axial and radial clearances within specification? **YES**	5I
	Are the axial and radial clearances within specification? **NO** **Repair:** Replace the turbocharger assembly. Refer to Procedure 010-033 (Turbocharger) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete

STEP 5I: Inspect the aftercooler.

Condition:

None.

Action	Specification/Repair	Next Step
Inspect the aftercooler.	Is the aftercooler free of cracks or damage? **YES**	2A
	Is the aftercooler free of cracks or damage? **NO** **Repair:** Repair or replace the aftercooler assembly. Refer to Procedure 010-005 (Aftercooler Assembly (Sea Water) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete

STEP 6: Electronic feature troubleshooting procedures.

STEP 6A: Verify the throttle travel.

Condition:
- Connect INSITE™ electronic service tool.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Verify the throttle travel. • Use INSITE™ electronic service tool to monitor the throttle position while fully depressing and releasing the throttle lever.	Does the throttle position read 0 when the throttle is released and 100 percent when the throttle is actuated? **YES**	2A
	Does the throttle position read 0 when the throttle is released and 100 percent when the throttle is actuated? **NO** **Repair:** Determine and correct the cause of the throttle lever restriction.	Repair complete

STEP 7: Base engine troubleshooting procedures

STEP 7A: Verify the overhead adjustments are correct.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Measure the overhead settings. • Measure the overhead settings. Refer to Procedure 003-004 (Overhead Set) in Section 3 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Are the overhead settings within the reset limits? **YES**	7B
	Are the overhead settings within the reset limits? **NO** **Repair:** Adjust the overhead settings. Refer to Procedure 003-004 (Overhead Set) in Section 3 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete

STEP 7B: Check the exhaust restriction.

Condition:

None.

Action	Specification/Repair	Next Step
Install a pressure gauge into the exhaust system just past the turbocharger outlet to check the exhaust system back pressure. Refer to Procedure 011-009 (Exhaust Restriction) in Section 11 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Is the exhaust back pressure less than 75 mm-Hg [3 in-Hg] or 1016 mm-H_2O [40 in-H_2O]? **YES**	7C
	Is the exhaust back pressure less than 75 mm-Hg [3 in-Hg] or 1016 mm-H_2O [40 in-H_2O]? **NO** **Repair:** Fix or clear the source of high exhaust restriction.	Repair complete

STEP 7C: Check the engine blowby.

Condition:

None.

Action	Specification/Repair	Next Step
Measure the engine blowby. Refer to Procedure 014-010 (Crancase Blowby, Measure) in Section 14 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Are the engine blowby measurements within specification? **YES**	Return to Step 2, or contact an authorized Cummins® service representative for further diagnostic and troubleshooting instructions.
	Are the engine blowby measurements within specification? **NO**	7C-1

STEP 7C-1: Verify the turbocharger contribution to the engine blowby.

Condition:
- Turn keyswitch OFF.
- Start the engine.

Action	Specification/Repair	Next Step
Verify the turbocharger contribution. • Connect the appropriate orifice to the end of the blowby draft tube. • Remove the turbocharger oil drain line from the block and drain into a bucket. • Load the engine to rated rpm. • Measure the engine blowby. Refer to Procedure 014-010 (Crancase Blowby, Measure) in Section 14 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Has the total engine blowby dropped more than 30 percent of the total? **YES** **Repair:** Replace the turbocharger assembly. Refer to Procedure 010-033 (Turbocharger) in Section 10 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Has the total engine blowby dropped more than 30 percent of the total? **NO** **Repair:** The engine may need to be rebuilt. Refer to Procedure 000-001 (Engine Removal) in Section 0 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418 and the engine rebuild specifications.	Repair complete

STEP 8: Excessive vibration troubleshooting procedures.

STEP 8A: Check the gear ratio and propeller configuration.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for an incorrect matching of the gear ratio and propeller to the engine power.	Are the gear ratio and the propeller incorrectly matched to the engine power? **YES** **Repair:** Contact a Cummins® Distributor or Marine District Field Service Manager.	Repair complete
	Are the gear ratio and the propeller incorrectly matched to the engine power? **NO**	8B

STEP 8B: Check for the correct engine mounting isolators and for proper installation requirements.

Condition:

None.

Action	Specification/Repair	Next Step
Check for the correct engine mount isolators and for propeller installation requirements.	Are the engine mount isolators correct and installed correctly? **YES**	8C
	Are the engine mount isolators correct and installed correctly? **NO** **Repair:** Check for proper isolator installation requirements. Replace and repair as needed. Refer to Procedure 016-026 (Marine Vibration Isolator) in Section 16 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Reference the Engine Mounting Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649. If isolators are non-Cummins®, refer to the OEM service manual.	Repair complete

STEP 8C: Check for damaged engine mounts and isolators.

Condition:

None.

Action	Specification/Repair	Next Step
Inspect the engine mounts and isolators for failure.	Are the engine mounts and isolators in good condition? **YES**	8D
	Are the engine mounts and isolators in good condition? **NO** **Repair:** Remove and replace the engine mount isolators. Refer to Procedure 016-026 (Marine Vibration Isolator) in Section 16 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Reference the Engine Mounting Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649. If the isolators are non-Cummins®, refer to the OEM service manual.	Repair complete

STEP 8D: Check the exhaust system.

Condition:

None.

Action	Specification/Repair	Next Step
Check for exhaust system deficiencies.	Is the exhaust system deficient? **YES** **Repair:** Repair or replace as needed. Reference the OEM service literature and instructions.	Repair complete
	Is the exhaust system deficient? **NO**	8E

STEP 8E: Check the engine driven accessories.

⚠CAUTION⚠

Some sea water pumps are belt driven. Operating the engine when the sea water pump is disconnected can result in engine damage due to overheating.

Condition:
- Turn keyswitch ON.
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for engine driven accessories malfunctions. Isolate or disconnect the accessories and check for vibration. Do **not** operate the engine if the sea water pump is disconnected.	Is an engine driven accessory malfunctioning? **YES** **Repair:** Determine the cause of the malfunctioning accessories and correct the problem. If the accessory is **not** installed by Cummins Inc., refer to the OEM service manual.	Repair complete
	Is an engine driven accessory malfunctioning? **NO**	8F

STEP 8F: Check the shaft coupling to gear coupling alignment.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the shaft coupling to gear coupling alignment.	Is the shaft coupling to gear coupling misaligned? **YES** **Repair:** Repair or replace as needed. Refer to Procedure 016-025 (Propeller Shaft) in Section 16 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Reference the Engine Mounting Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649. Reference the gear manufacturer's recommendations.	Repair complete
	Is the shaft coupling to gear coupling misaligned? **NO**	8G

STEP 8G: Check the propeller shaft for proper installation.

Condition:

None.

Action	Specification/Repair	Next Step
Check the propeller shaft for proper installation.	Is the propeller shaft installed correctly? **YES**	8H
	Is the propeller shaft installed correctly? **NO** **Repair:** Repair or replace as needed. Refer to Procedure 016-025 (Propeller Shaft) in Section 16 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Reference the Engine Mounting Drive Systems section in the Marine Recreational Installation Directions, Bulletin 3884649. Reference the OEM service literature.	Repair complete

STEP 8H: Check the propeller shaft for straightness.

Condition:

None.

Action	Specification/Repair	Next Step
Check the propeller shaft for straightness.	Is the propeller shaft straightness within the OEM specification? **YES**	8I
	Is the propeller shaft straightness within the OEM specification? **NO** **Repair:** Repair or replace the propeller shaft as needed. Refer to an authorized OEM Service Location.	Repair complete

STEP 8I: Isolate the engine.

Condition:
- Turn keyswitch ON.
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Run the engine without the drive shaft attached at the coupler.	Does the engine vibration persist? **YES** **Repair:** Check the engine vibration damper for damage. Repair or replace as needed. Refer to Procedure 001-052 (Vibration Damper, Viscous) in Section 1 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete
	Does the engine vibration persist? **NO**	8J

STEP 8J: Check for strut/cutlass bearing misalignment.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for strut/cutlass bearing misalignment or strut mounting is not secure.	Is the strut/cutlass bearing misaligned or strut mounting **not** secure? **YES** **Repair:** Check the strut for mounting stiffness. Repair or replace as needed. Refer to an authorized OEM Service Location.	Repair complete
	Is the strut/cutlass bearing misaligned or strut mounting **not** secure? **NO**	8K

STEP 8K: Check the propeller.

Condition:

None.

Action	Specification/Repair	Next Step
Check for propeller out-of-balance or propeller not fitted properly to shaft.	Is the propeller out of balance or **not** fitted properly to the shaft? **YES** **Repair:** Check the propeller for accuracy. Repair or replace as needed. Refer to an authorized OEM Service Location.	Repair complete
	Is the propeller out of balance or **not** fitted properly to the shaft? **NO**	8L

STEP 8L: Check the V-angle on the V-strut.

Condition:

None.

Action	Specification/Repair	Next Step
Check to see if the V-angle on the V-strut does not match the angle of the blade on the propeller.	Does the V-angle on the V-strut match the angle of the blade on the propeller? **YES**	8M
	Does the V-angle on the V-strut match the angle of the blade on the propeller? **NO** **Repair:** Repair or replace as needed. Refer to an authorized OEM Service Location.	Repair complete

STEP 8M: Check the propeller tunnels.

Condition:

None.

Action	Specification/Repair	Next Step
Check to see if the propeller tunnels are properly matched with the propellers.	Does the entry and exit of the propeller tunnel match with the propeller blades? **YES**	8N
	Does the entry and exit of the propeller tunnel match with the propeller blades? **NO** **Repair:** Repair or replace as needed. Refer to an authorized OEM Service Location.	Repair complete

STEP 8N: Check the engine to transmission torsional coupling.

Condition:

None.

Action	Specification/Repair	Next Step
Check for an incorrect or worn torsional coupling.	Is the torsional coupling incorrect or worn? **YES** **Repair:** Replace the coupling. Refer to the OEM service literature.	Repair complete
	Is the torsional coupling incorrect or worn? **NO**	8O

STEP 8O: Check the rudder.

Condition:

None.

Action	Specification/Repair	Next Step
Check the rudder for excessive play in the rudder post.	Does the rudder have excessive play in the rudder post? **YES** **Repair:** Repair or replace as needed. Refer to an authorized OEM Service Location.	Repair complete
	Does the rudder have excessive play in the rudder post? **NO** **Repair:** If the engine is **not** damaged, refer to an authorized OEM Service Location.	8P

STEP 8P: Check the engine flywheel housing to cylinder block alignment.

Condition:

None.

Action	Specification/Repair	Next Step
Check the engine flywheel housing to cylinder block alignment.	Is the flywheel housing alignment incorrect? **YES** **Repair:** Realign the flywheel housing to cylinder block. Refer to Procedure 016-006 (Flywheel Housing) in Section 16 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418.	Repair complete.
	Is the flywheel housing alignment incorrect? **NO** **Repair:** The engine might have internal damage that has **not** been detected. Analyze the oil and inspect the filters to locate an area of probable damage. Refer to Procedure 007-083 (Lubricating Oil Filter and Analysis) in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. The engine might need to be rebuilt. Refer to Procedure 000-001 (Engine Removal) in Section 0 in the ISC, ISCe, QSC8.3, ISL, ISLe3 and QSL9 Troubleshooting and Repair Manual, Bulletin 4021418. Refer to the engine rebuild specifications. If the engine is **not** damaged, the problem might be the vessel design. Refer to an authorized OEM service location.	Repair complete.

Engine Performance Troubleshooting Tree - ISB Engines Equipped with EGR (CM850 Electronic Control System)

This troubleshooting procedure should be followed for the following symptoms:

- Engine Acceleration or Response Poor
- Engine Difficult to Start or Will Not Start (Exhaust Smoke)
- Engine Difficult to Start or Will Not Start (No Exhaust Smoke)
- Engine Power Output Low
- Engine Runs Rough at Idle
- Engine Runs Rough or Misfires
- Engine Speed Surges at Low or High Idle
- Engine Speed Surges Under Load or in Operating Range
- Smoke, Black - Excessive
- Smoke, White - Excessive
- Engine Shuts Off or Dies Unexpectedly or Dies during Deceleration
- Engine Decelerates Slowly
- Engine Starts but Will Not Keep Running
- Engine Will Not Reach Rated Speed (RPM)
- Intake Manifold Pressure (Boost) is Below Normal
- Engine Vibration Excessive

How to Use This Troubleshooting Procedure:

This symptom tree can be used to troubleshoot all performance based symptoms listed above. Start by performing Step 1 troubleshooting. Step 2 will ask a series of questions and will provide a list of troubleshooting steps to perform, depending on the symptom. Perform the list of troubleshooting in the sequence shown in the Specifications/Repair section of the tree.

Many steps will reference using the electronic service to INSITE™ electronic service tool to check for fault codes, perform tests, monitor data, and check features and parameters. It is recommended that INSITE™ electronic service tool remain connected while using this troubleshooting tree to periodically check for fault codes. If any fault codes become active during use of the troubleshooting tree, discontinue using this troubleshooting tree and troubleshoot the active fault code.

This symptom tree often references other procedures and symptom trees. The procedures and symptom trees referenced may not be located in the same service literature as this symptom tree. Use the following procedure for a listing of the service literature available for the engine being serviced.Refer to Procedure 205-001 in Section L.

Shop Talk:

Driveability is a term that in general describes vehicle performance on the road. Driveability problems for an engine can be caused by several different factors. Some of the factors are engine-related and some are **not**. Before troubleshooting, it is important to determine the exact complaint and whether the engine has a real driveability problem or if it simply does not meet driver expectations.

Low power is a term that is used in the field to describe many different performance problems. Low power is defined as the inability of the engine to produce the power necessary to move the vehicle at a speed that can be reasonably expected under the given conditions of load, grade, wind, and so on. With industrial equipment, low power might reference the inability of the equipment to pick up or maintain load.

Poor acceleration or response is described as the inability of the vehicle to accelerate satisfactorily from a stop or from the bottom of a grade. It can also be the lag in acceleration during an attempt to pass or overtake another vehicle at conditions less than rated speed and load. Poor acceleration or response is difficult to troubleshoot since it can be caused by several factors.

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Perform basic troubleshooting procedures.**		
STEP 1A:	Check for active fault codes or high counts of inactive fault codes.	Active fault codes or high counts of inactive fault codes?	
STEP 1B:	Perform basic troubleshooting checks.	All steps have been verified to be correct?	
STEP 2:	**Determination of engine symptom.**		
STEP 2A:	Engine Difficult to Start or Will Not Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies during Deceleration, or Engine Starts but Will Not Keep Running.	Is the engine symptom Engine Difficult to Start or Will Not Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies during Deceleration, or Engine Starts but Will Not Keep Running?	
STEP 2B:	Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range.	Is the engine symptom Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range?	
STEP 2C:	Excessive white smoke.	Is the engine symptom Smoke, Black Excessive?	
STEP 2D:	Excessive white smoke.	Is the engine symptom Smoke, White Excessive?	
STEP 2D-1:	Excessive white smoke.	Is the engine using coolant?	
STEP 2D-2:	Excessive white smoke.	Is the white smoke excessive complaint only occurring when the engine is cold and during cold ambient conditions?	
STEP 2E:	Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, or Engine Will Not Reach Rated Speed (RPM).	Is the engine symptom Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will Not Reach Rated Speed (RPM)?	
STEP 2F:	Intake Manifold Pressure (Boost) is Below Normal	Is the engine symptom Engine Vibration Excessive?	
STEP 3:	**Engine will Not Start or Stalls Troubleshooting Procedures.**		
STEP 3A:	Verify the operation of cold weather starting aids.	Are the necessary cold weather starting aids are being used and are operational as required?	
STEP 3B:	Check electronic features and programmable parameters.	Are electronic features and programmable parameters the cause for the engine shutting down or the no-start complaint?	
STEP 3C:	Monitor the engine speed during cranking.	Is the engine speed greater than 150 rpm during cranking?	

STEP 3D:	Monitor the ECM Keyswitch Input.	Does the User Fueling State indicate Cranking or is the keyswitch voltage equal to battery voltage?
STEP 3E:	Monitor the ECM Battery Supply.	Is the ECM battery supply voltage greater than +11-VDC for 12 volt systems or +22-VDC for 24 volt systems?
STEP 3F:	Check the Load Carrying Capabilities of the ECM Power and Ground Circuits.	Do the headlights illuminate brightly?
STEP 3G:	Check orientation of connector.	Is the sensor correctly installed?
STEP 3H:	Verify rail fuel pressure sensor accuracy.	Is the Fuel Rail Pressure (measured) less than 30 bar [435]?
STEP 3I:	Monitor fuel rail pressure while cranking the engine.	Did the Fuel Rail Pressure (measured) equal the Fuel Rail Pressure (commanded)?

STEP 4: Fuel system troubleshooting procedures.

STEP 4A:	Check for air in the fuel supply line.	Is air present in the fuel supply?
STEP 4B:	Measure fuel flow/pressure at the inlet of the on engine fuel filter.	Was the pressure/flow measured within the specification?
STEP 4C:	Measure the fuel inlet restriction.	Is the fuel inlet restriction greater than the specification?
STEP 4D:	Check if the engine is equipped with a lift pump voltage regulator	Is the engine equipped with a lift pump voltage regulator?
STEP 4E:	Measure fuel pressure at the outlet of the on engine fuel filter.	Is the pressure drop across the filter greater than the specification?
STEP 4F:	Perform INSITE™ electronic service tool single cylinder cut-out test.	Can the miss or excessive smoke be attributed to a single cylinder?
STEP 4G:	Perform a manual single cylinder cut-out test.	Did the engine start after blocking off a cylinder(s) or can the miss or excessive smoke be attributed to a cylinder(s)?
STEP 4H:	Measure the injector return fuel drain flow from the cylinder head.	Is injector fuel drain flow from the cylinder head greater than specification?
STEP 4I:	Determine which cylinder(s) is causing excessive injector fuel drain flow from the cylinder head.	Did blocking off a cylinder(s) decrease the flow rate below the maximum specified flow rate?
STEP 4J:	Monitor Commanded Fuel Rail Pressure and Measured Fuel Rail Pressure.	Does the Measured Fuel Rail Pressure vary more than ± 35 bar [± 500 psi] from the Commanded Fuel Rail Pressure?
STEP 4K:	Check the fuel pressure relief valve for excessive leakage.	Is the fuel pressure relief valve within specification?

STEP 4L:	Measure the high-pressure fuel supply pump fuel drain flow.	Is the high pressure fuel supply pump fuel return flow greater than specification?
STEP 4M:	Measure fuel drain line restriction.	Is the drain line restriction less than specification?

STEP 5: Air handling troubleshooting procedures

STEP 5A:	Check intake manifold pressure sensor accuracy.	Intake manifold pressure reading is less than 102 mm-Hg [4 in-Hg]?
STEP 5B:	Check the Air intake System for Leaks.	Were any air intake system leaks found?
STEP 5C:	Check air intake restriction.	Is the air intake restriction greater than the specification?
STEP 5D:	Inspect the turbocharger blades for damage.	Damage found on the turbocharger blades?
STEP 5E:	Determine if the turbocharger is a variable geometry turbocharger.	Is the turbocharger a variable geometry turbocharger?
STEP 5F:	Perform INSITE™ electronic service tool turbocharger actuator test.	Does the turbocharger pass the turbocharger actuator test?
STEP 5G:	Inspect the wastegate actuator hose.	Holes or cracks found in the wastegate actuator hose?
STEP 5H:	Inspect the turbocharger wastegate capsule for air leaks.	Did the wastegate actuator capsule leak air?
STEP 5H-1:	Inspect the turbocharger wastegate actuator for proper operation.	Does the wastegate actuator rod move?
STEP 5H-2:	Inspect the turbocharger wastegate for proper operation.	Does the wastegate actuator rod move?
STEP 5I:	Measure turbocharger axial and radial clearance.	Are the axial and radial clearances within specification?
STEP 5J:	Inspect the charge-air cooler.	Does the charge-air cooler pass the visual inspection as well as the pressure test and temperature differential test?

STEP 6: EGR System checks.

STEP 6A:	Check for air leaks in the EGR system.	Air leaks found in the EGR connection tubing?
STEP 6B:	Check the EGR temperature sensor accuracy.	Are all temperature readings within 5.6°C or 10°F of each other?
STEP 6C:	Check differential pressure sensor for proper operation.	Is the EGR differential pressure greater than 5 mm-Hg [0.2 in-Hg] when the EGR valve is open greater than 50 percent?
STEP 6D:	Check exhaust gas pressure sensor accuracy.	There is less than a 102 mm-Hg [4 in-Hg] difference between the exhaust pressure sensor reading and the barometric air pressure sensor reading?

STEP 6E:	Perform the INSITE™ electronic service tool EGR valve actuator test.	Does the EGR Valve pass the INSITE™ EGR Valve Actuator Test?
STEP 6F:	Isolate EGR System.	Was the Performance or Excessive Smoke (Black) complaint corrected by disconnecting the EGR valve differential pressure sensor?
STEP 6F-1:	Check the EGR System for Blockage.	Was blockage or excessive carbon build up found in the EGR valve differential pressure sensor and/or intake connection passages?
STEP 6F-2:	Check the EGR system for correct or damaged components.	Was the air intake connection assembled properly with no damage to any components?

STEP 7: Verify electronic features are operating correctly.

STEP 7A:	Verify accelerator (throttle) pedal travel.	Does the throttle position read 0 percent when the accelerator (throttle) is released and 100 percent when the accelerator (throttle) is fully depressed?
STEP 7B:	Monitor the vehicle speed.	Does the vehicle speed read zero when the vehicle is not moving?
STEP 7C:	Verify the electronic feature settings are correct.	Are the electronic features set correctly?
STEP 7D:	Check the temperature sensor accuracy.	Are all temperature readings within 5.6°C or 10°F of each other?
STEP 7E:	Check ambient air pressure sensor accuracy	INSITE™ electronic service tool reading is within 102 mm-Hg [4 in-Hg] of local barometric pressure?

STEP 8: Perform base engine mechanical checks.

STEP 8A:	Verify the overhead adjustments are correct.	Are the overhead settings within the reset limits?
STEP 8B:	Check the exhaust restriction.	Is the exhaust back pressure greater than the specification?
STEP 8C:	Verify the engine crankcase pressure (blowby) is within specification.	Is the engine crankcase pressure (blowby) less than specification?
STEP 8D:	Check for internal engine damage.	Did cutting the oil filter open reveal evidence of internal engine damage?

STEP 9: Excessive vibration checks.

STEP 9A:	Check engine idle speed.	Is the engine idle speed within specification?
STEP 9B:	Check if the feature Fast Idle Warm Up is available and enabled.	Is the feature Fast Idle Warm Up available and enabled?
STEP 9B-1:	Monitor if the Fast Idle Warm Up Status.	Is the feature Fast Idle Warm Up becoming active?

STEP 9C:	**Check front engine driven accessory(s).**	**Did isolating the front engine driven accessory(s) correct the vibration?**
STEP 9D:	**Check the Vibration Damper/ Crankshaft speed indicator ring.**	**Is the vibration damper/ crankshaft speed indicator ring damaged?**
STEP 9E:	**Check the Engine Support Brackets, Mounts and/or Isolators.**	**Are the engine support brackets, mounts and/or isolators or damaged?**
STEP 9F:	**Check engine gear driven accessory(s).**	**Does the engine have an engine gear driven/air compressor driven hydraulic pump?**
STEP 9F-1:	**Isolate engine gear driven accessory(s)**	**Did isolating/removing engine gear driven/air compressor driven hydraulic pump correct the vibration?**
STEP 9F-2:	**Check if the engine is equipped with an air compressor.**	**Is the engine equipped with an engine gear driven air compressor?**
STEP 9F-3:	**Unload the Air Compressor and Operate.**	**Did unloading the air compressor significantly reduce or eliminate the vibration?**
STEP 9F-4:	**Check Air Compressor Timing.**	**Was the air compressor correctly timed to the engine?**
STEP 9G:	**Check/Isolate engine driven components.**	**Did isolating/removing any engine driven component correct the vibration?**
STEP 9H:	**Check the Flywheel Housing Alignment.**	**Is the flywheel housing bore and face runout within specification?**

TROUBLESHOOTING STEP

STEP 1: Perform basic troubleshooting procedures.

STEP 1A: Check for active fault codes or high counts of inactive fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check for an active fault code. • Use INSITE™ electronic service tool to read the fault codes. Reference the corresponding Electronics Troubleshooting and Repair Manual for the engine being serviced. For engines equipped with a CM850 Electronic Control Module, reference Bulletin 4021416.	Active fault codes or high counts of inactive fault codes? **YES** **Repair:** Follow the electronic fault code trees for the appropriate troubleshooting procedures.	Repair complete.
	Active fault codes or high counts of inactive fault codes? **NO**	1B

STEP 1B: Perform basic troubleshooting checks.

Condition:

N/A

Action	Specification/Repair	Next Step
The following items must be checked or verified before continuing: • Verify the fuel level in the tanks. • Verify the vehicle is in good working order • Check if any recent maintenance or service work has been performed • Verify there have **not** been any changes to CPL components on the engine. • Verify fuel grade is correct for the application. • Verify the engine is operating within the recommended altitude. • Verify engine oil is in good condition and at the correct level. • Verify engine parasitics have **not** changed. • Verify engine duty cycle has **not** changed. • Verify the air filter is **not** excessively plugged, by checking the filter minder. • Listen for air and exhaust leaks. • Verify there are no visible external fuel leaks. • Verify there are no visible coolant leaks. • Verify there are no visible signs (soot streaks) of an external EGR leak. • Verify the crankshaft position and the camshaft position sensors are correctly connected to the engine harness.	All steps have been verified to be correct? **YES**	2A
	All steps have been verified to be correct? **NO** **Repair:** Correct the condition and verify complaint is no longer present after repair.	Repair complete.

STEP 2: Determination of engine symptom.

STEP 2A: Engine Difficult to Start or Will Not Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies during Deceleration, or Engine Starts but Will Not Keep Running.

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Engine Difficult to Start or Will **Not** Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies during Deceleration, or Engine Starts but Will **Not** Keep Running? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 3 - Engine will **Not** Start or Stalls Troubleshooting Procedures Step 4 - Fuel System Checks Step 5 - Air Handling Checks Step 7 - Electronics Checks.	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Engine Difficult to Start or Will **Not** Start (With or Without Exhaust Smoke), Engine Shuts Off or Dies Unexpectedly or Dies during Deceleration, or Engine Starts but Will **Not** Keep Running? **NO**	2B

STEP 2B: Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range.

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 4 - Fuel System Checks Step 7 - Electronic Checks Step 5 - Air Handling Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Engine Runs Rough at Idle, Engine Runs Rough or Misfires, Engine Speed Surges at Low or High Idle, Engine Speed Surges under Load or in Operating Range? **NO**	2C

STEP 2C: Smoke, Black - Excessive

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Smoke, Black Excessive? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 6 - EGR System Checks Step 5 - Air Handling Checks Step 4 - Fuel System Checks Step 7 - Electronics Checks Step 8 - Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Smoke, Black Excessive? **NO**	2D

STEP 2D: Smoke, White - Excessive.

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Smoke, White Excessive? **YES**	Step 2D-1
	Is the engine symptom Smoke, White Excessive? **NO**	Step 2E

STEP 2D-1: Smoke, White Excessive.

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. Verify if, along with the white smoke complaint, coolant is being used. Check the coolant level.	Is the engine using coolant? **YES**	Refer to the Coolant Loss - Internal Troubleshooting Symptom (TS) Tree.
	Is the engine using coolant? **NO**	Step 2D-2

STEP 2D-2: Smoke, White Excessive

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. Check if the white smoke excessive complaint is only occurring when the engine is cold and during cold ambient conditions? Some white smoke after a cold start in cold ambient conditions is not uncommon. If white smoke persists once the engine has reached the minimum operating coolant temperature, troubleshoot the white smoke complaint. Minimum Operating Coolant Temperature: 60°C [140°F]	Is the white smoke excessive complaint only occurring when the engine is cold and during cold ambient conditions? **YES** **Repair:** Perform the Checks in Step 3A only Step 4 - Fuel System Checks Step 7 - Electronics Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the white smoke excessive complaint only occurring when the engine is cold and during cold ambient conditions? **NO** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 4 - Fuel System Checks Step 7 - Electronics Checks	Perform the troubleshooting steps suggested in the repair procedure.

STEP 2E: Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will Not Reach Rated Speed (RPM)

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will **Not** Reach Rated Speed (RPM)? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Step 5 - Air Handling Checks Step 4 - Fuel Systems Checks Step 7 - Electronics Checks Step 8 - Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Engine Acceleration or Response Poor, Engine Power Output Low, Engine Decelerates Slowly, Intake Manifold Pressure (Boost) is Below Normal or Engine Will **Not** Reach Rated Speed (RPM)? **NO**	Step 2F

STEP 2F: Engine Vibration Excessive

Condition:

N/A

Action	Specification/Repair	Next Step
Interview the driver and verify the complaint. N/A	Is the engine symptom Engine Vibration Excessive? **YES** **Repair:** Perform the troubleshooting steps in the recommended order listed below: Perform Step 4G and 4H of the Fuel System Checks Only Step 9 - Excessive Vibration Checks Step 8 - Base Engine Checks	Perform the troubleshooting steps suggested in the repair procedure.
	Is the engine symptom Engine Vibration Excessive? **NO**	For engine related symptoms, refer to the correct troubleshooting symptom (TS) tree.

STEP 3: Engine will Not Start or Stalls Troubleshooting Procedures.

STEP 3A: Verify the operation of cold weather aids.

Condition:

- Engine and Ambient Conditions Cold.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Make sure the necessary cold weather aids are being used and are operational as required. Minimum Ambient Air Temperature for Unaided Cold Start is 12.2°C [10°F] The INSITE™ electronic service tool Intake Air Heater Override test can be used to diagnose intake air heater problems. For engines equipped with air intake heaters, the air intake heaters should begin to function at 19°C [66°F].	Are the necessary cold weather starting aids are being used and are operational as required? **YES**	3B
	Are the necessary cold weather starting aids are being used and are operational as required? **NO** **Repair:** Install or repair cold weather starting aids. • For the engine coolant heater, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 008-011 in Section 8. • For the intake air heater(s), use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-029 in Section 10. • For the engine oil heaters, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 007-001 in Section 7. • For any OEM installed cold starting aids (radiator shutters, etc.), refer to the OEM service manual.	Repair complete

STEP 3B: Check electronic features and programmable parameters.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check if the electronic features and programmable parameters are the cause for the engine shutting down or the no-start complaint. The electronic features and programmable parameters include: Idle Shutdown, Engine Protection Shutdown, and Vehicle Anti-theft Protection.	Are electronic features and programmable parameters the cause for the engine shutting down or the no-start complaint? **YES** **Repair:** Program the electronic features per the customer or OEM requirements.	Repair Complete.
	Are electronic features and programmable parameters the cause for the engine shutting down or the no-start complaint? **NO**	Step 3C

STEP 3C: Monitor the engine speed during cranking.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- INSITE™ Monitor.

Action	Specification/Repair	Next Step
Monitor the engine speed. • Use INSITE™ electronic service tool to monitor engine speed while cranking the engine. Attempt to start the engine; engage the engine starter for at least 30 continuous seconds. Do **not** overheat the starter. Attempting to start the engine for 30 continuous seconds also allows the fault code logic time to perform. If any fault codes become active, stop using this troubleshooting tree and reference the corresponding fault code troubleshooting tree.	Is the engine speed greater than 150 rpm during cranking? **YES**	3D
	Is the engine speed greater than 150 rpm during cranking? **NO** **Repair:** Find and correct the cause for low cranking speed. Consider the batteries, engine starting motor, drive units and accessory loads.	Refer to the Engine Will Not Crank or Cranks Slowly (Electric or Air Starter) troubleshooting symptom (TS) tree.

STEP 3D: Monitor the ECM Keyswitch Input.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine **not** operating.

Action	Specification/Repair	Next Step
Monitor User Fueling State. • Use INSITE™ electronic service tool to monitor fuel state while cranking the engine. If the engine is intermittently shutting down, User Fueling State can also be monitored during engine shut down. If the INSITE™ electronic service tool is unavailable: • Disconnect the OEM harness. • Turn keyswitch ON. Measure the signal voltage from the keyswitch input signal wire of the OEM harness to the engine block ground. Measure the keyswitch voltage with the keyswitch in the ON position and also with the keyswitch in the cranking position. Refer to the corresponding wiring diagram for the engine being serviced for connector pin identification.	Does the User Fueling State indicate Cranking or is the keyswitch voltage equal to battery voltage? **YES**	3E
	Does the User Fueling State indicate Cranking or is the keyswitch voltage equal to battery voltage? **NO** **Repair:** Check the keyswitch battery supply circuit. Use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-064 in Section 19. Repair or replace the OEM harness, keyswitch, or check the battery connections. Refer to the OEM service manual for the proper procedures.	Repair complete.

STEP 3E: Monitor the ECM Battery Supply.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine **not** running.

Action	Specification/Repair	Next Step
Monitor battery voltage. • Use INSITE™ electronic service tool to monitor battery voltage while cranking the engine. If the INSITE™ electronic service tool is unavailable: • Disconnect the ECM power supply connection. • Turn keyswitch ON. Measure the voltage from the ECM battery supply (-) pin(s) to the ECM battery supply (+) pin(s) in the ECM connector. Measure the ECM voltage with the keyswitch in the ON position and also with the keyswitch in the cranking position. Refer to the corresponding wiring diagram for the engine being serviced for connector pin identification.	Is the ECM battery supply voltage greater than +11-VDC for 12 volt systems or +22-VDC for 24 volt systems? **YES**	3F
	Is the ECM battery supply voltage greater than +11-VDC for 12 volt systems or +22-VDC for 24 volt systems? **NO** **Repair:** Repair or replace the ECM power and ground connections. Check the battery connections and fuse terminals.	Repair complete.

STEP 3F: Check the Load Carrying Capabilities of the ECM Power and Ground Circuits.

Condition:
- Turn keyswitch OFF.
- Disconnect the ECM Power Supply Connection.

Action	Specification/Repair	Next Step
Connect a headlight (12 volt or 24 volt systems) A headlight **must** be used to make sure that the wattage rating will put enough of a load on the circuit. Use the ECM battery SUPPLY (+) pin in the ECM power supply connection for the battery positive (+) and the ECM battery SUPPLY (-) pin in the ECM power harness connector for the battery negative (-). Refer to the corresponding wiring diagram for the engine being serviced for connector pin identification.	Do the headlights illuminate brightly? **YES**	3G
	Do the headlights illuminate brightly? **NO** **Repair:** Repair or replace the ECM power and ground connections. Check the battery connections and fuse terminals.	Repair complete

STEP 3G: Check orientation of connector.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for the appropriate orientation of the rail fuel pressure sensor connector. Connector can be installed rotated 180 degrees.	Is the sensor correctly installed? **YES**	3H
	Is the sensor correctly installed? **NO** **Repair:** Reorient connector.	4A

STEP 3H: Verify rail fuel pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- INSITE™ electronic service tool monitor.
- Engine **not** operating.

Action	Specification/Repair	Next Step
Monitor the fuel rail pressure. Use INSITE™ electronic service tool to measure the fuel rail pressure.	Is the Fuel Rail Pressure (measured) less than 30 bar (435 psi)? **YES**	3I
	Is the Fuel Rail Pressure (measured) less than 30 bar (435 psi)? **NO**	Repair Complete

STEP 3I: Monitor fuel rail pressure while cranking the engine.

Condition:

- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- INSITE™ electronic service tool monitor.

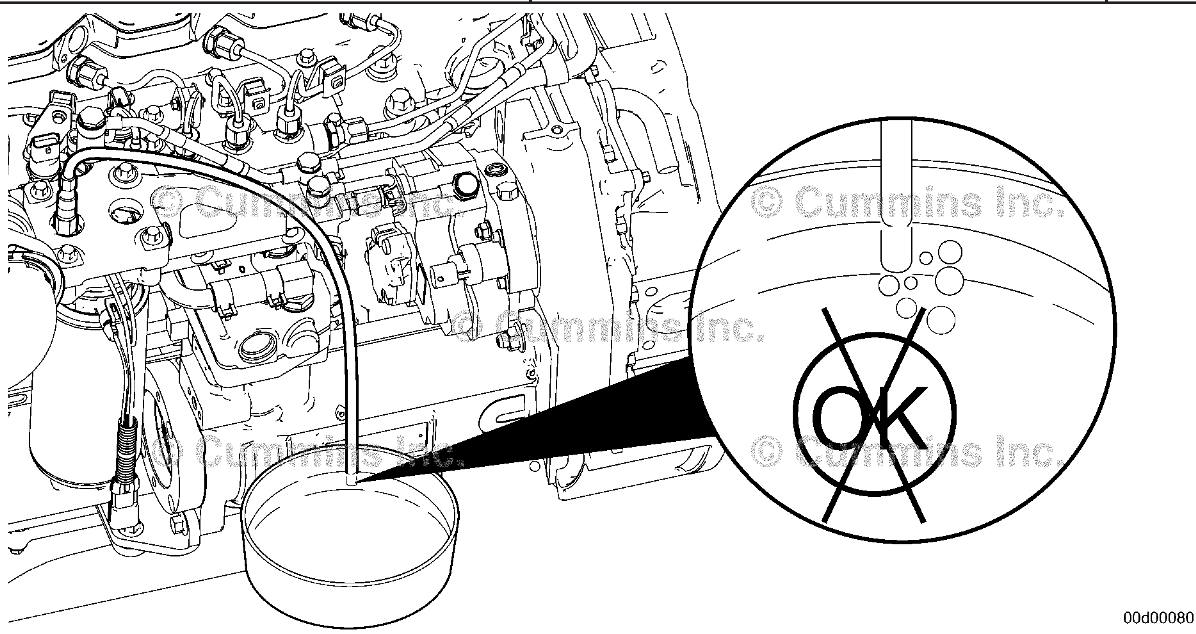
Action	Specification/Repair	Next Step
Monitor Fuel Rail Pressure (measured) and Fuel Rail Pressure (commanded). Use INSITE™ electronic service tool. Fuel Rail Pressure (commanded) can also be referred to as HPCR fuel setpoint. Attempt to start the engine, engage the engine starter for at least 30 continuous seconds. Do **not** overheat the starter. A minimum of 100 bar [1450 psi] of fuel rail pressure is required before the injectors will open and provide fuel. Attempting to start the engine for 30 continuous seconds allows the fault code logic time to run. If Fault Code 2215 or 559 becomes active, adequate fuel rail pressure is **not** being developed. Discontinue using this troubleshooting tree and troubleshoot Fault Code 2215 or 559.	Did the Fuel Rail Pressure (measured) equal the Fuel Rail Pressure (commanded)? **YES**	5A
	Did the Fuel Rail Pressure (measured) equal the Fuel Rail Pressure (commanded)? **NO**	4A

STEP 4: Fuel system troubleshooting procedures.

STEP 4A: Check for air in the fuel supply line.

Condition:
- Turn keyswitch OFF.
- Engine OFF.
- Connect required service tools at the fuel filter head diagnostic port (inlet).
- Turn keyswitch ON.

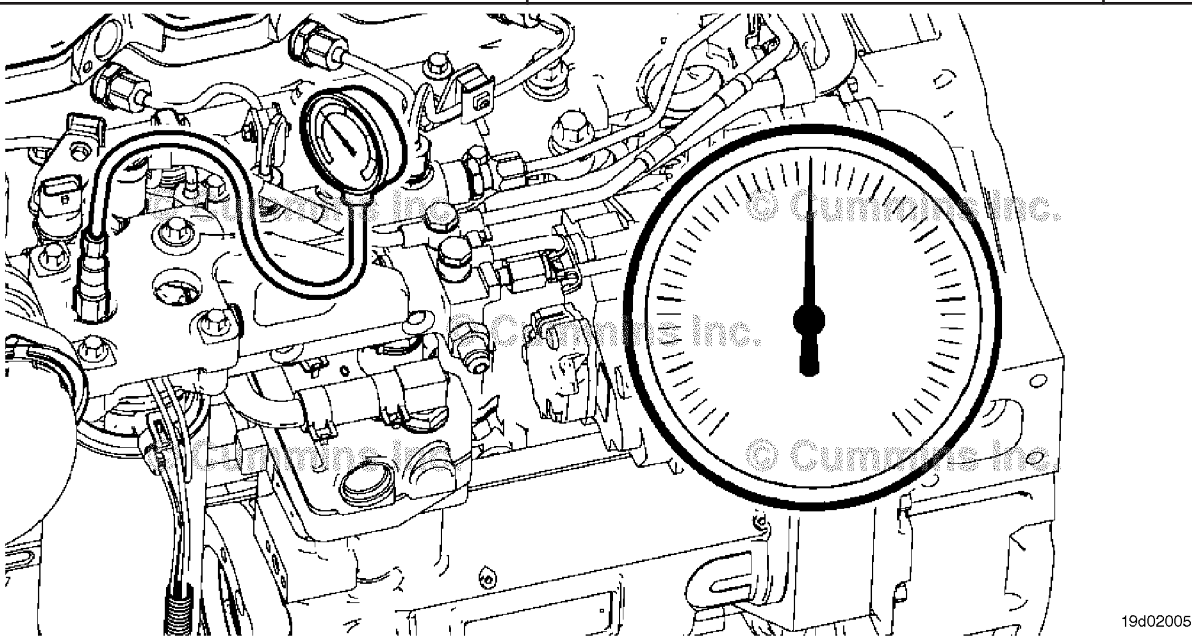
Action	Specification/Repair	Next Step
Check for air in the fuel. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-003 in Section 6. Operate the fuel lift pump. At initial key ON, the lift pump will run for 60 seconds and then turn OFF. The lift pump can also be operated, use INSITE™ electronic service tool lift pump override test.	Is air present in the fuel supply? **YES** **Repair:** Locate and correct the cause of air ingestion in the fuel supply system. Sources of air ingestion include loose fuel filters, loose fuel line fittings, loose or cracked fuel tank stand-pipes, or severe restrictions in the fuel supply lines and filters that cause cavitation at high fuel flow rates.	Repair complete
	Is air present in the fuel supply? **NO**	4B



STEP 4B: Measure fuel flow/pressure at the inlet of the on engine fuel filter.

Condition:
- Turn keyswitch OFF.
- Engine OFF.
- Connect required service tools at the fuel filter head diagnostic port (inlet).
- Turn keyswitch ON.

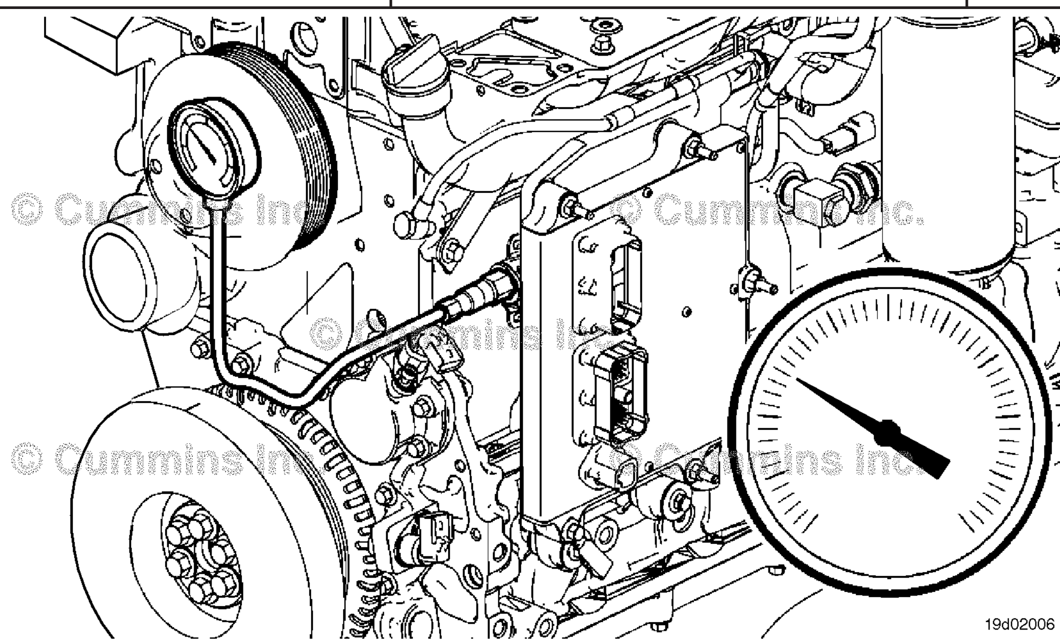
Action	Specification/Repair	Next Step
Measure fuel inlet pressure and flow at the inlet diagnostic port of the fuel filter. Use the following procedure(s) in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-045 in Section 5. Refer to Procedure 006-015 in Section 6. Operate the fuel lift pump. At initial key ON, the lift pump will run for 60 seconds and then turn OFF. The lift pump can also be operated, use INSITE™ electronic service tool lift pump override test. Fuel flow rate for lift pump (engine **not** operating) - greater than 300 ml in 30 seconds. Measure the pressure at **high** idle: • Fuel pressure range lift pump (engine operating) - 0 to 0.8 bar [0 to 11.6 psi]. Record the fuel filter inlet flow and pressure measured.	Was the pressure/flow measured within specification? NOTE: Record the measured fuel inlet pressure for use in the next step. **YES**	4E
	Was the pressure/flow measured within specification? **NO**	4C



STEP 4C: Measure the fuel inlet restriction.

Condition:
- Turn keyswitch OFF.
- Engine OFF.
- Connect required service tools at the fuel lift pump inlet.

Action	Specification/Repair	Next Step
Measure the fuel inlet restriction. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-020 in Section 6. Operate the engine at **high** idle: Maximum inlet restriction - 6 in-Hg (vacuum) 20.3 kPa If the engine will **not** start, operate the lift pump, use INSITE™ electronic service tool Fuel Lift Pump Override Test. If the issue is intermittent (no start or engine shuts off unexpectedly) and no issues can be found while the engine is being serviced, there may be debris in the fuel system causing an intermittent restriction. Install a fuel filter minder, Fleetguard® Part Number 3892576s, at the connection between the OEM fuel supply lines and the engine. A fuel filter minder will capture the peak restriction in millimeters and inches of mercury. If the issue occurs again, the fuel filter minder can be checked to see if there is something on the OEM side causing an intermittent high restriction.	Is the fuel inlet restriction greater than the specification? **YES** **Repair:** Find and correct cause of high inlet restriction. Look for plugged OEM fuel filters or screens, or a restricted ECM cooler, pinched OEM fuel lines or a restricted stand pipe in the OEM fuel tank.	Repair Complete.
	Is the fuel inlet restriction greater than the specification? **NO**	4D

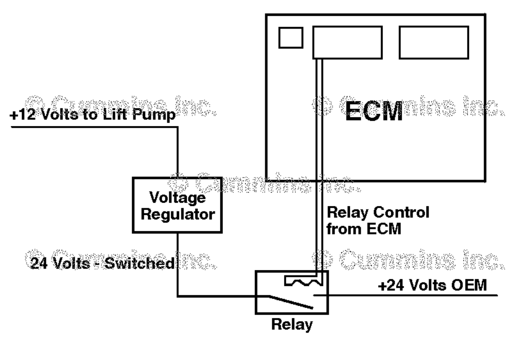


STEP 4D: Check if the engine is equipped with a lift pump voltage regulator.

Condition:

N/A

Action	Specification/Repair	Next Step
Check if the engine is equipped with an on engine voltage regulator to convert 24 volts to 12 volts. This allows for the use of a 12 volt lift pump in a 24 volt engine configuration. If equipped, the voltage regulator is mounted below the ECM.	Is the engine equipped with a lift pump voltage regulator? **YES** **Repair:** If equipped, verify the voltage regulator is operating properly. Replace if necessary. If OK, replace the electric fuel lift pump. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-045 in Section 5.	Repair Complete
	Is the engine equipped with a lift pump voltage regulator? **NO** **Repair:** Replace the electric fuel lift pump. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-045 in Section 5.	Repair Complete



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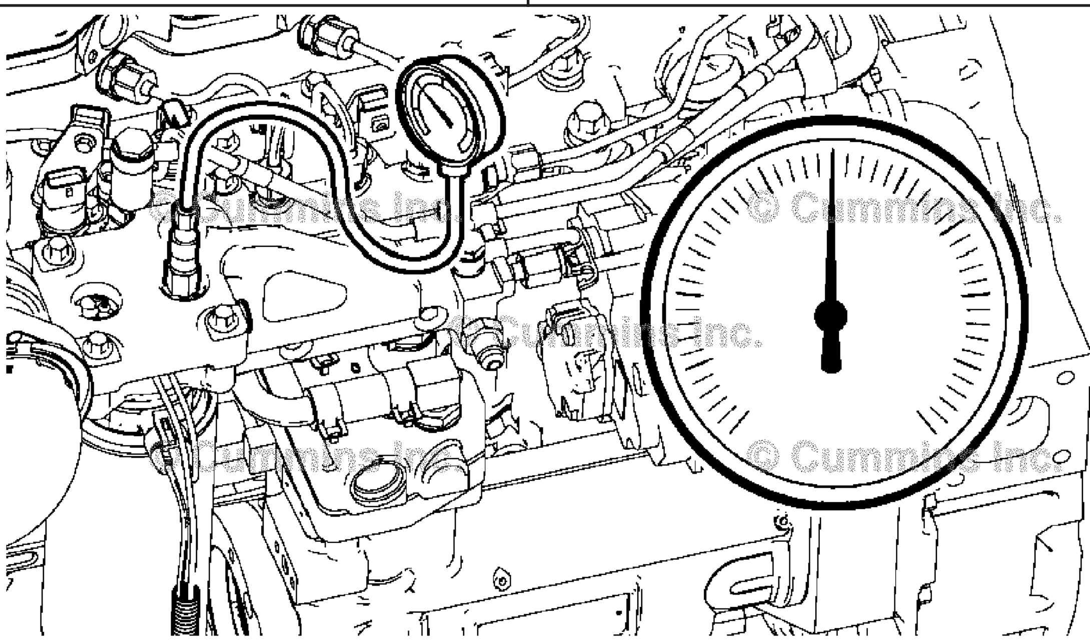
STEP 4E: Measure fuel pressure at the outlet of the on engine fuel filter

Condition:
- Turn keyswitch OFF.
- Connect required service tools at the fuel filter head diagnostic port(outlet).
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Measure fuel outlet pressure outlet diagnostic port of the fuel filter. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-015 in Section 6. Calculate the pressure drop across the fuel filter by subtracting the pressure measured here from the pressure measured in Step 4B. Measure the pressure at **low** idle: • Maximum pressure drop across the fuel filter - 0.35 bar [5 psi]. If the engine will **not** start, use INSITE™ electronic service tool Fuel Lift Pump Override Test to operate the lift pump.	Is the pressure drop across the filter greater than the specification? **YES** **Repair:** Replace the fuel filter. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-015 in Section 6.	Repair complete
	Is the pressure drop across the filter greater than the specification? **NO**	4F



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STEP 4F: Perform INSITE™ electronic service tool single cylinder cutout test.

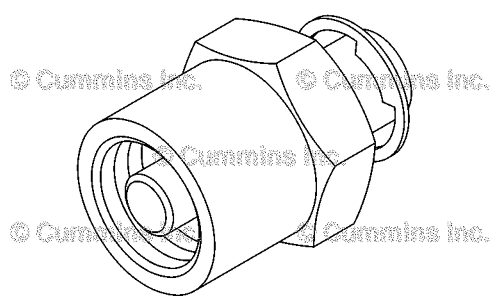
Condition:
- Turn keyswitch ON.
- Engine operating at **low** idle.
- Connect INSITE™ electronic service tool.

<table>
<tr><th>Action</th><th>Specification/Repair</th><th>Next Step</th></tr>
<tr><td rowspan="2">Perform single cylinder cutout test.
If the engine will not start or is difficult to start, move to the next step.
• In the ECM Diagnostic Tests menu of INSITE™ electronic service tool, click on the Cylinder Cutout Test, and follow the instructions on the screen.
• Operate the engine under the conditions in which the complaint occurs.
• Use INSITE™ electronic service tool to perform the Cylinder Cutout Test to disable individual injectors.
If this test is performed and there is not a significant change while cutting out one injector, there may be a problem with more than one injector. It may be necessary to cut out multiple cylinders at a time.</td><td>Can the miss or excessive smoke be attributed to a single cylinder?
YES
Repair:
Look for a cause of the complaint, including valve lash and excessive crankcase pressure that may indicate power cylinder damage, or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder that was identified using the single cylinder cut-out test. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-026 in Section 6.</td><td>Repair complete</td></tr>
<tr><td>Can the miss or excessive smoke be attributed to a single cylinder?
NO</td><td>4G</td></tr>
</table>

STEP 4G: Perform a manual single cylinder cut-out test.

Condition:
- Turn keyswitch OFF.
- Install the injector leakage isolation too.
- Turn keyswitch ON.

Action	Specification/Repair	Next Step
Perform a manual cut-out test. • With the engine **not** operating, disconnect the fuel line running from the rail to cylinder number 1. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-051 in Section 6. • Install the injector leakage isolation tools. For 3.9L and 5.9L engines, install the injector leakage isolation tool, Part Number 3164325, on the rail where the number 1 cylinder fuel line connects. Torque Value: 30 N•m [22 ft-lb]. Attempt to start the engine or operate the engine at idle. Repeat the above test, as necessary, with each cylinder blocked off.	Did the engine start after blocking off a cylinder(s) or can the miss or excessive smoke be attributed to a cylinder(s)? **YES** **Repair:** Look for a cause of the complaint, including valve lash and excessive crankcase pressure that can indicate power cylinder damage or camshaft lobe wear. If no other damage is found, replace the fuel injector in the cylinder that was identified using the manual single cylinder cut-out test. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-051 in Section 6.	Repair complete
	Did the engine start after blocking off a cylinder(s) or can the miss or excessive smoke be attributed to a cylinder(s)? **NO**	4H



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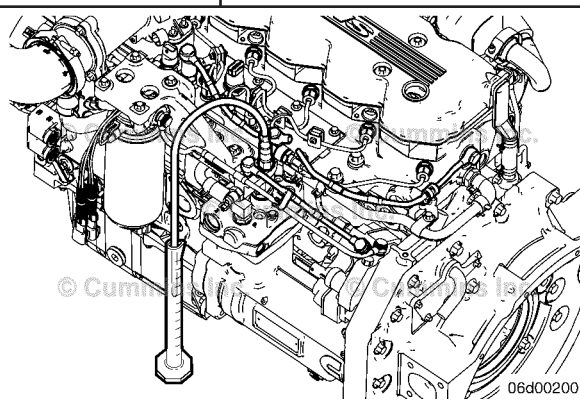
STEP 4H: Measure the injector return fuel drain flow from the cylinder head.

Condition:
- Turn keyswitch OFF.
- Connect appropriate service tools to measure injector fuel drain flow from the cylinder head.

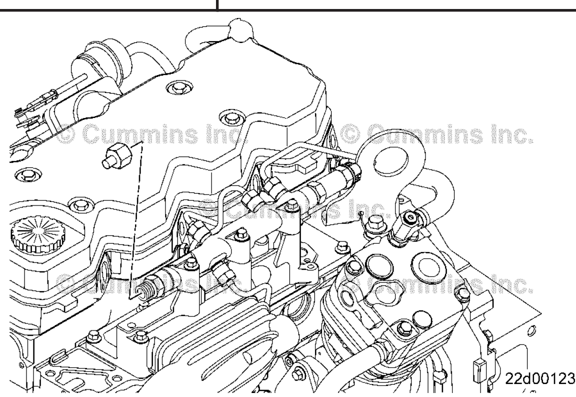
Action	Specification/Repair	Next Step
Measure the injector return fuel drain flow from the cylinder head. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-051 in Section 6. Flow Specification: Idle Conditions 6 cylinder engines - 180 ml/minute [6 fl-oz per minute] maximum Cranking Conditions Make sure **not** to overheat the starter 6 cylinder engines - 90 ml/minute [3 fl-oz per minute] maximum	Is injector fuel drain flow from the cylinder head greater than specification? **YES**	4I
	Is injector fuel drain flow from the cylinder head greater than specification? **NO**	4J



STEP 4I: Determine which cylinder(s) is causing excessive injector fuel drain flow from the cylinder head.

Condition:
- Turn keyswitch OFF.
- Connect appropriate service tools to measure injector fuel drain flow from the cylinder head.
- Install the injector leakage isolation tool.

Action	Specification/Repair	Next Step
Measure the injector return fuel drain flow from the cylinder head and isolate a cylinder one at a time using the injector leakage isolation tool. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-051 in Section 6. The flow rate will decrease below the maximum specified flow when the cylinder with the leak is blocked. Flow Specification: Idle Conditions 6 cylinder engines - 180 ml/ minute [4 fl-oz per minute] maximum. Cranking Conditions Make sure **not** to overheat the starter 6 cylinder engines - 90 ml/minute [3 fl-oz per minute] maximum. If this test is performed and there is not a significant change in fuel return flow while cutting out one injector, there may be a problem with more than one injector. Compare the fuel flow difference across all injectors. Is there more than one injector that caused a noticeable decrease in fuel flow? If so, these could be the injectors with the problems. Another cause of this problem could be that the customer is operating on fuels lighter than specified. Fuels with low viscosity will result in higher injector leakage and greater drain flow rates.	Did blocking off a cylinder(s) decrease the flow rate below the maximum specified flow rate? **YES** **Repair:** Remove the fuel connector and inspect for damage. Replace if necessary. Remove the injector and inspect the fuel connector contact surface for damage. Replace if necessary. Use the following procedure(s) in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-051 in Section 6. Refer to Procedure 006-052 in Section 6.	Repair Complete
	Did blocking off a cylinder(s) decrease the flow rate below the maximum specified flow rate? **NO**	4J



STEP 4J: Monitor Commanded Fuel Rail Pressure and Measured Fuel Rail Pressure.

Condition:
- Turn keyswitch ON.
- Electronic service tool connected.
- Engine idling.

Action	Specification/Repair	Next Step
Use an electronic service tool to monitor Commanded Fuel Rail Pressure and Measured Fuel Rail Pressure while the engine is idling. When monitoring, note whether any engine driven accessory (air conditioning compressor, air compressor, fan clutch, etc.) turns on. Also, note whether any accessories that put demand/load on the alternator (intake air heater, vehicle accessories, etc.). These items can affect the outcome of this check. The load on the engine should be constant.	Does the Measured Fuel Rail Pressure vary more than ± 35 bar [± 500 psi] from the Commanded Fuel Rail Pressure? **YES** **Repair:** Replace the fuel pump actuator. Use the following procedure in the ISB, ISBe, ISBe4, QSB4.5, QSB5.9, and QSB6.7 (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-007 in Section 5.	Repair complete
	Does the Measured Fuel Rail Pressure vary more than ± 35 bar [± 500 psi] from the Commanded Fuel Rail Pressure? **NO**	4K

STEP 4K: Check the fuel pressure relief valve for excessive leakage.

Condition:
- Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-061 in Section 6.

Action	Specification/Repair	Next Step
Measure the fuel pressure relief valve drain flow. Use the following procedure in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System) Series Engines, Bulletin 4021271. Refer to Procedure 006-061 in Section 6.	Is the fuel pressure relief valve within specification? **YES**	4L
	Is the fuel pressure relief valve within specification? **NO** **Repair:** Replace the fuel pressure relief valve. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-061 in Section 6.	Repair complete

STEP 4L: Measure the high-pressure fuel supply pump fuel drain flow.

Condition:
- Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-016 in Section 5.

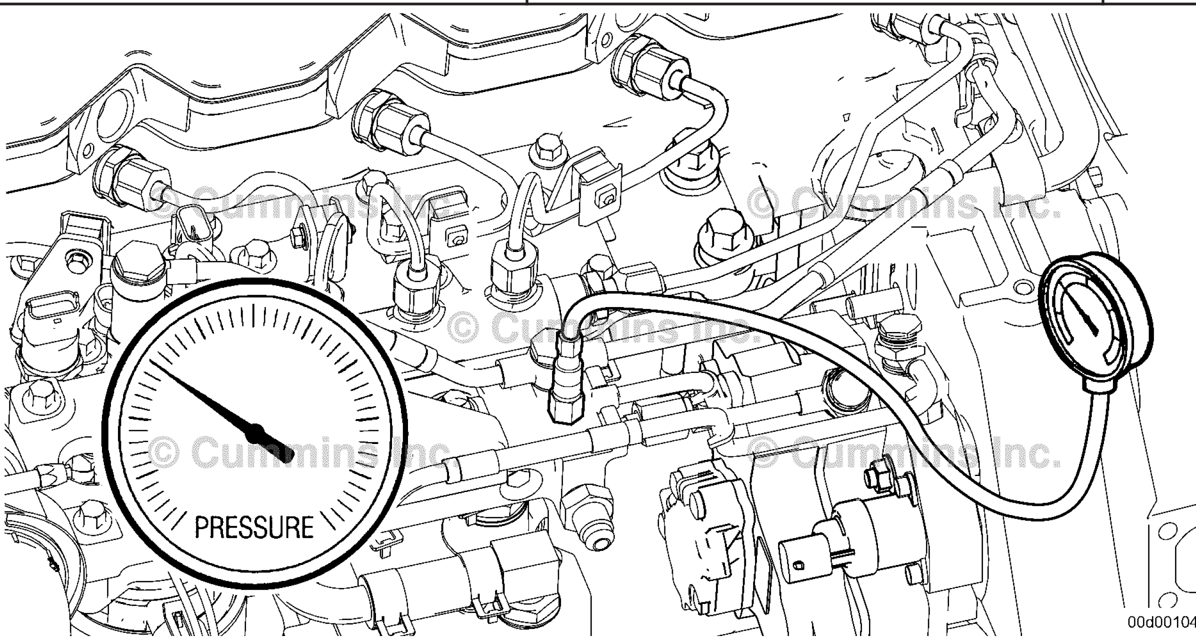
Action	Specification/Repair	Next Step
Measure the high-pressure fuel supply pump return flow. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-016 in Section 5.	Is the high-pressure fuel supply pump fuel drain flow greater than specification? **YES** **Repair:** Replace the high-pressure fuel supply pump. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 005-016 in Section 5.	Repair complete
	Is the high-pressure fuel supply pump fuel drain flow greater than specification? **NO**	4M

STEP 4M: Measure fuel drain line restriction.

Condition:

- Turn keyswitch OFF.
- Connect appropriate service tools to measure fuel drain line restriction.

Action	Specification/Repair	Next Step
Measure the fuel drain line restriction. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 006-012 in Section 6. Operate the engine at high idle: Maximum fuel drain line restriction: 0.19 bar (2.7 psi).	Is the drain line restriction less than specification? **YES**	Perform next troubleshooting procedure as outlined in Step 2.
	Is the drain line restriction less than specification? **NO** **Repair:** Check OEM fuel drain lines to tank for proper size, leaks, bends, clogs and fuel tank vents for plugging.	Repair Complete



STEP 5: Air handling troubleshooting procedures.

STEP 5A: Check intake manifold pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine OFF.

Action	Specification/Repair	Next Step
Start the data monitor/logger and monitor reading. Start INSITE™ electronic service tool data monitor/logger and monitor INSITE™ electronic service tool reading for intake manifold pressure with the engine off.	Intake manifold pressure reading is less than 102 mm-Hg [4 in-Hg]? **YES**	5B
	Intake manifold pressure reading is less than 102 mm-Hg [4 in-Hg]? **NO** **Repair:** Replace the intake manifold pressure sensor. Use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-061 in Section 19. If equipped with a combination Intake Manifold Pressure/Temperature Sensor, use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-159 in Section 19.	Repair complete

STEP 5B: Check the air intake system for leaks.

Condition:

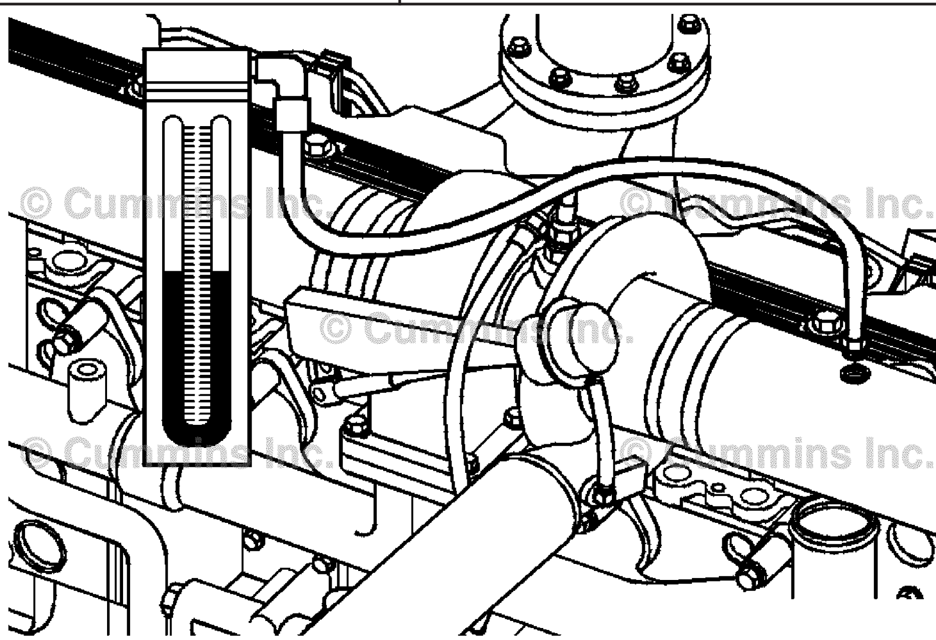
N/A

Action	Specification/Repair	Next Step
Check the air intake system for leaks. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-024 in Section 10. On engines equipped with a turbocharged air compressor, one often overlooked item as a source for air leaks is the air compressor intake line. The intake line supplies intake air from the intake of the engine to the air compressor.	Were any air intake system leaks found? **YES** **Repair:** Repair or replace the damaged component.	Repair Complete.
	Were any air intake system leaks found? **NO**	5C

STEP 5C: Check air intake restriction.

Condition:
- Turn keyswitch ON.
- Engine operating at rated speed and full load.

Action	Specification/Repair	Next Step
Check the air intake restriction. • Install a vacuum gauge, Part Number ST-1111-3, or equivalent, into the air intake system. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-031 in Section 10. Maximum Air Intake Restriction: Dirty Filter: 25 in-H_2O/635 mm-H_2O. Clean Filter: 10 in-H_2O/254 mm-H_2O.	Is the air intake restriction greater than the specification? **YES** **Repair:** Correct the cause of high intake air restriction. Check for a plugged air filter or restricted air intake piping.	Repair Complete
	Is the air intake restriction greater than the specification? **NO**	5D



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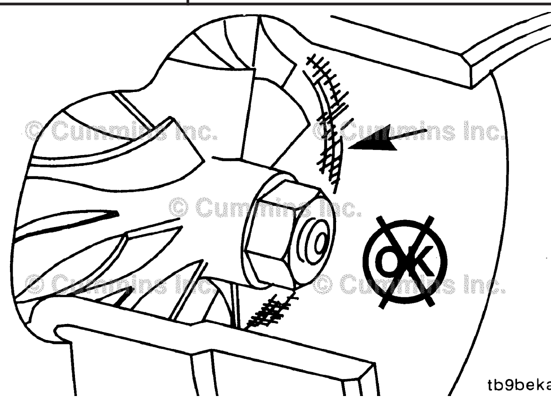
STEP 5D: Inspect the turbocharger blades for damage.

Condition:
- Engine OFF.
- Remove the intake piping from the turbocharger.

Action	Specification/Repair	Next Step
Inspect the compressor blades for damage or wear. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Damage found on the turbocharger blades? **YES** **Repair:** Replace the turbocharger. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Repair complete
	Damage found on the turbocharger blades? **NO**	5E



STEP 5E: Determine if the turbocharger is a variable geometry turbocharger.

Condition:

N/A

Action	Specification/Repair	Next Step
Determine if the turbocharger is a variable geometry turbocharger. N/A	Is the turbocharger a variable geometry turbocharger? **YES**	5F
	Is the turbocharger a variable geometry turbocharger? **NO**	5G

STEP 5F: Perform INSITE™ electronic service tool turbocharger actuator test.

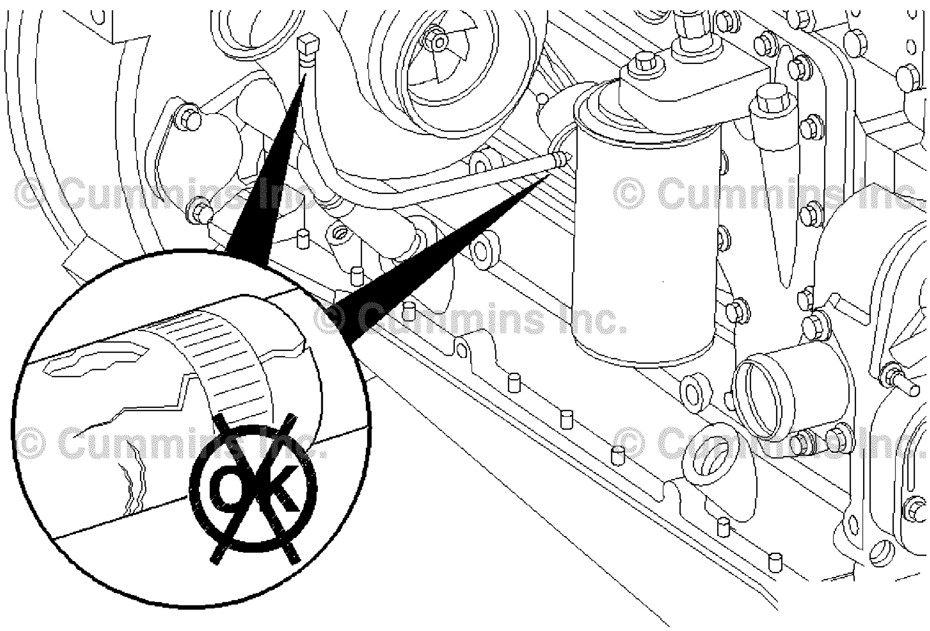
Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Select turbocharger actuator test. • In the ECM Diagnostic Tests menu of INSITE™ electronic service tool click on the turbocharger actuator test, and follow the instructions on the screen. • Open and close the turbocharger actuator. When opened, the actuator position will be 100 percent open. When closed, the actuator position will be less than 10 percent closed.	Does the turbocharger pass the turbocharger actuator test? **YES**	Step 5I
	Does the turbocharger pass the turbocharger actuator test? **NO** **Repair:** Replace the variable geometry turbocharger. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Repair complete

STEP 5G: Inspect the wastegate actuator hose.

Condition:
- Engine OFF.
- Remove turbocharger if wastegate actuator is inaccessible.

Action	Specification/Repair	Next Step
Inspect the integral wastegate actuator hose for cracks or holes. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10.	Holes or cracks found in the wastegate actuator hose? **YES** **Repair:** Replace the wastegate actuator hose. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10.	Repair complete
	Holes or cracks found in the wastegate actuator hose? **NO**	5H



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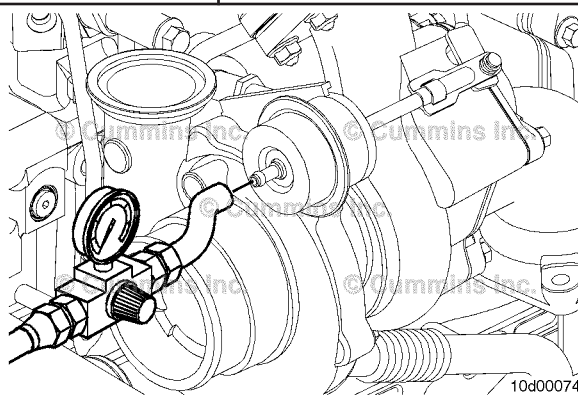
STEP 5H: Inspect the turbocharger wastegate capsule for air leaks.

Condition:
- Engine OFF.
- Remove the wastegate actuator hose from the wastegate actuator.

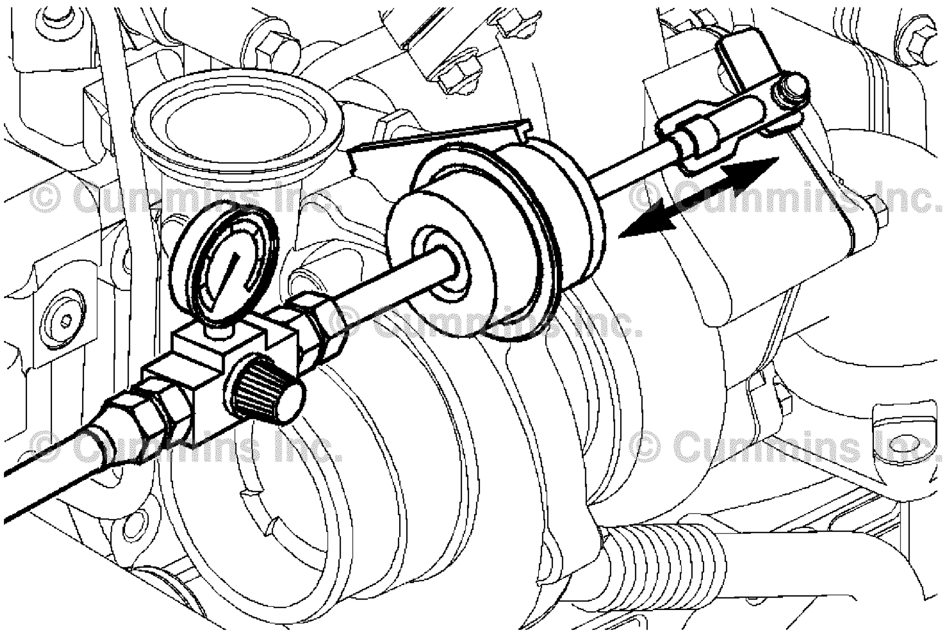
Action	Specification/Repair	Next Step
Perform a leak test on the wastegate actuator capsule. Refer to Procedure 010-050 in Section 10 of the Service Manual, ISBe, ISB, QSB (Common Rail Fuel System), Bulletin 4021271. Use Cummins® tool, Part Number 3823799, to apply a regulated air supply of 59 in-Hg (29 psi) to the wastegate actuator capsule. No air should be heard (i.e., leaking noise) through a functional wastegate capsule.	Did the wastegate actuator capsule leak air? **YES** **Repair:** Replace the wastegate actuator. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10.	Repair complete
	Did the wastegate actuator capsule leak air? **NO**	5H-1



STEP 5H-1: Inspect the turbocharger wastegate actuator for proper operation.

Condition:
- Engine OFF.
- Remove the wastegate actuator hose from the wastegate actuator.

Action	Specification/Repair	Next Step
Check the wastegate actuator rod for movement. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10. Use Cummins® tool, Part Number 3823799, to apply a regulated air supply of 59 in-Hg (29 psi) to the wastegate actuator capsule. Check for wastegate actuator rod for movement.	Does the wastegate actuator rod move? **YES**	Step 5I
	Does the wastegate actuator rod move? **NO**	Step 5H-2



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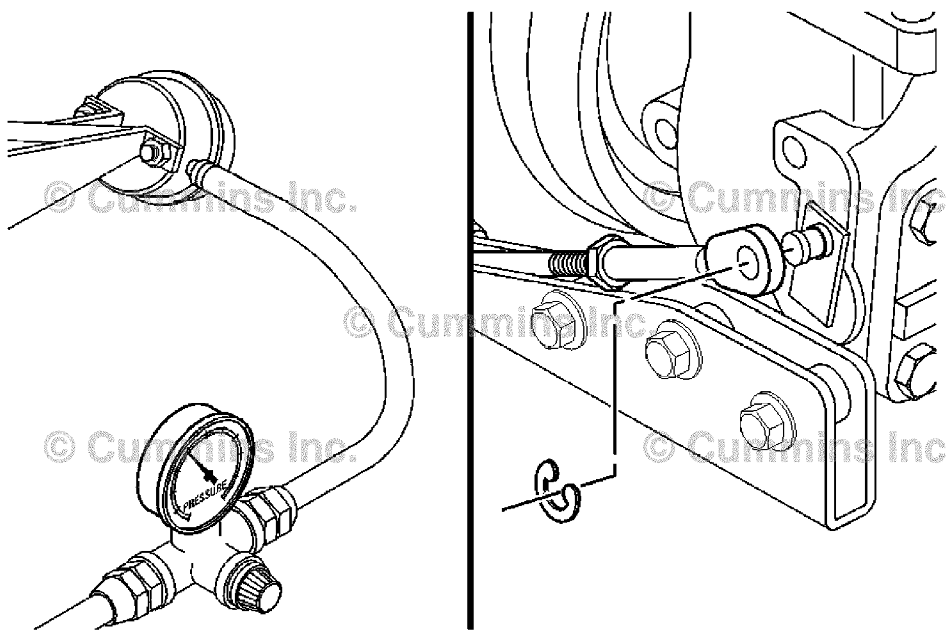
STEP 5H-2: Inspect the turbocharger wastegate for proper operation.

Condition:
- Engine OFF.
- Remove the e-clip from the wastegate pin and disconnect the actuator rod from the wastegate lever.

Action	Specification/Repair	Next Step
Check the wastegate actuator rod for movement with it disconnected from the turbocharger wastegate. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10. Use Cummins® Tool Part Number 3823799 to apply a regulated air supply of 59 in-Hg (29 psi) to the wastegate actuator capsule. Check for wastegate actuator rod for movement.	Does the wastegate actuator rod move? **YES** **Repair:** Move the wastegate lever back and forth and check for smooth 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 in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Repair Complete.
	Does the wastegate actuator rod move? **NO** **Repair:** Replace the wastegate actuator. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-050 in Section 10.	Repair Complete.



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STEP 5I: Measure turbocharger axial and radial clearance.

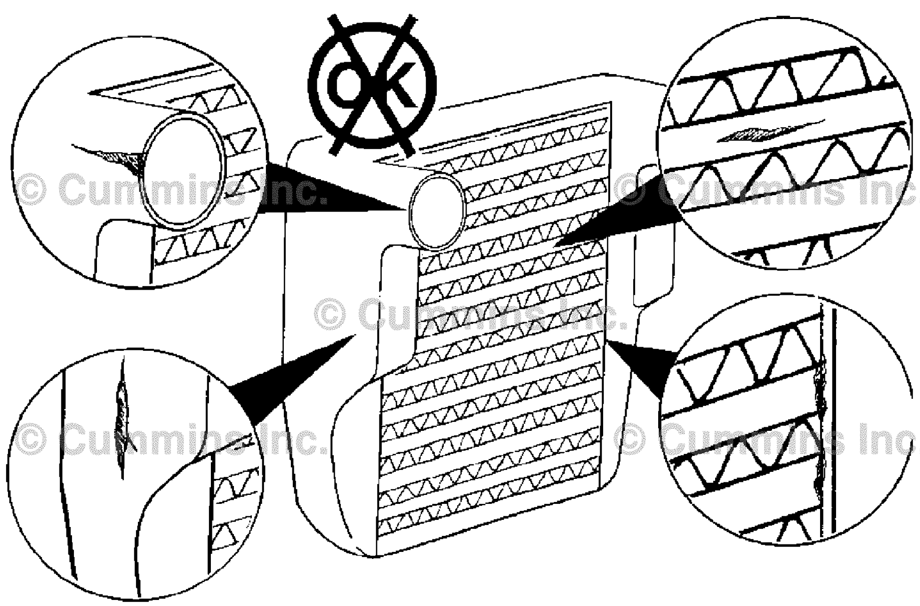
Condition:
- Engine OFF.
- Disconnect the exhaust and intake connections from the turbocharger.

Action	Specification/Repair	Next Step
Follow the procedure for measuring the axial clearance of the turbocharger. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Are the axial and radial clearances within specification? **YES**	5J
	Are the axial and radial clearances within specification? **NO** **Repair:** Replace the turbocharger assembly. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-033 in Section 10.	Repair Complete

STEP 5J: Inspect the charge-air cooler.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Inspect the charge air cooler for cleanliness, blockage, cracks, holes, or other damage. • Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-027 in Section 10. The pressure and temperature checks in the chargeair cooler procedure can be used to verify charge-air cooler problems.	Does the charge-air cooler pass the visual inspection as well as the pressure test and temperature differential test? **YES**	Perform the next troubleshooting procedure as outlined in Step 2.
	Does the charge-air cooler pass the visual inspection as well as the pressure test and temperature differential test? **NO** **Repair:** Repair or replace the charge-air cooler assembly. Use the following procedure in the ISBe, ISB, and QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-027 in Section 10.	Repair complete



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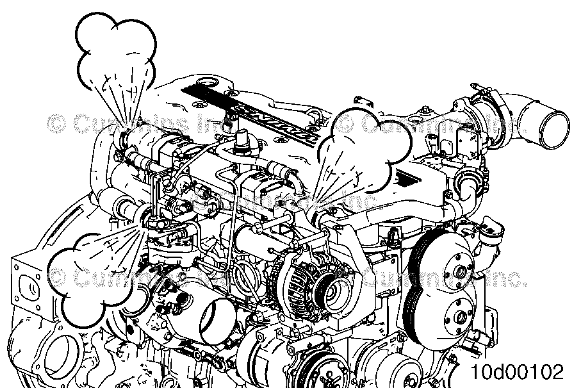
STEP 6: EGR system checks.

STEP 6A: Check for air leaks in the EGR system.

Condition:

N/A

Action	Specification/Repair	Next Step
Check for air leaks in the EGR connection tubing and other connections. • Check for EGR at the mounting flange for the differential pressure sensor. • Soot streaks can be noticeable where leaks are present.	Air leaks found in the EGR connection tubing? **YES** **Repair:** Repair any leaks in the EGR system.	Repair complete
	Air leaks found in the EGR connection tubing? **NO**	6B



STEP 6B: Check the EGR temperature sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- The engine **must** be turned off long enough for engine coolant temperature to be equal to ambient air temperature.

Action	Specification/Repair	Next Step
Monitor the following temperatures. Use INSITE™ electronic service tool to monitor temperature of the following: • EGR temperature sensor • Engine coolant temperature sensor • Intake manifold air temperature sensor • Turbocharger compressor inlet air temperature sensor.	Are all temperature readings within 5.6°C [10°F] of each other? **YES**	Step 6C
	Are all temperature readings within 5.6°C [10°F] of each other? **NO** **Repair:** Check for a short from the signal pin of the temperature sensor in question to all other pins in the harness. Refer to Procedure 019-360 in Section 19. If no short is found, replace the temperature sensor that is reading higher or lower than the other sensors. See Section 19 for specifics on each temperature sensor.	Repair complete

STEP 6C: Check differential pressure sensor for proper operation.

Condition:
- Turn keyswitch ON.
- Engine operating.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Operate the engine until the EGR valve opens. Use INSITE™ electronic service tool to monitor the EGR Differential Pressure and the EGR valve position (Percent Open). The EGR valve may **not** open until the engine has reached normal operating temperature. Once the engine has reached normal operating temperature, quick throttle snaps can help induce EGR valve movement.	Is the EGR differential pressure greater than 5 mm-Hg [0.2 in-Hg] when the EGR valve is open greater than 50 percent? **YES**	6D
	Is the EGR differential pressure greater than 5 mm-Hg [0.2 in-Hg] when the EGR valve is open greater than 50 percent? **NO**	6F

STEP 6D: Check exhaust gas pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- Engine OFF.

Action	Specification/Repair	Next Step
Start the data monitor/logger. • Use INSITE™ electronic service tool to compare the reading for exhaust pressure sensor and barometric pressure sensor. If working on an engine **not** equipped with an exhaust pressure sensor, go to the next step. The exhaust pressure sensor is an absolute pressure sensor. This means that the sensor reads exhaust pressure plus barometric air pressure.	There is less than a 102 mm-Hg [4 in-Hg] difference between the exhaust pressure sensor reading and the barometric air pressure sensor reading? **YES**	6E
	There is less than a 102 mm-Hg [4 in-Hg] difference between the exhaust pressure sensor reading and the barometric air pressure sensor reading? **NO** **Repair:** Remove the exhaust pressure sensor, pedestal and exhaust pressure sensor tube. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 011-027 in Section 11. Check for condensation or foreign material build up. Clean or replace as necessary, any of the removed components.	Repair Complete.

STEP 6E: Perform the INSITE™ electronic service tool EGR valve actuator test.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
ECM diagnostic tests. • Use INSITE™ electronic service tool menu on the EGR Valve Actuator Test and follow the instructions on the screen. Open and close the EGR valve actuator. When opened, the actuator position will be 100 percent open. When closed, the actuator position will be less than 10 percent closed.	Does the EGR Valve pass the INSITE™ electronic service tool EGR Valve Actuator Test? **YES**	6F
	Does the EGR Valve pass the INSITE™ electronic service tool EGR Valve Actuator Test? **NO** **Repair:** Replace the EGR valve. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 011-022 in Section 11.	Repair Complete.

STEP 6F: Isolate EGR System.

Condition:
- Turn keyswitch OFF.
- Disconnect the EGR valve differential pressure sensor.

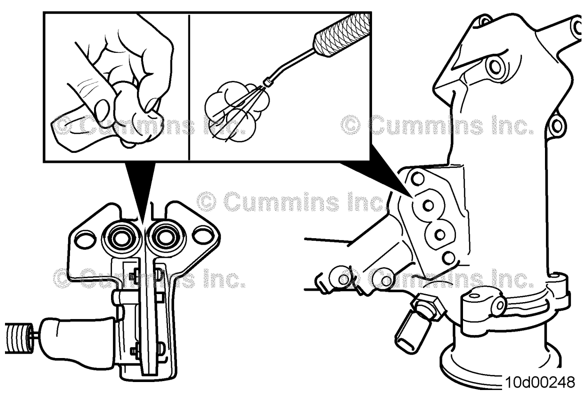
Action	Specification/Repair	Next Step
Disconnect the EGR valve differential pressure sensor. Use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-370 in Section 19. Operate the engine at which the Performance or Excessive Smoke (Black) complaint occurs. By disconnecting the EGR valve differential pressure sensor, the ECM will command the EGR valve to close. No engine derate will be commanded by the ECM. Fault Code 2274 will become active with the EGR valve differential pressure sensor disconnected.	Was the Performance or Excessive Smoke (Black) complaint corrected by disconnecting the EGR valve differential pressure sensor? **YES**	6F-1
	Was the Performance or Excessive Smoke (Black) complaint corrected by disconnecting the EGR valve differential pressure sensor? **NO**	Perform next troubleshooting procedure as outlined in Step 2.

STEP 6F-1: Check the EGR System for Blockage

Condition:

- Turn keyswitch OFF.
- Remove the EGR valve differential pressure sensor.

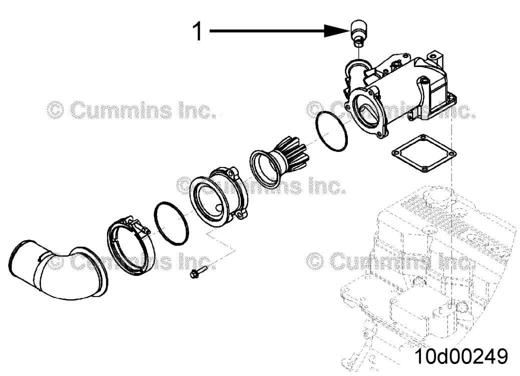
Action	Specification/Repair	Next Step
Remove the EGR valve differential pressure sensor and inspect the passages in the sensor and in the air intake connection for blockage or excessive carbon build up. Use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-370 in Section 19. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-080 in Section 10.	Was blockage or excessive carbon build up found in the EGR valve differential pressure sensor and/or intake connection passages? **YES** **Repair:** Clean the passages in the sensor and in the air intake connection. If the blockage or carbon build up is to severe, replace the EGR valve differential pressure sensor and/or air intake connection. Use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-370 in Section 19. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-080 in Section 10.	Repair Complete
	Was blockage or excessive carbon build up found in the EGR valve differential pressure sensor and/or intake connection passages? **NO**	6F-2



STEP 6F-2: Check the EGR system for correct or damaged components.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check if the air intake connection is assembled properly and/or any components are damaged. 1. Disconnect the EGR connection tubes from the air intake connection. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 011-025 in Section 11. Inspect the EGR inlet to the air intake connection to make sure the EGR flow measurement venture (1) is present and **not** damaged or blocked. 2. Remove the two-piece air intake connection adapter. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-131 in Section 10. Verify the EGR mixer is installed and remove the EGR mixer. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 011-021 in Section 11. Inspect the EGR Mixer for damage or excessive carbon build up. If replacing the air intake connection on engines equipped with EGR, check to make sure the EGR flow measurement venture (1) is properly installed in the new air intake connection.	Was the air intake connection assembled properly with no damage to any components? **YES** **Repair:** Replace the EGR valve differential pressure sensor and air intake connection. Use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-370 in Section 19. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-080 in Section 10.	Repair Complete
	Was the air intake connection assembled properly with no damage to any components? **NO** **Repair:** Replace or clean the necessary component. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 011-021 in Section 11. If the EGR flow measurement venturi is damaged or missing, the entire air intake connection must be replaced as an assembly. The EGR flow measurement venturi can **not** be serviced separately. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 010-080 in Section 10.	Repair Complete



STEP 7: Verify electronic features are operating correctly.

STEP 7A: Verify accelerator (throttle) pedal travel.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to monitor throttle position while fully depressing and releasing the accelerator (throttle) pedal. N/A	Does the throttle position read 0 percent when the accelerator (throttle) is released and 100 percent when the accelerator (throttle) is fully depressed? **YES**	7B
	Does the throttle position read 0 percent when the accelerator (throttle) is released and 100 percent when the accelerator (throttle) is fully depressed? **NO** **Repair:** Refer to the OEM service manual for accelerator (throttle) pedal troubleshooting.	Repair complete

STEP 7B: Monitor vehicle speed.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Monitor the vehicle speed. • Use INSITE™ electronic service tool to monitor vehicle speed while the vehicle is **not** moving.	Does the vehicle speed read zero when the vehicle is **not** moving? **YES**	7C
	Does the vehicle speed read zero when the vehicle is **not** moving? **NO** **Repair:** Check the vehicle speed sensor and circuit for problems. Refer to the OEM service manual.	Repair complete

STEP 7C: Verify the electronic feature settings are correct.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to verify the following adjustable parameters are correctly set: • Maximum vehicle speed • Powertrain protection • Rear axle ratio • Tailshaft teeth • Tire revolutions per mile • Gear-down protection • Cruise control droop settings • Cruise control maximum vehicle speed • Accelerator type • Road speed governor • Vehicle acceleration management • Transmission type.	Are the electronic features set correctly? **YES**	7D
	Are the electronic features set correctly? **NO** **Repair:** Correct programmable features.	Repair complete

STEP 7D: Check the temperature sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- The engine **must** be turned off long enough for coolant temperature to be equal to ambient air temperature.

Action	Specification/Repair	Next Step
Use INSITE™ elctronic service tool to monitor the following temperatures: • Engine coolant temperature senor • Intake manifold air temperature sensor • If equipped, the turbocharger compressor inlet air temperature sensor • If equipped, the EGR temperature sensor.	Are all temperature readings within 5.6°C or 10°F of each other? **YES**	Step 7E
	Are all temperature readings within 5.6°C or 10°F of each other? **NO** **Repair:** Check for a short from the SIGNAL pin of the temperature sensor in question to all other pins in the harness. Refer to Procedure 019-360 in Section 19. If no short is found, replace the temperature sensor that is reading higher or lower than the other sensors. See Section 19 for specifications on each temperature sensor.	Repair complete

STEP 7E: Check ambient air pressure sensor accuracy.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

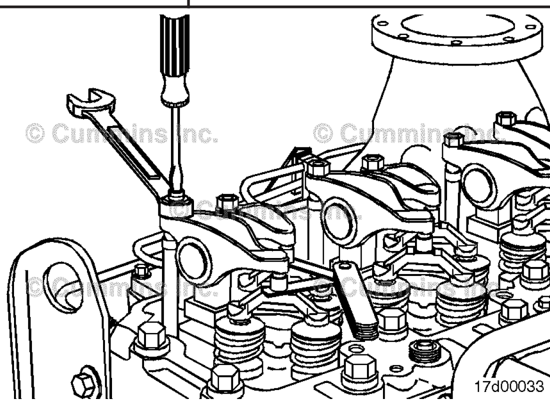
Action	Specification/Repair	Next Step
Start INSITE™ electronic service tool data monitor/logger and compare the INSITE™ electronic service tool reading for barometric air pressure to the local barometric pressure. Refer to Procedure 018-028 in Section V.	INSITE™ electronic service tool reading is within 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **YES**	Perform next troubleshooting procedure as outlined in Step 2.
	INSITE™ electronic service tool reading is within 50.8 mm-Hg [2 in-Hg] of local barometric pressure? **NO** **Repair:** Replace the barometric pressure sensor. Use the following procedure in the ISB (4 cylinder) and ISBe (4 and 6 cylinder) Electronic Control System Troubleshooting and Repair manual, Bulletin 3666477. Refer to Procedure 019-004 in Section 19.	Repair Complete

STEP 8: Perform base engine mechanical checks.

STEP 8A: Verify the overhead adjustments are correct.

Condition:
- Turn keyswitch OFF.
- Remove valve cover.

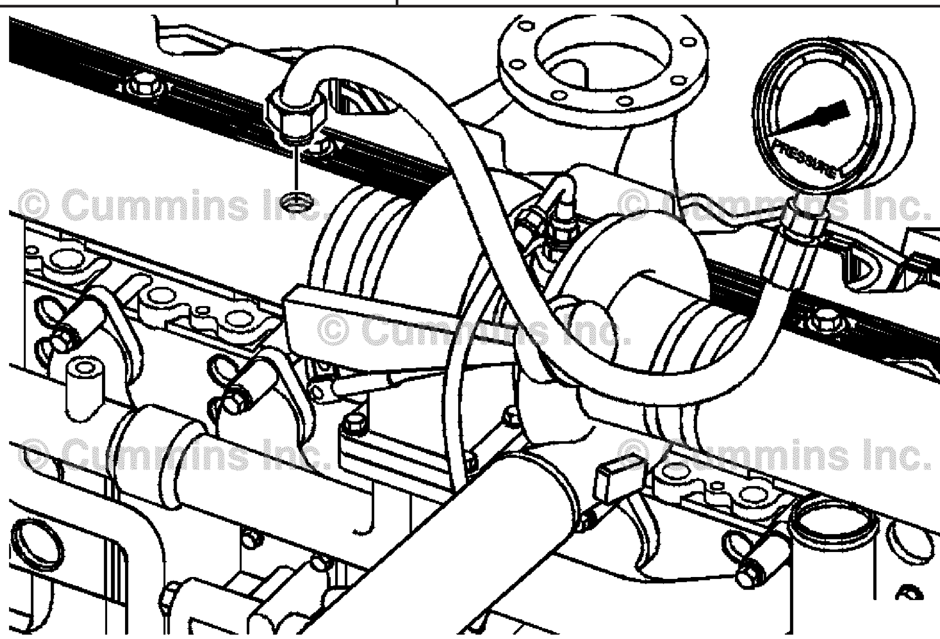
Action	Specification/Repair	Next Step
Measure the overhead settings. • Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 003-004 in Section 3.	Are the overhead settings within the reset limits? **YES**	8B
	Are the overhead settings within the reset limits? **NO** **Repair:** Adjust the overhead settings. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 003-004 in Section 3.	Repair complete



STEP 8B: Check the exhaust restriction.

Condition:
- Turn keyswitch ON.
- Engine running at advertised horsepower and rpm.

Action	Specification/Repair	Next Step
Measure exhaust system back pressure. Measure the exhaust system back pressure by installing a pressure gage, Cummins® Part Number ST-1273, or equivalent, into the exhaust system immediately downstream of the turbocharger exhaust outlet. Maximum Exhaust Back Pressure = 10.2 kPa [1.5 PSI].	Is the exhaust back pressure greater than the specification? **YES** **Repair:** Correct the cause of high back pressure, look for collapsed or plugged exhaust pipes.	Repair complete
	Is the exhaust back pressure greater than the specification? **NO**	8C



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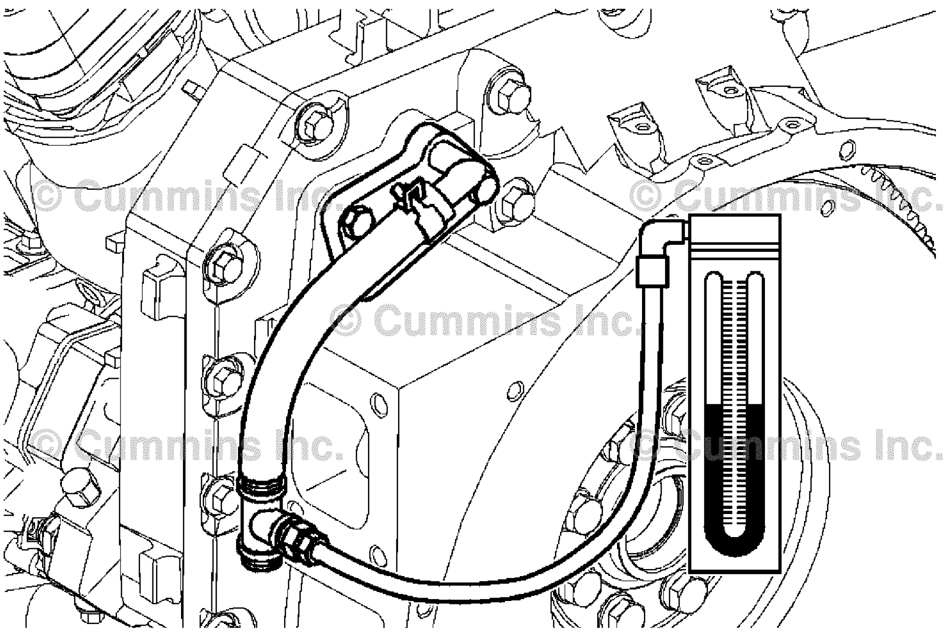
STEP 8C: Verify the engine crankcase pressure (blowby) is within specification.

Condition:
- Turn keyswitch OFF.
- Connect appropriate service tools to measure blowby.

Action	Specification/Repair	Next Step
Measure engine crankcase pressure (blowby). Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 014-010 in Section 14.	Is the engine crankcase pressure (blowby) less than specification? **YES**	8D
	Is the engine crankcase pressure (blowby) less than specification? **NO** **Repair:** Record the engine blowby pressure for later use.	Refer the Crankcase Gases (Blowby) Excessive troubleshooting symptom (TS) tree.



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STEP 8D: Check for internal engine damage.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Remove the oil filter. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 007-013 in Section 7. Cut the oil filter open and inspect for debris and area of probable damage. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 007-083 in Section 7.	Did cutting the oil filter open reveal evidence of internal engine damage? **YES** **Repair:** Determine the area of probable damage and repair as necessary. Remove the lubricating oil pan and rocker lever cover, if necessary, to inspect for damage. • Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 007-025 in Section 7. • Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 003-011 in Section 3.	Repair complete
	Did cutting the oil filter open reveal evidence of internal engine damage? **NO**	Perform next troubleshooting procedure as outlined in Step 2.

STEP 9: Excessive vibration checks.

STEP 9A: Check engine idle speed.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- INSITE™ electronic service tool monitor.

Action	Specification/Repair	Next Step
Monitor the engine speed. • Use INSITE™ electronic service tool to monitor engine speed while engine is idling. See the engine dataplate for idle speed specifications.	Is the engine idle speed within specification? **YES** **Repair:** N/A	9B
	Is the engine idle speed within specification? **NO** **Repair:** Adjust or increase the engine idle speed.	Repair Complete

STEP 9B: Check if the feature Fast Idle Warm Up is available and enabled.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Check the features and parameters with INSITE™ electronic service tool. Check if the feature Fast Idle Warm Up is available and enabled.	Is the feature Fast Idle Warm Up available and enabled? **YES**	9B-1
	Is the feature Fast Idle Warm Up available and enabled? **NO**	9C

STEP 9B-1: Monitor the Fast Idle Warm Up Status.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.
- INSITE™ electronic service tool monitor.

Action	Specification/Repair	Next Step
Monitor the Fast Idle Warm Up INSITE™ electronic service tool status. N/A	Is the feature Fast Idle Warm Up becoming active? **YES** **Repair:** Adjust the fast idle warm up idle speed or check with the customer on disabling the feature. Disabling the fast idle warm up feature can affect warranty.	Repair Complete
	Is the feature Fast Idle Warm Up becoming active? **NO**	9C

STEP 9C: Check front engine driven accessory(s).

Condition:
- Turn keyswitch OFF.
- Isolate front engine driven accessory(s).

Action	Specification/Repair	Next Step
Isolate front engine driven accessory(s) one at a time, including: • Alternator(s) • Refrigerant compressor(s) • Fan hub(s) • Hydraulic/Power steering pump(s) • Water pump • Cooling fan • Crankshaft driven PTO accessories.	Did isolating the front engine driven accessory(s) correct the vibration? **YES** **Repair:** Repair or replace the malfunctioning component.	Repair Complete.
	Did isolating the front engine driven accessory(s) correct the vibration? **NO**	9D

STEP 9D: Check the Vibration Damper/Crankshaft speed indicator ring.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the vibration damper/ crankshaft speed indicator ring for damage. For engines equipped with a rubber vibration damper, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 001-051 in Section 1. For engines equipped with a viscous damper, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 001-052 in Section 1. For engines equipped with a crankshaft speed indicator ring **only**, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 001-071 in Section 1.	Is the vibration damper/crankshaft speed indicator ring damaged? **YES** **Repair:** Replace the damaged vibration damper/ crankshaft speed indicator ring.	Repair Complete.
	Is the vibration damper/crankshaft speed indicator ring damaged? **NO**	9E

STEP 9E: Check the Engine Support Brackets, Mounts and/or Isolators.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check the engine support brackets, mounts and/or isolators for damage. For front engine supports, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 016-002 in Section 16. For rear engine supports, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 016-003 in Section 16.	Are the engine support brackets, mounts and/or isolators damaged? **YES** **Repair:** Replace the damaged engine support brackets, mounts and/or isolators.	Repair Complete.
	Are the engine support brackets, mounts and/or isolators damaged? **NO**	9F

STEP 9F: Check engine gear driven accessory(s).

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check if the engine has an engine gear driven/air compressor driven hydraulic pump? N/A	Does the engine have an engine gear driven/air compressor driven hydraulic pump? **YES**	9F-1
	Does the engine have an engine gear driven/air compressor driven hydraulic pump? **NO**	9F-2

STEP 9F-1: Isolate engine gear driven accessory(s).

Condition:
- Turn keyswitch OFF.
- Isolate/remove the gear/air compressor driven hydraulic pump.

Action	Specification/Repair	Next Step
Isolate/remove the gear driven/air compressor driven hydraulic pump and operate the engine. For general hydraulic pump remove and install instructions, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 009-016 in Section 9. Some engines require an accessory drive to drive the hydraulic pump. It may be necessary to isolate this as well. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 009-001 in Section 9.	Did isolating/removing engine gear driven/air compressor driven hydraulic pump correct the vibration? **YES** **Repair:** Repair or replace the malfunctioning component.	Repair Complete.
	Did isolating/removing engine gear driven/air compressor driven hydraulic pump correct the vibration? **NO**	9F-2

STEP 9F-2: Check if the engine is equipped with an air compressor.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check if the engine is equipped with an engine gear driven air compressor. N/A	Is the engine is equipped with an engine gear driven air compressor? **YES**	9F-3
	Is the engine is equipped with an engine gear driven air compressor? **NO**	9G

STEP 9F-3: Unload the Air Compressor and Operate.

Condition:
- Turn keyswitch OFF.
- Unload the air compressor.

Action	Specification/Repair	Next Step
With the air compressor unloaded, operate the engine in the condition in which the vibration complaint occurs. The air compressor can be unloaded by: Disconnecting the air governor signal line and connecting regulated shop air, with a pressure gauge, to the air compressor governor air signal port. Typically 621 kPa (90 psi) of air pressure is the set point for unloading the air compressor. Refer to the OEM service manual. Disconnect the air compressor discharge line and air intake hose from the air compressor. On turbocharged air compressors, make sure to plug the air intake hose attached to the intake manifold.	Did unloading the air compressor significantly reduce or eliminate the vibration? **YES**	9F-4
	Did unloading the air compressor significantly reduce or eliminate the vibration? **NO**	Repair Complete.

STEP 9F-4: Check Air Compressor Timing.

Condition:
- Turn keyswitch OFF.
- Check the timing of the air compressor.

Action	Specification/Repair	Next Step
Check that the air compressor is correctly timed to the engine. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 012-014 in Section 12. When troubleshooting a vibration issue in which it is suspected that the air compressor is the cause of the vibration, it may be necessary to isolate the air compressor from the engine.	Was the air compressor correctly timed to the engine? **YES** **Repair:** Replace the air compressor. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 012-014 in Section 12.	Repair Complete.
	Was the air compressor correctly timed to the engine? **NO** **Repair:** Correctly time the air compressor to the engine. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 012-014 in Section 12.	Repair Complete.

STEP 9G: Check/Isolate engine driven components.

Condition:
- Turn keyswitch OFF.
- Isolate/remove any engine driven components.

Action	Specification/Repair	Next Step
Isolate/remove any engine driven components and operate the engine. Engine driven components include: • Transmissions (Torque converters/Clutches) • Hydraulic pumps • Direct drive shafts • For flywheels, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 016-005 in Section 16. • For flexplates, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 016-004 in Section 16.	Did isolating/removing any engine driven component correct the vibration? **YES** **Repair:** Replace the malfunctioning component. Refer to the OEM service manual.	Repair Complete.
	Did isolating/removing any engine driven component correct the vibration? **NO**	9H

STEP 9H: Check the Flywheel Housing Alignment.

Condition:
- Turn keyswitch OFF.
- Engine driven components removed.

Action	Specification/Repair	Next Step
Measure the flywheel housing bore and face runout. Use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 016-006 in Section 16.	Is the flywheel housing bore and face runout within specification? **YES**	8A
	Is the flywheel housing bore and face runout within specification? **NO** **Repair:** For flywheel housing repair options, use the following procedure in the ISBe, ISB, QSB (Common Rail Fuel System) Service Manual, Bulletin 4021271. Refer to Procedure 016-006 in Section 16.	Repair Complete.

Fuel Economy Troubleshooting Tree

This troubleshooting procedure should be followed for the following symptoms:

- Fuel Consumption Excessive

How to Use This Troubleshooting Procedure:

This symptom tree is to be used to troubleshoot fuel economy complaints. This tree is used along with the Fuel Consumption - Customer Complaint Form and the Driveability Low Power/Excessive Fuel - Consumption Checklist to help isolate engine, chassis, or driver issues associated with excessive fuel consumption.

Shop Talk:

The Fuel Consumption - General Information section of this manual and Troubleshooting Excessive Fuel Consumption, Bulletin 3666094, **must** be referenced prior to any troubleshooting being performed on a customer's engine.

The cause of excessive fuel consumption is difficult to diagnose and correct because of the potential number of factors involved. Actual fuel consumption problems can be caused by any of the following factors:

- Engine factors
- Vehicle factors and specifications
- Environmental factors
- Driver technique and operating practices
- Fuel system factors
- Low power or driveability problems.

Before troubleshooting, it is important to determine the exact complaint. Is the complaint based on whether the problem is real or perceived, or does **not** meet driver expectations? The Fuel Consumption - Customer Complaint Form is a valuable list of questions that can be used to assist the service technician in determining the cause of the problem. Complete the form before troubleshooting the complaint.

The following are some of the factors that **must** be considered when troubleshooting fuel consumption complaints.

Factors to Consider When Troubleshooting Fuel Consumption Complaints	
Excessive Idling Time	Idling the engine can use from 0.5 to 1.5 gallons per hour depending on the engine idle speed
Vehicle Aerodynamics	The largest single power requirement for a truck is the power needed to overcome air resistance. As a general rule, each 10 percent reduction in air resistance results in a 5 percent increase in mile per gallon
Rolling Resistance	Rolling resistance is the second largest consumer of power on a truck. The type of tire and tread design have a sizeable effect on fuel economy and performance. Changing from a bias ply to a low profile radial tire can reduce rolling resistance by about 36 percent.
Environmental and Seasonal Weather Changes	There can be as much as 1 to 1.5 mile per gallon difference in fuel consumption, depending on the season and the weather conditions.
Truck Route and Terrain	East and west routes experience almost continual crosswinds and head winds. Less fuel can be used on north and south routes where parts of the trip are **not only** warmer, but have less wind resistance.
Driver Technique and Operating Practices	A 1 mile per hour increase in road speed equals a 0.1 mile per gallon increase in fuel consumption. This means that increasing road speed from 50 to 60 mph will result in a loss of fuel mileage of 1 mpg.

Factors to Consider When Troubleshooting Fuel Consumption Complaints	
Result of a Low Power or Driveability Problem	An operator will change driving style to compensate for a low power or driveability problem. Some things the driver is likely to do are (a) shift to a high engine rpm (b) run on the droop curve in a lower gear instead of upshifting to drive at part-throttle conditions. These changes in driving style will increase the amount of fuel used.

Additional vehicle factors, vehicle specifications, and axle alignment can also affect fuel consumption. For additional information on troubleshooting fuel consumption complaints, reference the Troubleshooting Excessive Fuel Consumption, Bulletin 3666094.

TROUBLESHOOTING SUMMARY

STEPS		SPECIFICATIONS	SRT CODE
STEP 1:	**Verify the complaint.**		
STEP 1A:	Fill out the Fuel Consumption - Customer Complaint Form.	Problem caused by vehicle factors, environmental factors, or driver technique?	
STEP 2:	**Electronic Checks, use INSITE™ electronic service tool.**		
STEP 2A:	Check for fault codes.	Any active or high counts of inactive fault codes?	
STEP 2B:	Confirm Features and Parameters.	Features and Parameters set correctly?	
STEP 2C:	Check the engine control module (ECM) calibrations.	Calibration correct?	
STEP 2D:	Monitor vehicle speed.		
STEP 2D-1:	Inspect the engine and chassis grounds.	Does vehicle speed read 0 when the vehicle is not moving?	
STEP 3:	**Engine performance.**		
STEP 3A:	Engine performance troubleshooting.	Poor fuel economy complaint still exists?	

TROUBLESHOOTING STEP

STEP 1: Verify the complaint.

STEP 1A: Fill the Fuel Consumption - Customer Complaint Form.

Condition:

N/A

Action	Specification/Repair	Next Step
Fill out the Fuel Consumption - Customer Complaint Form in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418. N/A	Problem caused by vehicle factors, environmental factors, or driver technique? **YES**	Repair complete
	Problem caused by vehicle factors, environmental factors, or driver technique? **NO**	2A

STEP 2: Electronic Checks, use INSITE™ electronic service tool.

STEP 2A: Check for fault codes.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to read the fault codes. N/A	Any active or high counts of inactive fault codes? **YES**	Troubleshoot fault codes
	Any active or high counts of inactive fault codes? **NO**	2B

STEP 2B: Confirm Features and Parameters.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Confirm the Programmable Features and Parameters are set correctly. N/A	Features and Parameters set correctly? **YES**	2C
	Features and Parameters set correctly? **NO** **Repair:** Reset the Features and Parameters to their appropriate values.	Repair complete

STEP 2C: Check the ECM calibration.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Compare the ECM code with the engine rating and control parts list (CPL). Verify the calibration is correct. N/A	Calibration correct? **YES**	2D
	Calibration correct? **NO** **Repair:** Recalibrate the ECM with the correct ECM code.	Repair complete

STEP 2D: Monitor vehicle speed.

Condition:
- Turn keyswitch ON.
- Connect INSITE™ electronic service tool.

Action	Specification/Repair	Next Step
Use INSITE™ electronic service tool to monitor Vehicle Speed while the vehicle is **not** moving. N/A	Does vehicle speed read 0 when the vehicle is **not** moving? **YES**	3A
	Does vehicle speed read 0 when the vehicle is **not** moving? **NO**	2D-1

STEP 2D-1: Inspect the engine and chassis grounds.

Condition:
- Turn keyswitch OFF.

Action	Specification/Repair	Next Step
Check for loose or corroded engine, chassis, or battery ground connection. • Check the engine ground connection • Check the chassis ground connections • Check the battery terminal connections.	All grounds present, properly grounded, free of corrosion, and tight? **YES** **Repair:** Check the variable speed sensor (VSS) and the VSS circuit. Refer to Procedure 019-091 in Section 19.	Repair complete
	All grounds present, properly grounded, free of corrosion, and tight? **NO** **Repair:** Replace, clean, or tighten the grounds.	Repair complete

STEP 3: Engine performance.

STEP 3A: Engine performance troubleshooting.

Condition:

N/A

Action	Specification/Repair	Next Step
Perform the Fuel System Checks, Air Handling Checks, and Base Engine Checks in the Engine Performance Troubleshooting Tree. N/A	Poor fuel economy complaint still exists? **YES** **Repair:** Perform the Fuel System Checks, Air Handling Checks, and Base Engine Checks in the Engine Performance Troubleshooting Tree.	Repair complete
	Poor fuel economy complaint still exists? **NO**	Repair complete

Notes

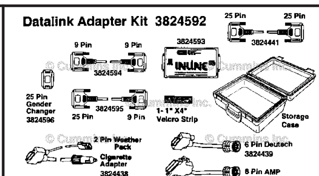
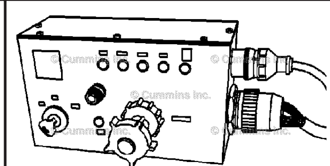
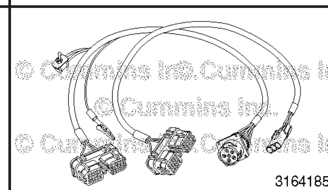
Section 19 - Electronic Controls - Group 19

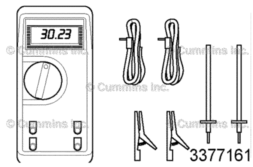
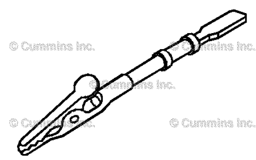
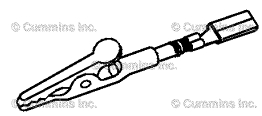
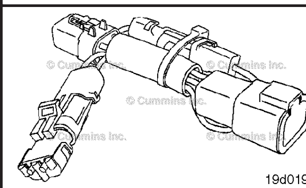
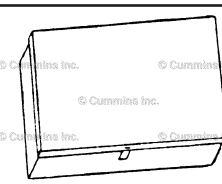
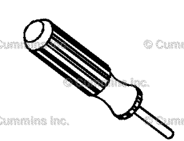
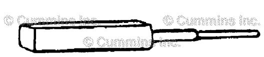
Section Contents

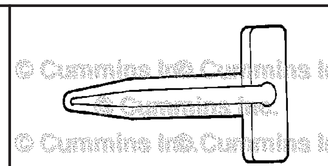
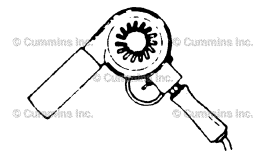
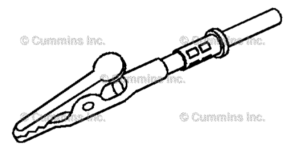
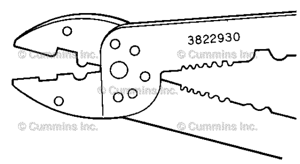
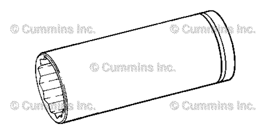
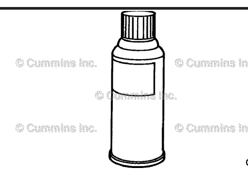
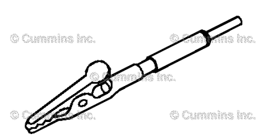
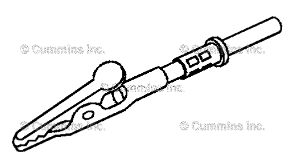
Service Tools

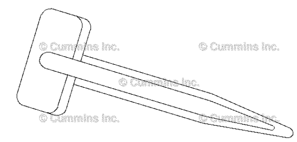
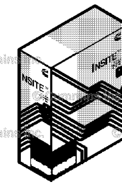
Electronic Engine Controls

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
3163682	**Data Link Adapter Kit** INLINE II adapter and associated cables are used to connect a computer to an engine data link.	 3824592
3163890	**Engine Controller** Used in conjunction with the engine controller adapter harness to provide fault lamps, throttle control, and keyswitch.	 19d01980
3164110	**Bosch® Male Test Lead** Used to test electrical circuits.	
3164111	**Bosch® Female Test Lead** Used to test electrical circuits.	
3164185	**ECM Bench Top Calibration Harness** Used to calibrate electronic control modules off the engine.	 3164185
3164242	**Engine Controller Adapter Harness** Used to separate engine wiring issues from chassis issues. Also used on the dynometer.	

Tool No.	Tool Description	Tool Illustration
3164488	**Multimeter** Used to measure voltage (volts), resistance (ohms), and current (amps) in electrical circuits.	
3164596	**Framatome Male Test Lead** Used to test electrical circuits.	
3164597	**Framatome Female Test Lead** Used to test electrical circuits.	
3164653	**Data Link Power Adapter Harness** Used to provide power straight from the ECM for the INLINE II kit.	
3165117	**Wiring Repair Kit** Contains a variety of connectors, pins, seals, terminals, test leads, and other tools used to repair connectors. Use with base Wiring Repair Kit, Part Number 3164573.	
3822608	**Weather-Pack Terminal Removal Tool** Used to repair Weather-Pack connectors.	
3822758	**Deutsch/AMP/Metri-Pack Male Test Lead** Used to test electrical circuits.	
3822759	**AMP Terminal Removal Tool** Used to repair AMP connectors.	

Tool No.	Tool Description	Tool Illustration
3822760	**Deutsch Terminal Removal Tool (Blue)** Used to repair Deutsch connectors.	 3822760
3822860	**Heat Gun** Used to repair connector wires.	
3822917	**Deutsch/AMP/Metri-Pack Female Test Lead** Used to test electrical circuits.	 3164132
3822930	**Wire Crimping Pliers** Used when repairing connector wires.	 3822930
3823843	**Deep Well Socket (1.25 inch)** Used to remove and install sensors and actuators.	 3823843
3824510	**Electrical Contact Cleaner** Used to clean electrical contacts and connectors.	 oi8togt
3824811	**Deutsch Male Test Lead** Used to test electrical circuits.	 3164133
3824812	**Deutsch Female Test Lead** Used to test electrical circuits.	 3164132

Tool No.	Tool Description	Tool Illustration
3824815	**Deutsch Terminal Removal Tool (Red)** Used to repair Deutsch connectors.	
3886388	**INSITE™ Software Kit** Used to troubleshoot, program, and adjust CM850 ISC and ISL engines. Refer to your local Cummins Authorized Repair Location for Part Number.	

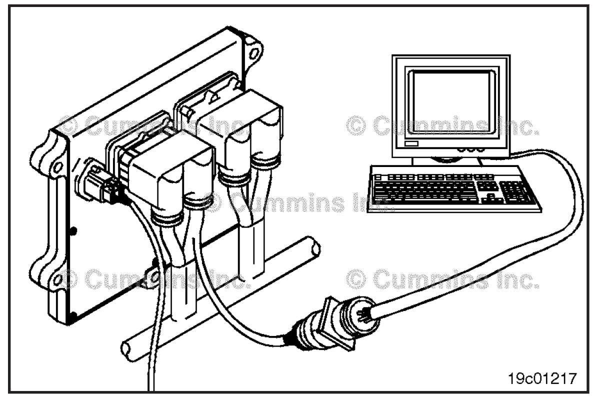
Barometric Air Pressure Sensor (019-004)

Initial Check

Connect an electronic service tool to the vehicle data link.

Turn the keyswitch to the ON position.

Monitor the barometric air pressure. If the barometric air pressure is less than or equal to 523 mm Hg [20.6 in Hg] and the present elevation is less than 3.048 km [10,000 ft], replace the barometric air pressure sensor.

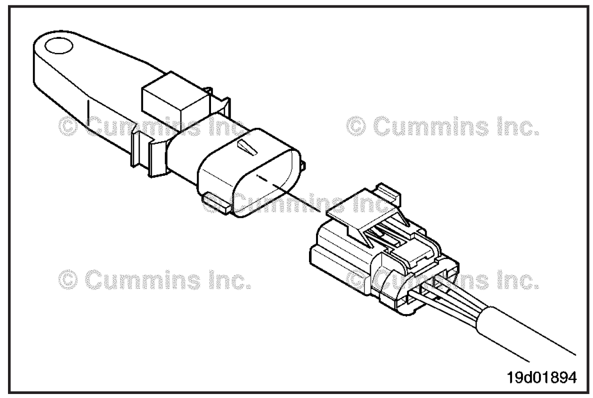


Remove

Slide the locking tab sideways.

Push down on the button towards the rear of the connector and disconnect from the sensor.

The sensor is connected to the intake manifold cover by a capscrew.



Install

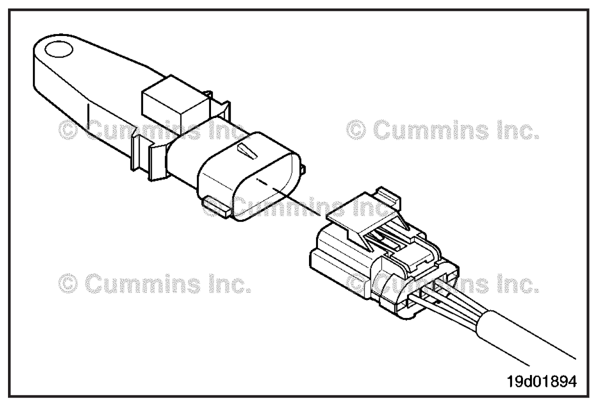
Install a new sensor on the engine.

Attach the sensor to the intake manifold cover.

Torque Value: 9 N•m [80 in-lb]

Push the connectors together until they lock.

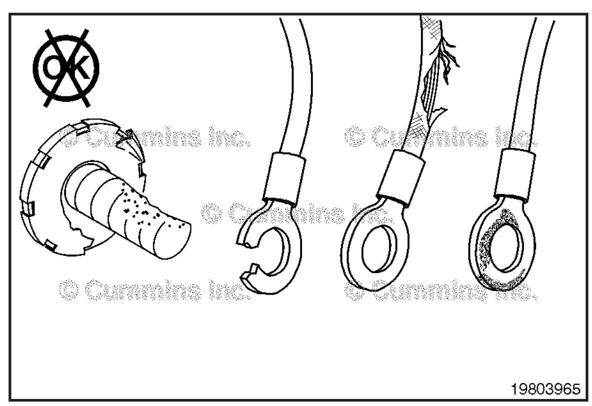
Slide the locking tab to the lock position.

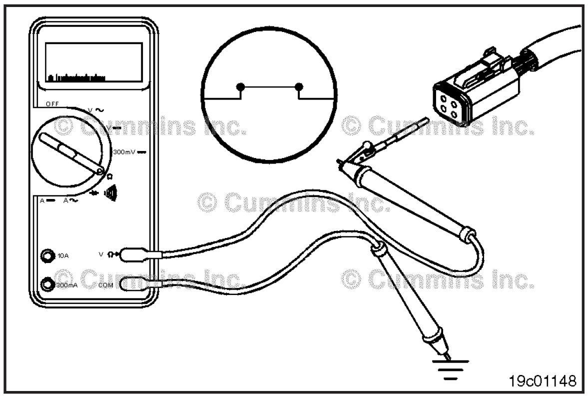


Battery Ground Circuit (019-008)

Resistance Check

Check the Original Equipment Manufacturer harness ground connection for loose, corroded, or broken connections.

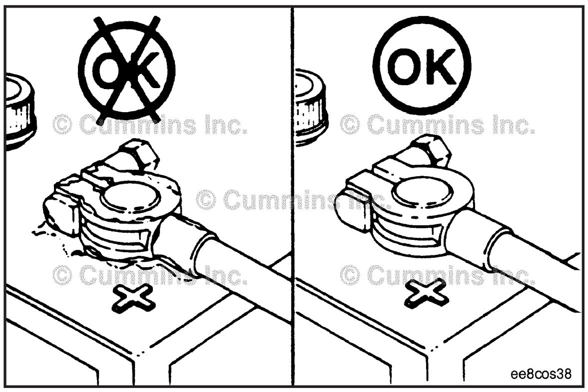




⚠CAUTION⚠

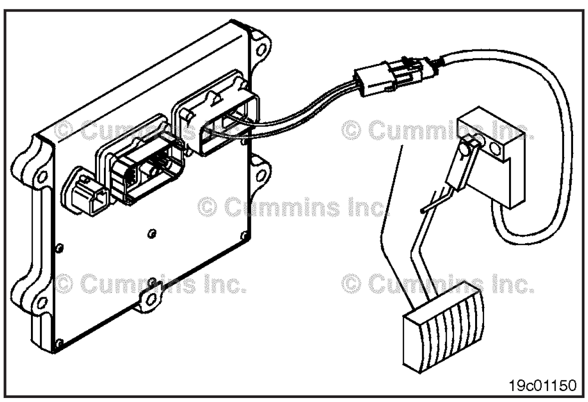
The leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

Measure the resistance between the battery supply negative (-) pin of the Original Equipment Manufacturer harness control module connector(s) and engine block ground or chassis ground for each control module. Reference the wiring diagram for connector pin identification. The resistance **must** be 10 ohms or less.



If the resistance value is **not** correct, check the batteries, cables, and cable connections.

Repair or replace the parts as required.

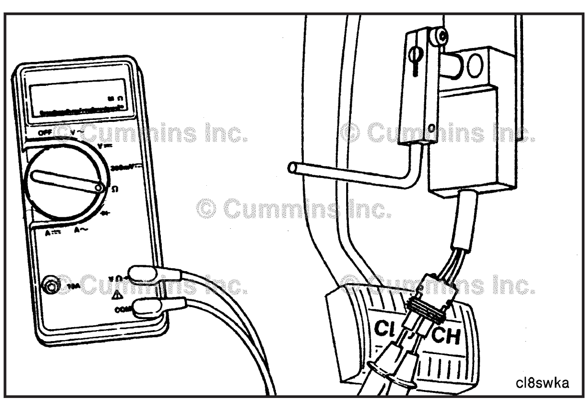


Clutch Pedal Position Switch (019-009)

General Information

The clutch pedal position switch circuit is used to disable the PTO and cruise control features.

The circuit consists of an open control switch, a clutch pedal position switch signal wire, and a switch return. When the clutch pedal position switch is installed and adjusted, the contact points are held closed. When the clutch pedal is depressed, the clutch pedal position switch is in its normally open position. This will disable the PTO or cruise control operation.



Resistance Check

If INSITE™ is available, monitor the clutch switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

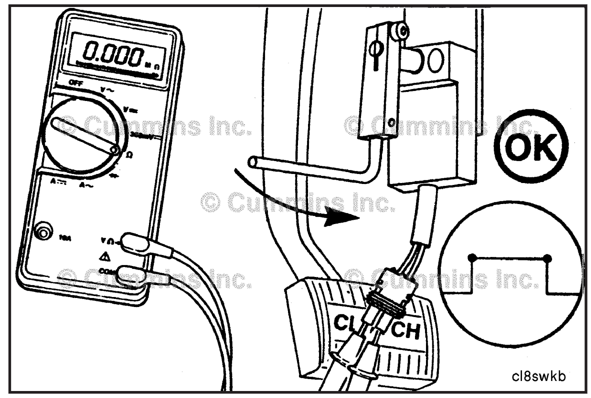
Find the clutch pedal position switch. The location will depend on the OEM installation procedures.

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).

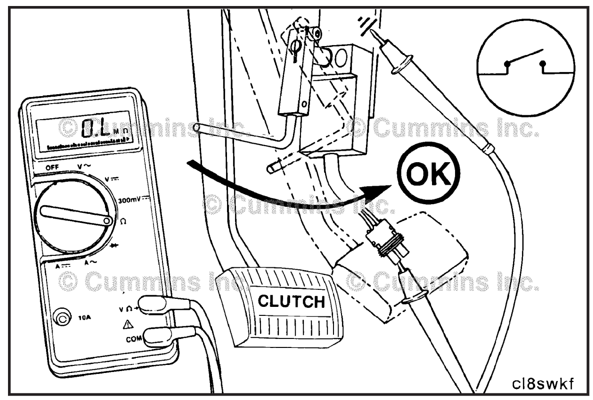


If the switch is **not** closed when the clutch is fully engaged, adjust the clutch switch trip lever. If the switch is **not** closed after adjusting the trip lever, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

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.

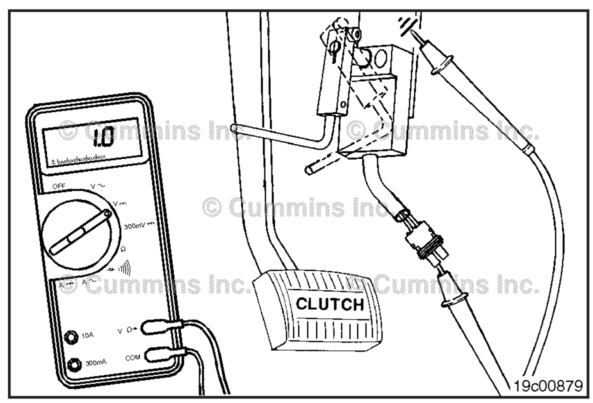
Check for Short Circuit to Ground



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

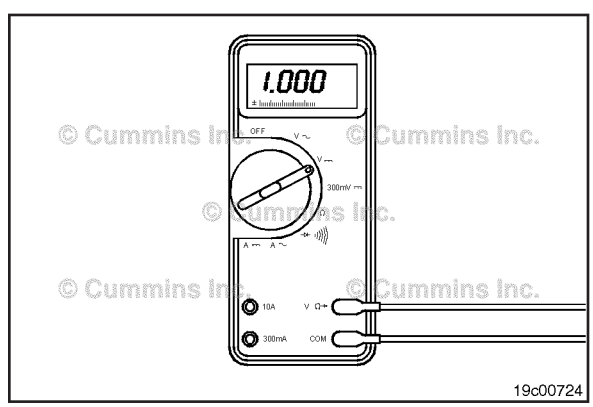


Turn the keyswitch to the ON position.

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.

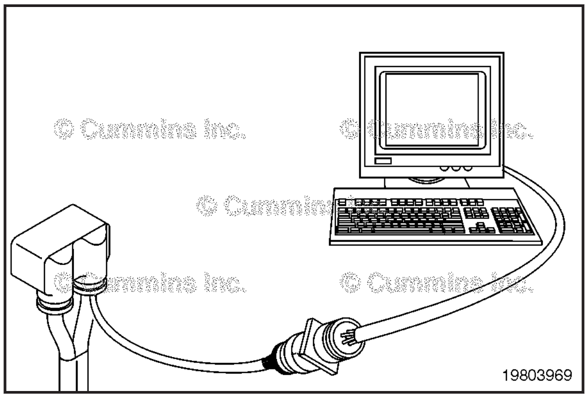
NOTE: An external voltage source is any wire in the OEM harness wiring that carries the voltage.

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.

Clutch Pedal Position Switch Circuit (019-010)

Resistance Check



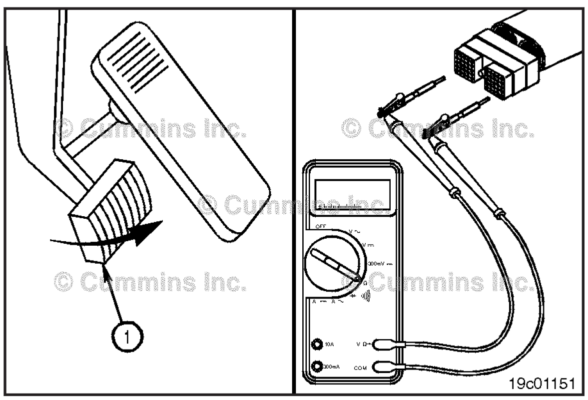
CAUTION

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.

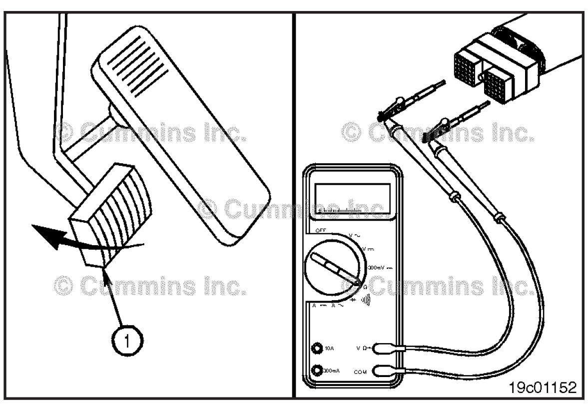
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

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.



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.

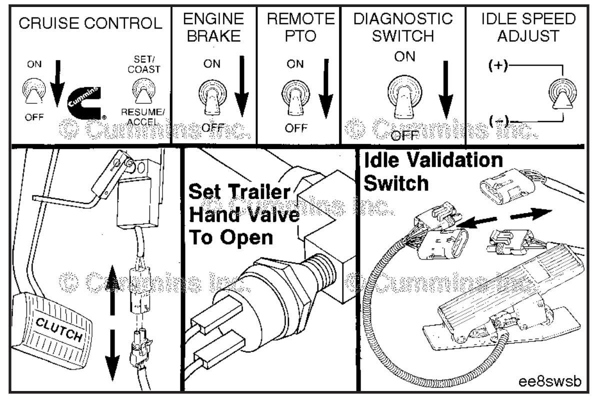
If the values are correct, the circuit **must** still be checked for a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.

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.

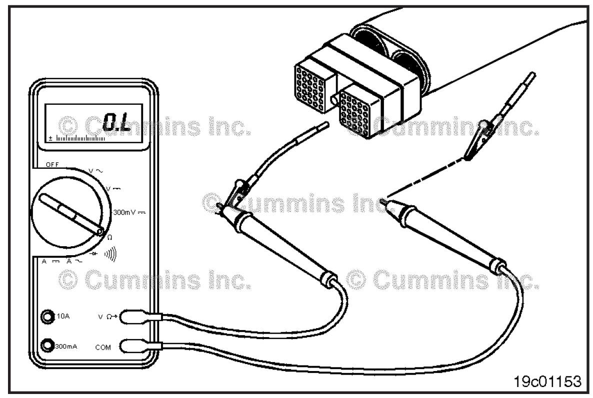
Set the service brake using the trailer brake hand valve.

Disconnect the clutch pedal position switch, the idle validation switch, and the throttle pedal.



Remove the test lead from the switch return pin.

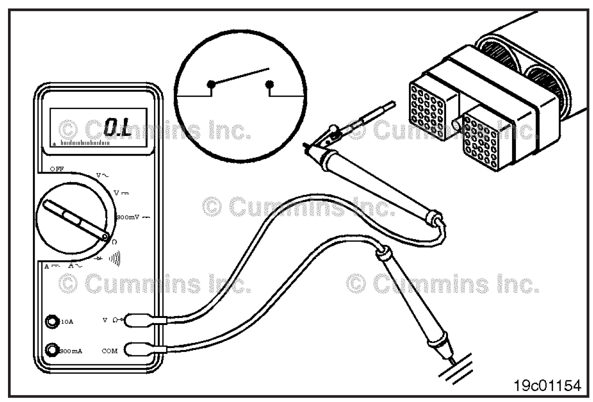
Disconnect the multimeter probe from the alligator clip.

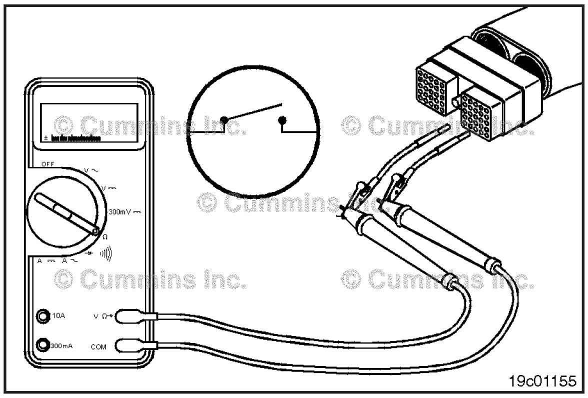


Touch the other multimeter probe to the engine block ground. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the clutch pedal position switch circuit.

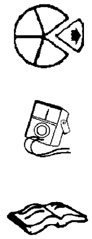
Repair or replace the wire connected to the clutch pedal position switch signal pin in the OEM harness according to the vehicle manufacturer's procedures.

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).

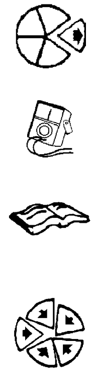
With the first test lead still touching the clutch pedal position switch signal pin, remove the test lead from the clutch pedal position switch return pin and touch it to all other pins, one at a time. The multimeter **must** show an open circuit (100k ohms or more) at all pins.

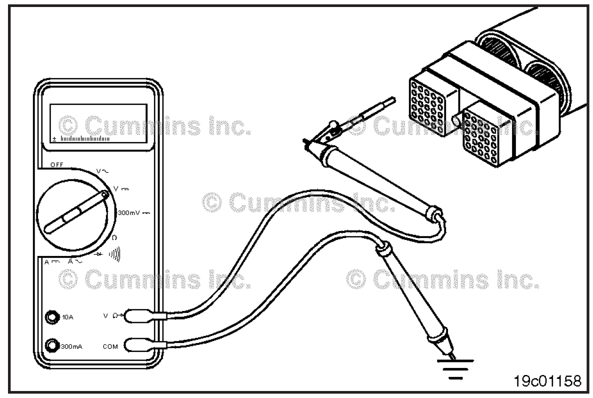
If the circuit is **not** open, there is a short circuit between the wire connected to the clutch pedal position switch signal pin and any pin that shows a closed circuit. Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

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.

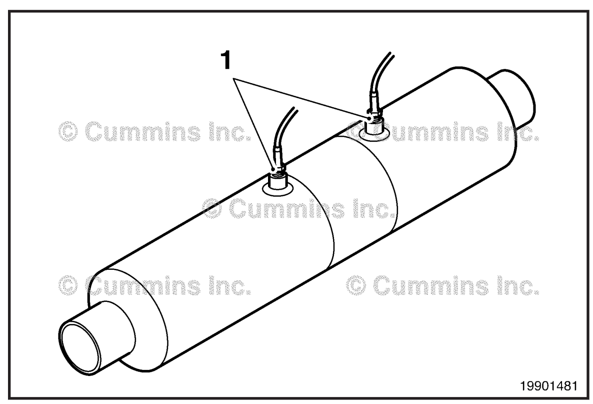
If the voltage value is more than 1.5 VDC, there is a short circuit between the wire connected to the clutch pedal position switch signal pin and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.

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.

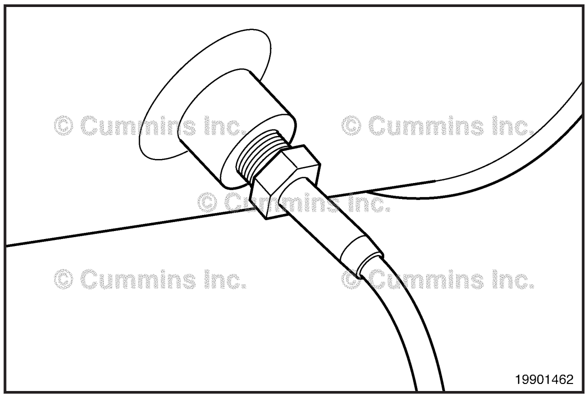
Exhaust Gas Temperature Sensor (019-013)

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.



19901462

Remove

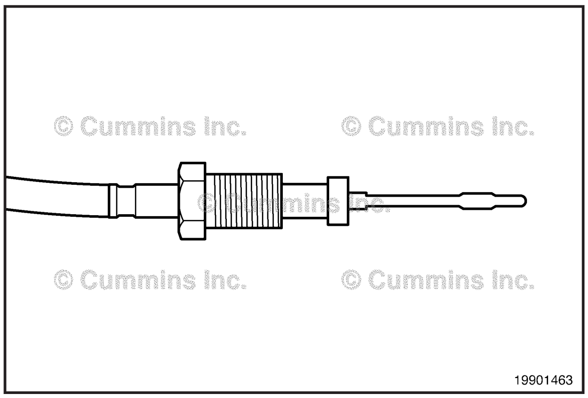
CAUTION

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.



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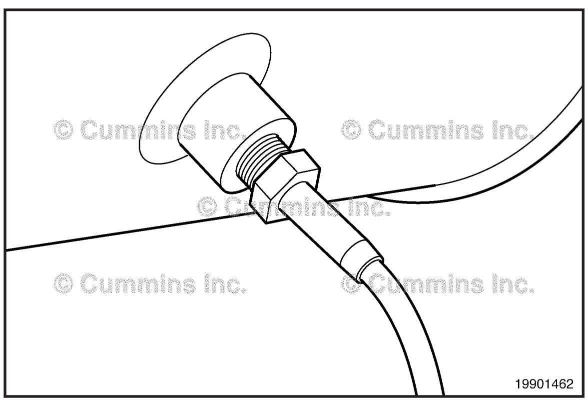
Clean and Inspect for Reuse

Visually inspect the exhaust gas temperature sensors for damage to wiring or body.

Visually inspect the tip of the exhaust gas temperature sensor for damage and carbon build up



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Install

Apply anti-sieze compound to the sensor threads of the exhaust gas temperature sensor.

Make sure the exhaust gas temperature sensors are connected to 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 after-treatment system.

Torque Value: 30 N•m [22 ft-lb]

Engine Coolant Level Sensor (019-017)

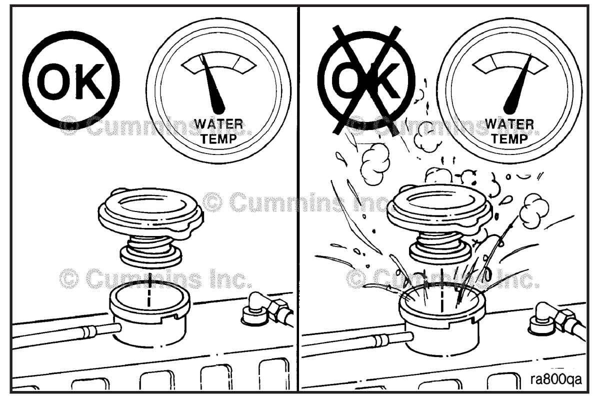
Remove

⚠WARNING⚠

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

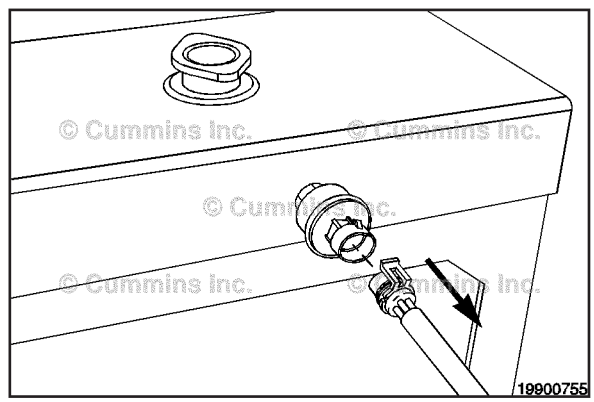
⚠WARNING⚠

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



Remove the radiator cap.

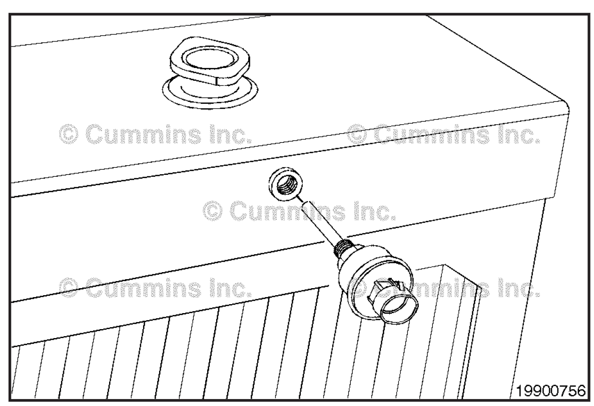
Drain enough coolant from the cooling system to empty the radiator top tank. Refer to Procedure 008-018 in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting Repair Manual, ISB^{e}, ISB, and QSB5.9 (Common Rail Fuel System), Bulletin 4021271.



Lift up on the locking tab and pull the electrical connectors apart.

Remove the sensor.

Install



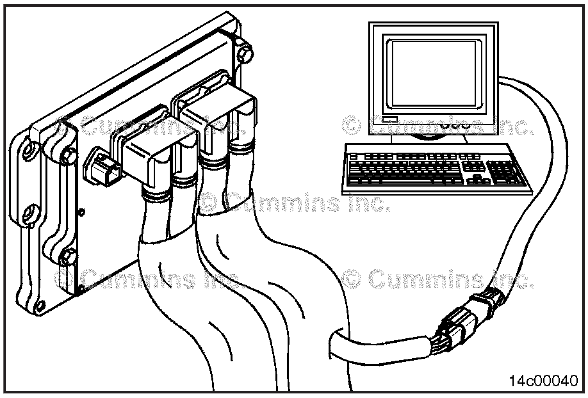
Install and tighten the new sensor according to the vehicle manufacturer's procedures.

Push the electrical connectors together until they lock.

Fill the cooling system and check for leaks. Refer to Procedure 008-018 in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting Repair Manual, ISB^{e}, ISB, and QSB5.9 (Common Rail Fuel System), Bulletin 4021271.

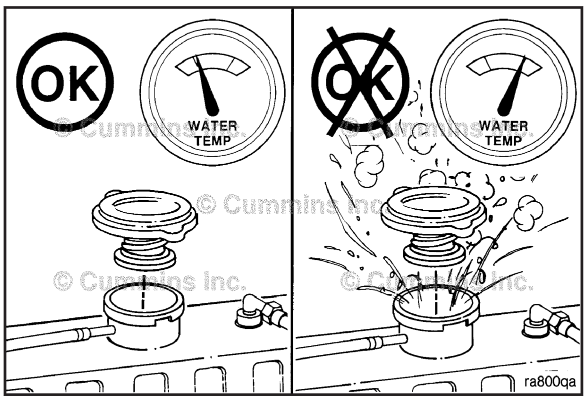
Engine Coolant Temperature Sensor (019-019)

Initial Check



Connect INSITE™ electronic service tool and verify the coolant temperature reading is the same on INSITE™ electronic service tool as the gauge reading.

Remove



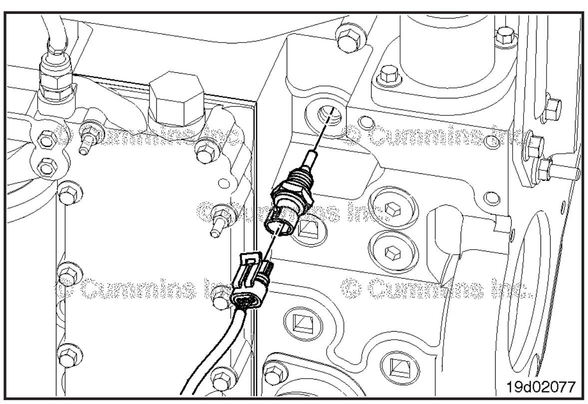
⚠WARNING⚠

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

⚠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 the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting Repair Manual, ISB^{e}, ISB, and QSB5.9 (Common Rail Fuel System), Bulletin 4021271.



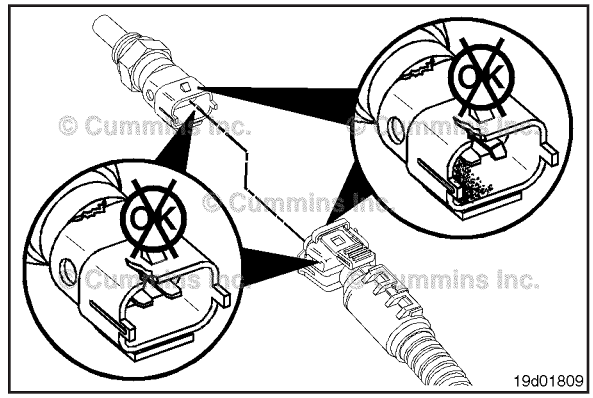
Lift up on the locking tab and pull the electrical connectors apart.

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.



Install

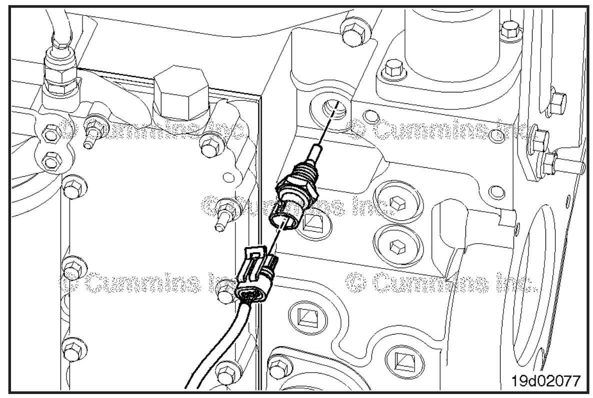
Make sure the new sensor has an o-ring installed.

Lubricate the o-ring with clean engine oil.

Install the new sensor into the engine. Tighten the sensor.

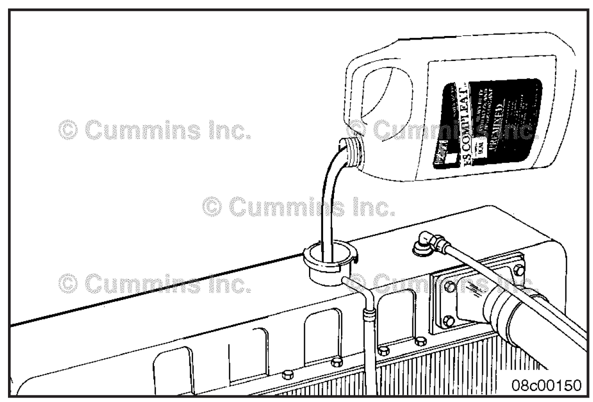
Push the connectors together until they lock.

Torque Value: 23 N•m [17 ft-lb]



Fill the cooling system and operate the engine to check for leaks. Refer to Procedure 008-018 in the Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting Repair Manual, ISB^{e}, ISB, and QSB5.9 (Common Rail Fuel System), Bulletin 4021271.

Monitor the engine coolant temperature sensor with INSITE™ electronic service tool for proper operation.

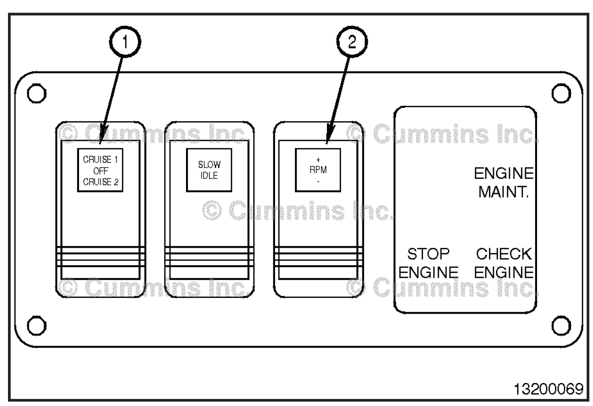


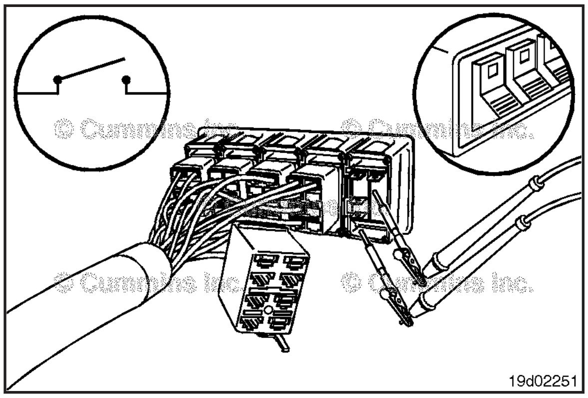
Cruise Control or PTO ON/OFF Switch (019-021)

General Information

Marine Applications

The Cruise 1/2 control switch is located on the control panel and has three settings, Cruise 1, Cruise 2 and OFF. The rocker switch is used to activate or disable the cruise control operation. The cruise control ON and OFF circuit consists of the Cruise Control 1 and 2 signal lines, switch common ground and the rocker switch.





Resistance Check

Marine Applications

If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate and remove the Cruise 1/2 switch from the connector.

Adjust the multimeter to measure resistance.

Touch the multimeter probes to the Cruise 1 signal switch prong (3) and the battery ground prong switch prong (2).

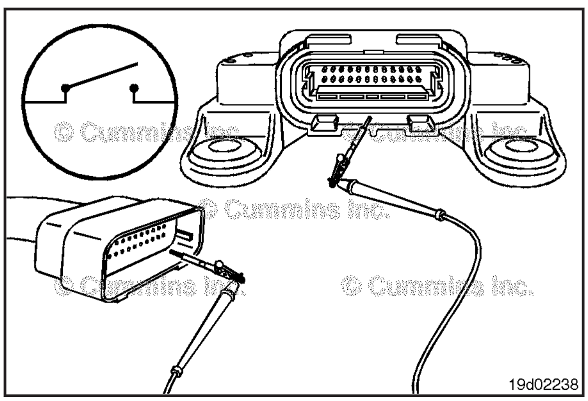
Turn the switch to the OFF position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Replace the switch.

Touch the multimeter probes to the Cruise 2 signal switch prong (1) and the battery ground prong switch prong (2).

Turn 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. Replace the switch.



Check for Short Circuit to Ground

Marine Applications

Touch the multimeter probes to the Cruise 1 signal switch prong (3) and the battery ground prong switch prong (2).

Turn the switch to the Cruise 1 position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

Touch the multimeter probes to the Cruise 2 signal switch prong (1) and the battery ground prong switch prong (2).

Turn the switch to the Cruise 2 position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

Check for Short Circuit from Pin to Pin

Marine Applications

Check for a short circuit from pin to pin.

Touch the multimeter probe to the Cruise 1 switch signal prong (3). Touch the other multimeter probe to the Cruise 2 switch signal prong (1).

Turn the cruise control switch to the OFF position.

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 1 and Cruise 2 signal lines. Replace the switch.

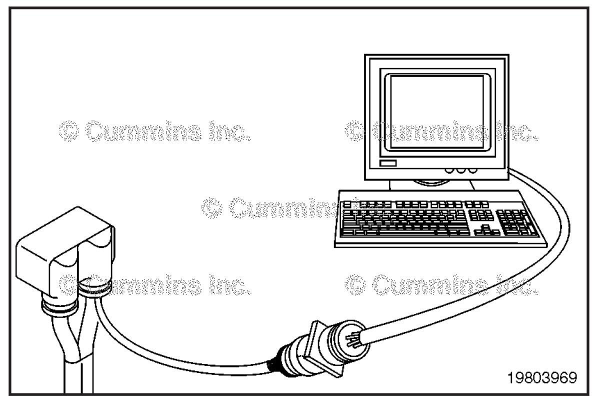
Cruise Control or PTO ON/OFF Switch Circuit (019-022)

Resistance Check

⚠CAUTION⚠

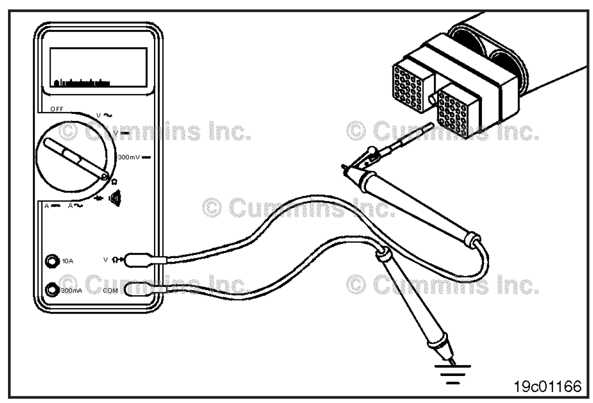
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If INSITE™ electronic service tool is available, monitor the switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



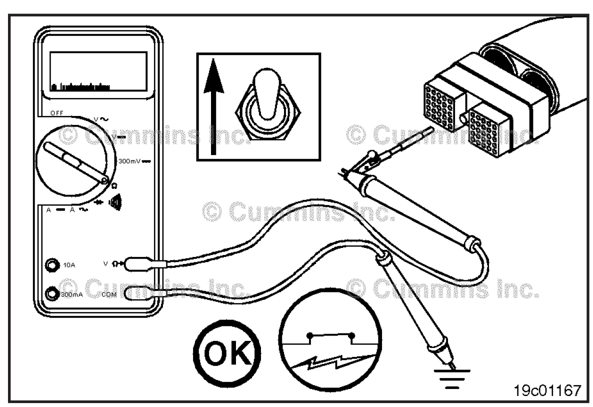
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

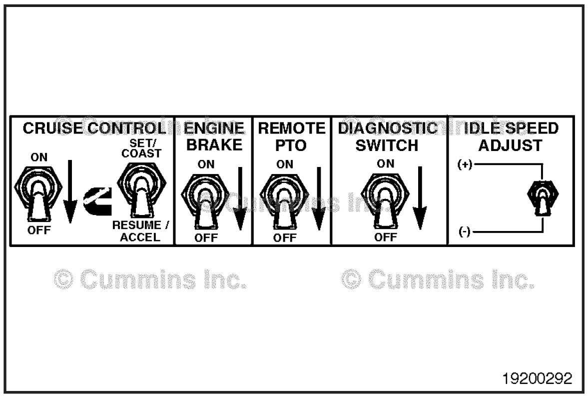
Insert the test lead into the cruise control ON/OFF switch signal pin of the original equipment manufacturer (OEM) harness connector and attach it to the multimeter probe. Touch the other probe to the engine block ground.



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.





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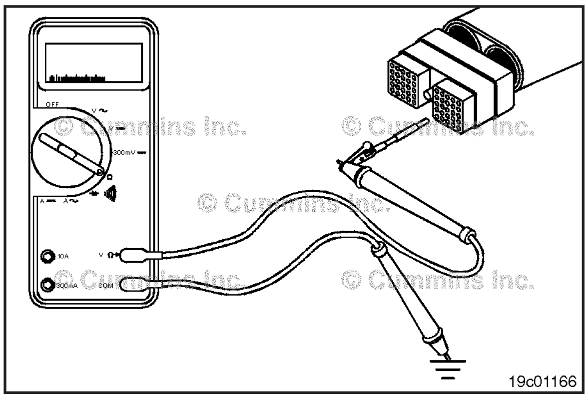
Check for Short Circuit to Ground

To isolate the cruise control circuit when checking for a short circuit, disconnect the OEM harness connector from the ECM and the OEM harness from the cruise control switch.

Disconnect the clutch pedal position switch, idle validation on/off switch, and the accelerator pedal position switch. Set all cab panel switches to the OFF or neutral position.

Set the service brake using the trailer brake hand valve.

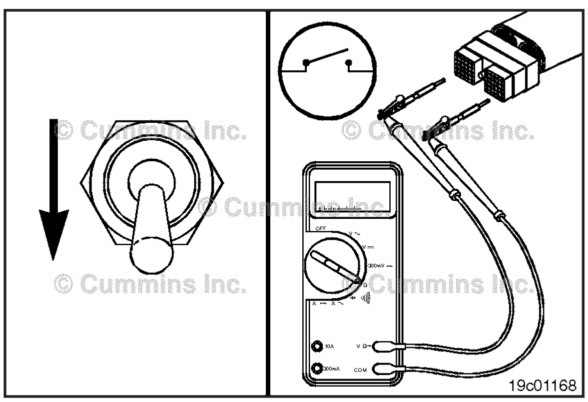

19c01166

Adjust the multimeter to measure resistance. Insert a test lead into the cruise control ON/OFF switch input of the OEM harness connector and attach it to a multimeter probe. Remove the other multimeter probe from the alligator clip and touch it to the engine block ground.

Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the cruise control circuit, provided that the switch has been previously checked.

Repair or replace the wire connected to the cruise control ON/OFF switch input in the OEM harness according to the vehicle manufacturer's procedures.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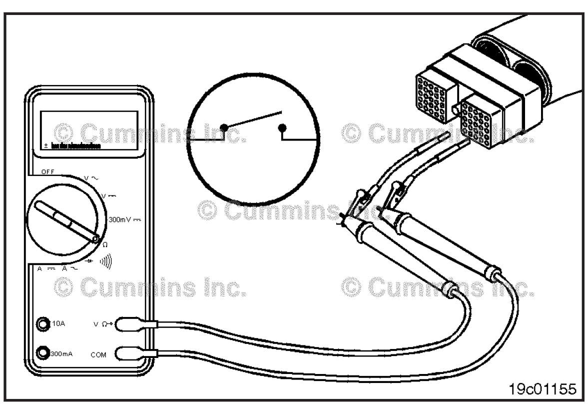
Check for Short Circuit from Pin to Pin

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).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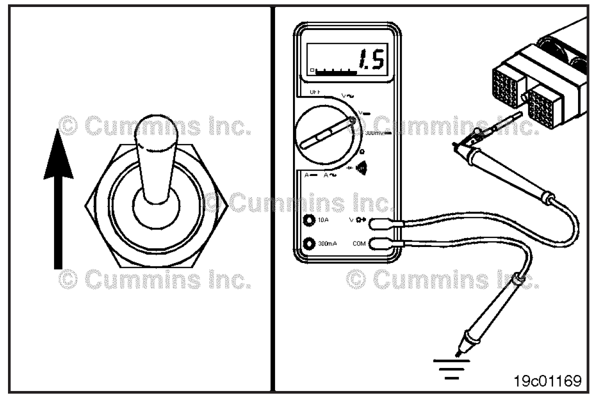
Remove the lead from the cruise control ON/OFF switch input and check all other pins. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

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.

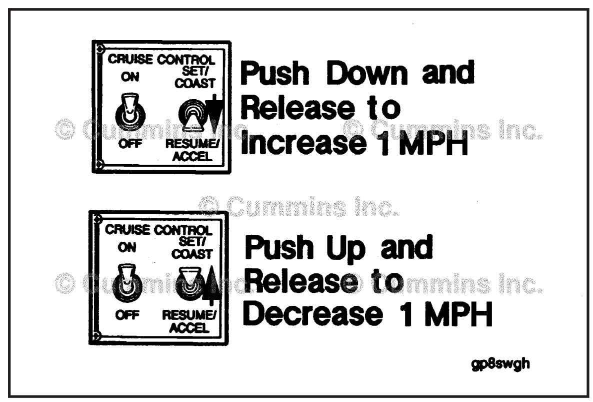


If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the cruise control/PTO ON/OFF switch circuit and a wire carrying power in the OEM harness. Remove the voltage source or repair the wiring in the OEM harness according to 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



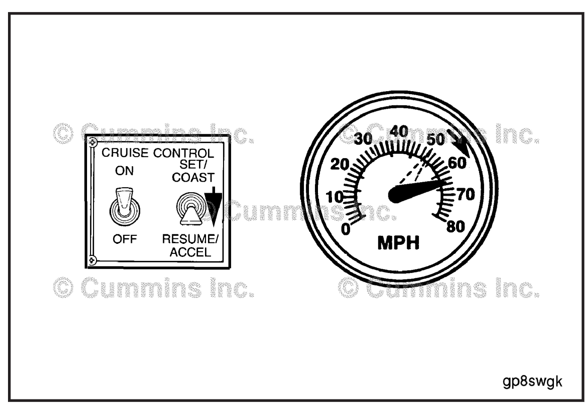
The cruise control/PTO set/resume select switch has two positions: SET/COAST and RESUME/ACCEL.

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.

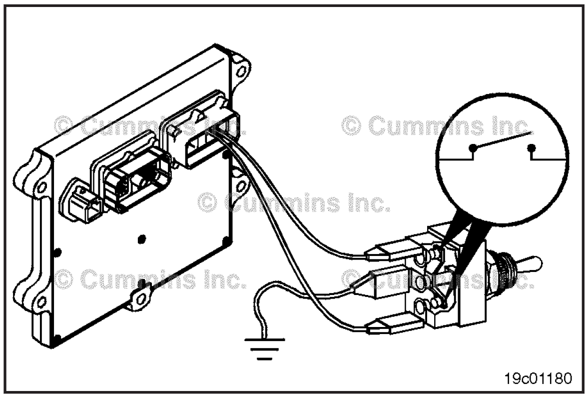
The operator can set the vehicle cruising speed when the switch is in the SET/COAST position. The SET/COAST position can also be used to reduce the vehicle cruising speed. Hold the switch in the SET/COAST position and the vehicle will coast down to a lower speed. When the select switch is released, the cruising speed will be reset.

NOTE: Some OEM's have switches labeled SET/ACCEL and RESUME/COAST.

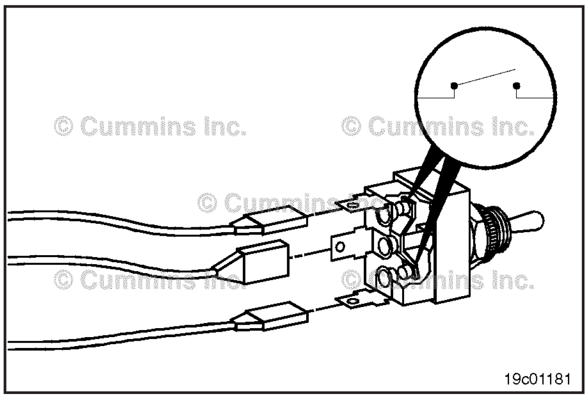
The operator can resume cruise control, after clutching or braking, by moving the switch to RESUME/ACCEL. The vehicle speed will return to the last set mph.



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.



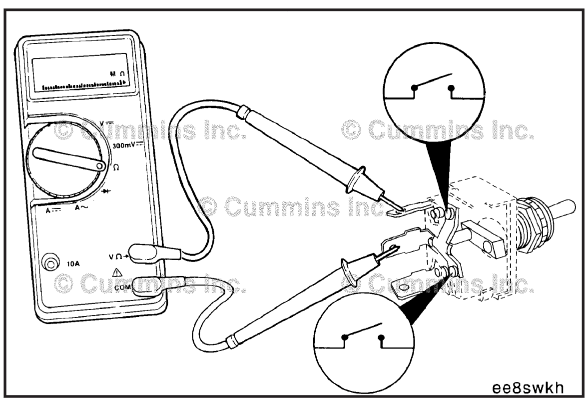
The cruise control/PTO set/resume switch circuit consists of the switch return, the cruise control/PTO resume/accel switch signal, cruise control/PTO set/coast switch signal and the vehicle mounted switch.



Resistance Check

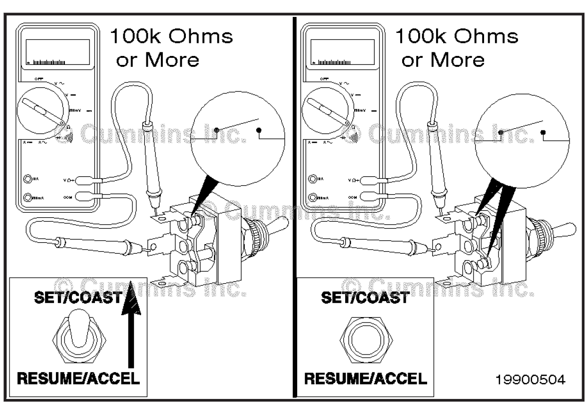
If INSITE™ is available, monitor the cruise control/PTO set/resume select switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

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.

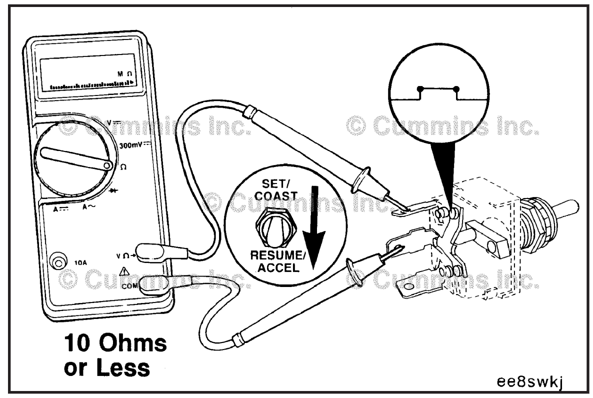
Touch one multimeter probe to the center terminal of the switch. Touch the other multimeter probe to the RESUME/ ACCEL terminal of the switch.



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.

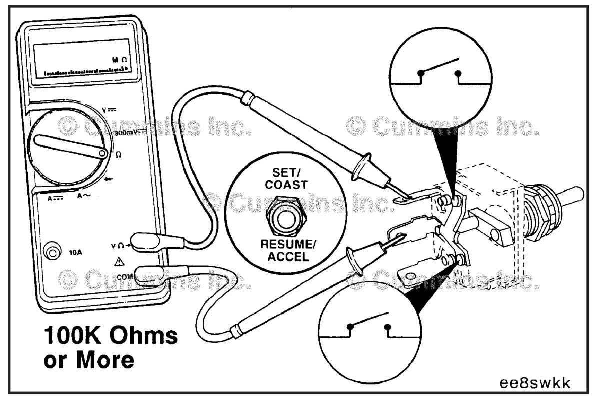
Hold the switch in the RESUME/ACCEL position. The multimeter **must** show a closed circuit (10 ohms or less) when the switch is held in the RESUME/ACCEL position.



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.

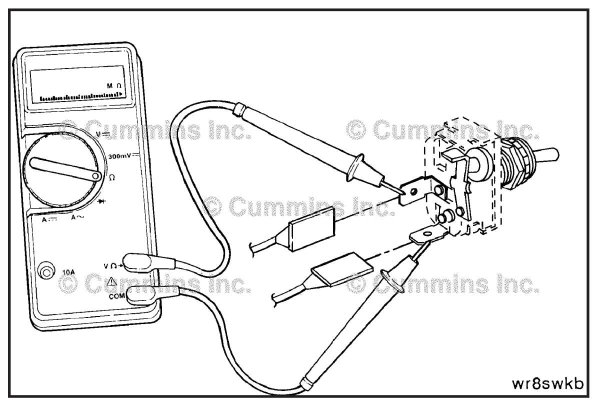
If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.



Touch one multimeter probe to the center terminal of the switch. Touch the other multimeter probe to the SET/ COAST terminal of the switch.

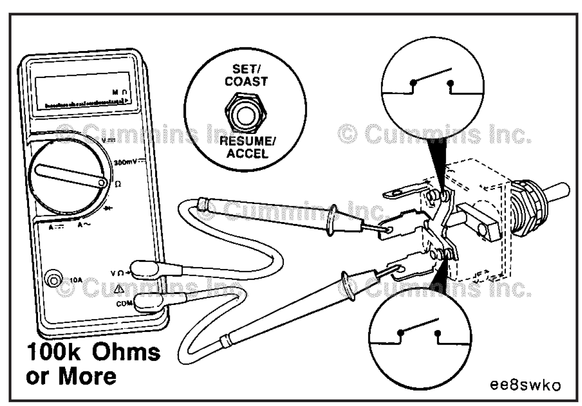
Hold the switch in the SET/COAST position.

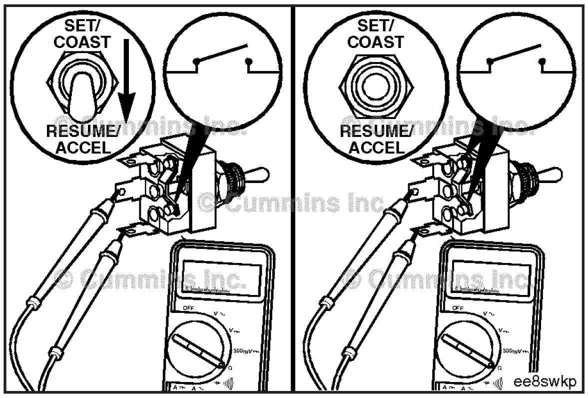
The multimeter **must** show a closed circuit (10 ohms or less) while the switch is held to the SET/COAST position.



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.

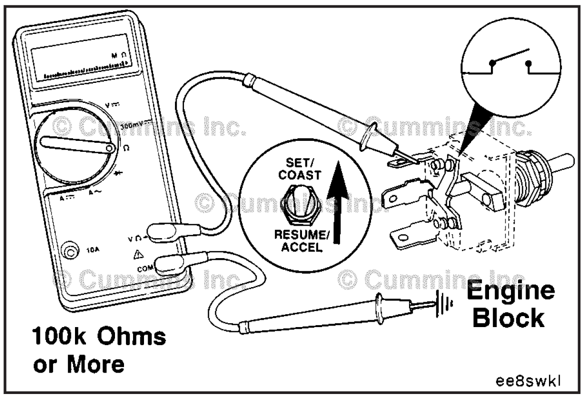




Move the switch to the RESUME/ACCEL position.

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.

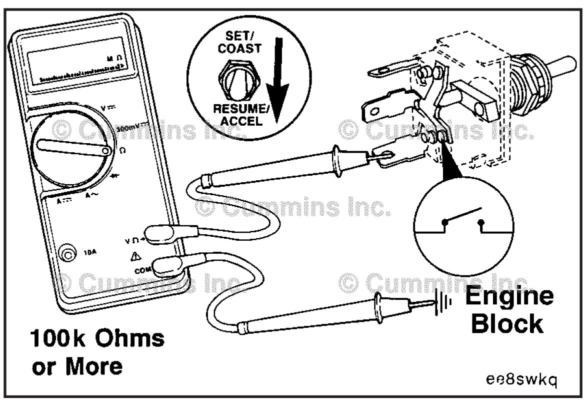


Check for Short Circuit to Ground

Adjust the multimeter to measure resistance.

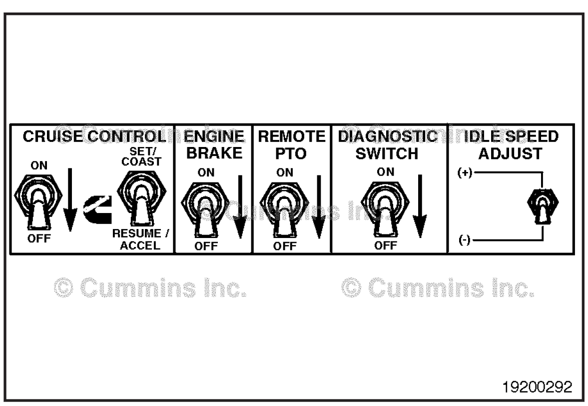
Touch one multimeter probe to the RESUME/ACCEL terminal of the switch. Touch the other multimeter probe to the chassis ground. Move the switch to the SET/ COAST position then to the RESUME/ACCEL position. Measure the resistance.

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

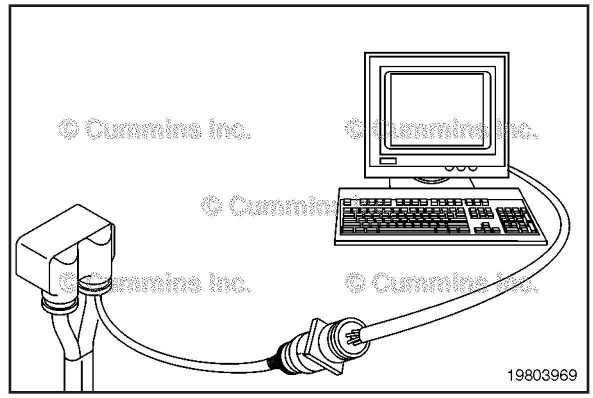
In addition to cruise control functions, the cruise control select switch also provides for increasing/decreasing idle speed, PTO speed, fault code flashout, and road speed governor limit.

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.

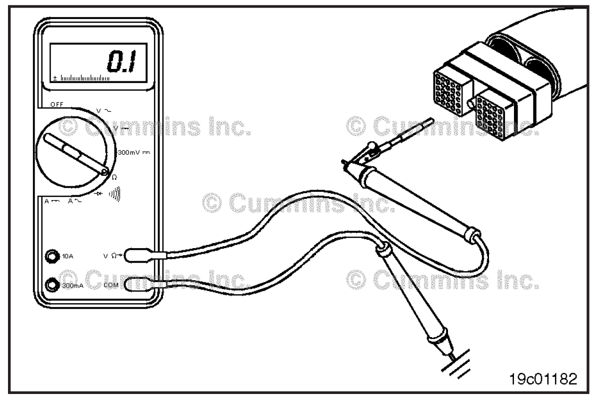
If INSITE™ electronic service tool is available, monitor the cruise control/PTO set/resume select switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

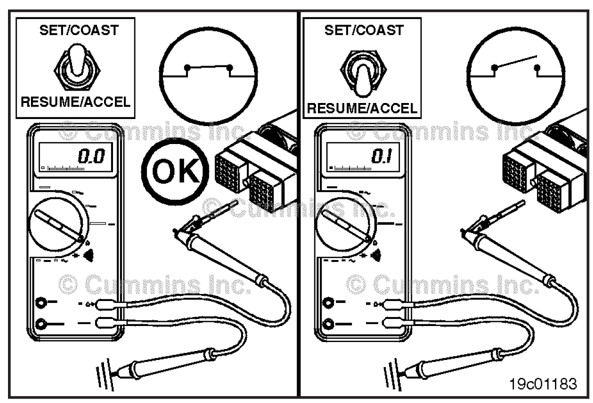
Insert a test lead into the cruise control/PTO set/coast switch signal of the OEM harness connector and connect the alligator clip to the multimeter probe.

Touch the other probe to engine block ground.

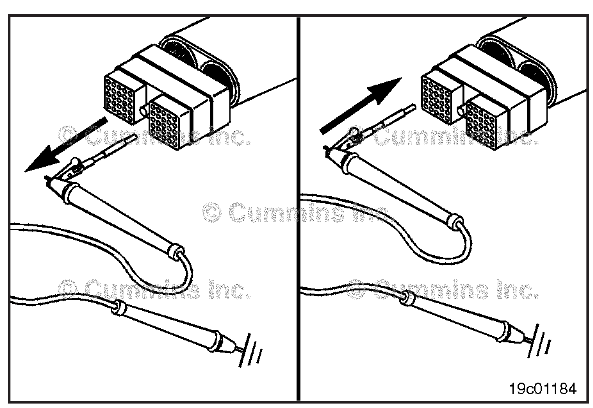


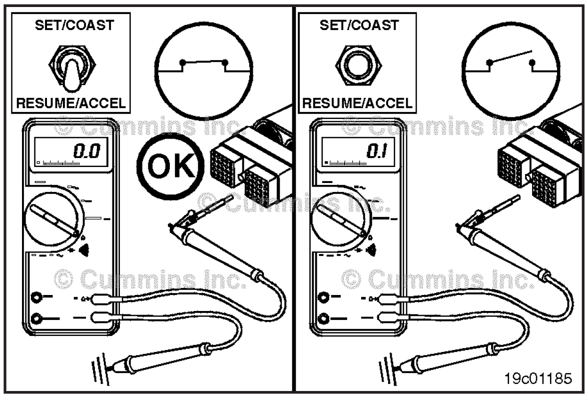
Hold the cruise control select switch in the SET/COAST position. The multimeter **must** show a closed circuit (10 ohms or less) while holding the switch in the SET/COAST position and return to an open circuit (100k ohms or more) when the switch is released. The circuit **must** remain an open circuit (100k ohms or more) when the switch is in the RESUME/ACCEL position.

If the resistance values are **not** correct, make sure the cruise control/PTO set/coast input and the cruise control/PTO resume/accel input wires are properly installed on the cruise control select switch. If both control wires are correctly installed, inspect the cruise control/PTO set/coast input and the cruise control/PTO resume/accel wires for an open circuit, provided the cruise control select switch has been previously checked.



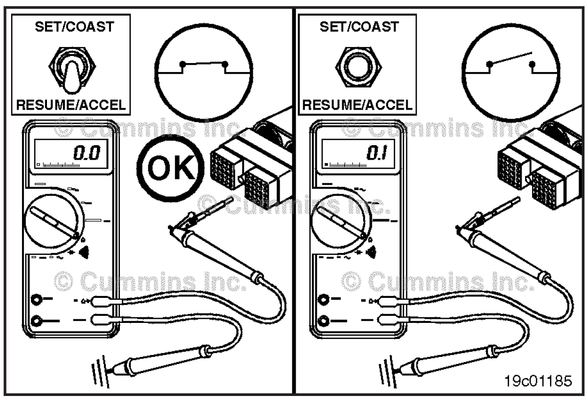
Remove the lead from the cruise control/PTO set/coast switch signal and insert it into the cruise control/PTO resume/accel switch signal.





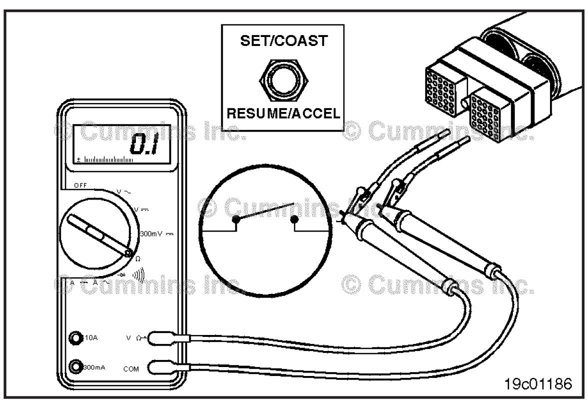
Hold the cruise control select switch in the RESUME/ACCEL position. The multimeter **must** show a closed circuit (10 ohms or less) when the switch is in the RESUME/ACCEL position and an open circuit (100k ohms or more) when the switch is released.

The circuit **must** remain an open circuit (100k ohms or more) when the switch is held in the SET/COAST position.



If the resistance values are **not** correct, make sure the cruise control/PTO resume/accel wire is properly installed on the cruise control select switch. If the cruise control/PTO resume/accel wire is properly installed on the cruise control select switch, inspect the cruise control/PTO resume/accel signal for an open circuit, provided the cruise control select switch has been previously checked.

If the resistance values are correct in the previous checks, the cruise control/PTO set/coast signal and cruise control/PTO resume/accel signal **must** still be checked for a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.



Check for Short Circuit from Pin to Pin

Isolate the cruise control/PTO set/resume select switch circuit as described in the previous section. Insert a test lead into the cruise control/PTO set/coast switch signal pin of the OEM harness connector. Insert the other lead into the first pin in the connector. Connect the alligator clips to the multimeter probes. Measure the resistance.

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.

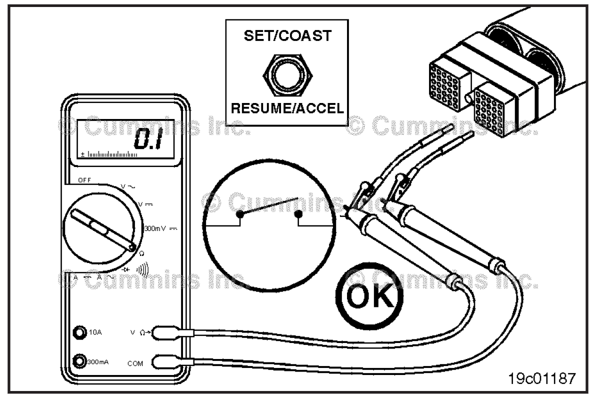
Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.

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).

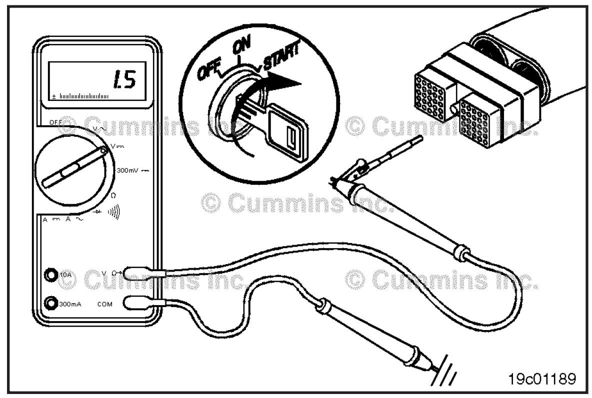
Remove the lead from the first pin in the connector and measure the resistance to all other pins. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit between the wire connected to the cruise control/PTO resume/accel switch signal 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.

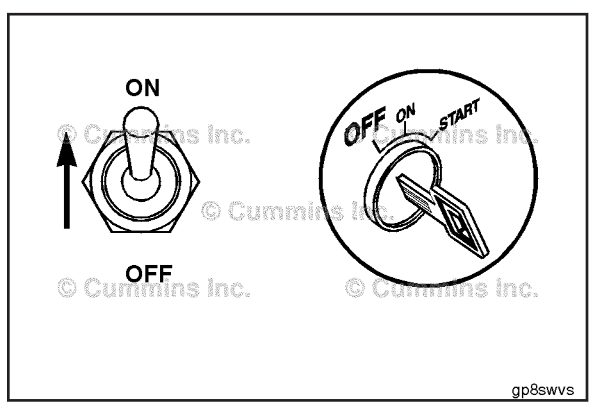
Connect all components after completing the repair.

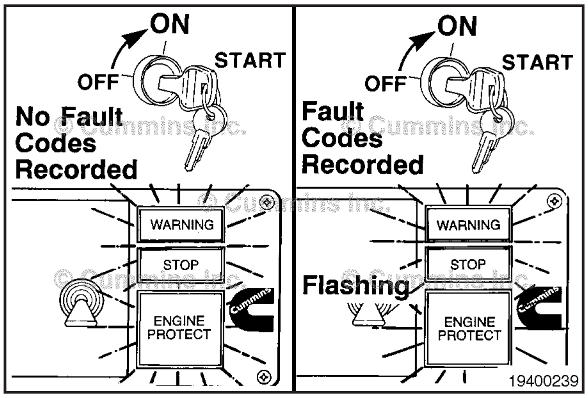
Diagnostic Test Mode Switch (019-027)

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.

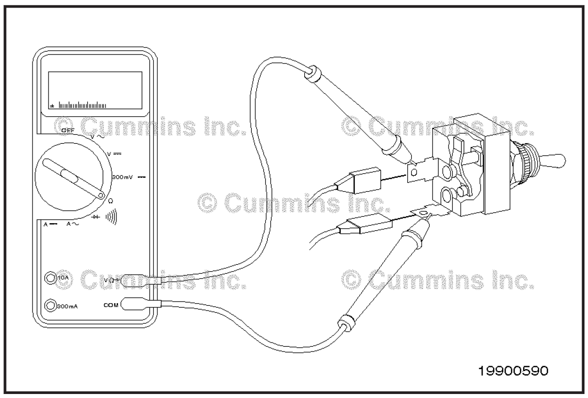
NOTE: Some OEM's use a shorting plug rather than a switch.





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.

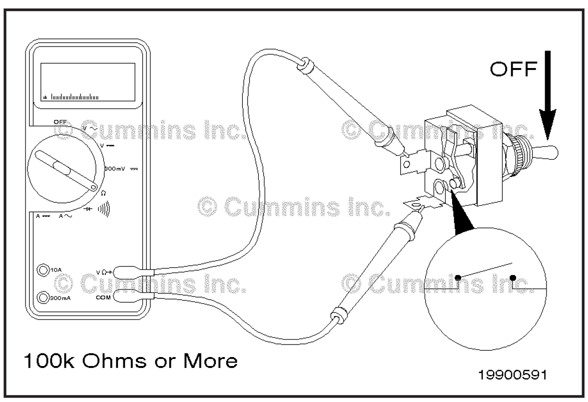


Resistance Check

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.

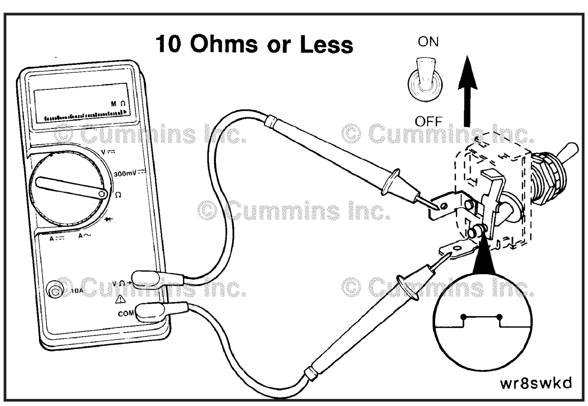
Touch the multimeter probes to the terminals on the switch.



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.



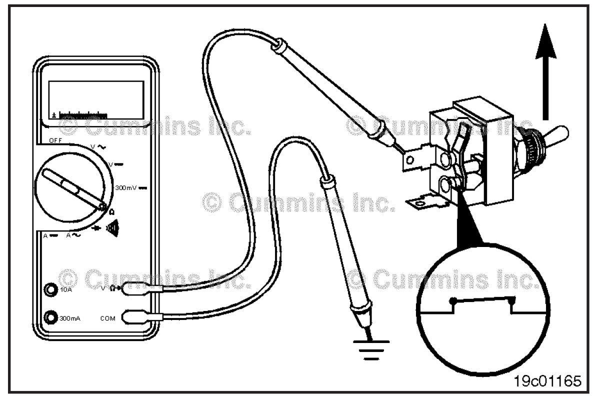
Move the switch to the ON position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed.

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.



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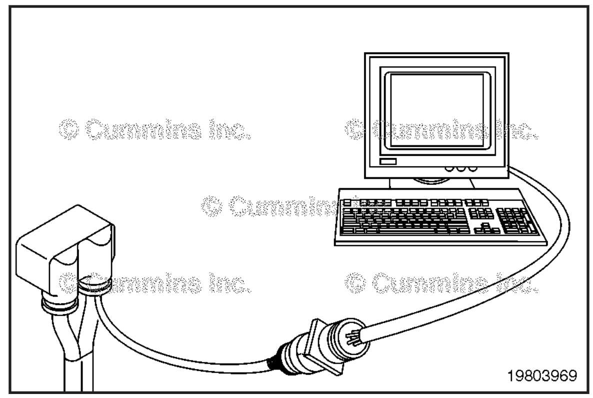
Diagnostic Test Mode Switch Circuit (019-028)

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.



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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.

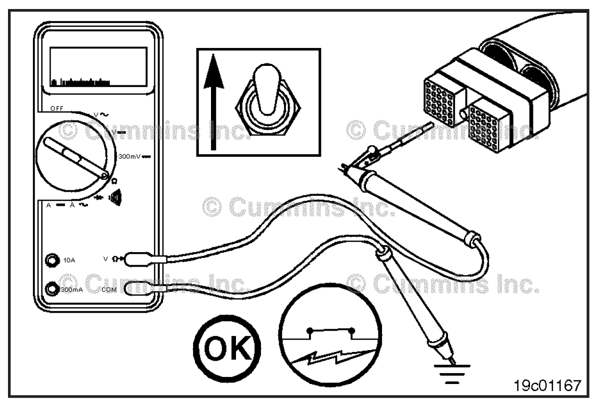
Move the ON/OFF switch to the ON position.

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.



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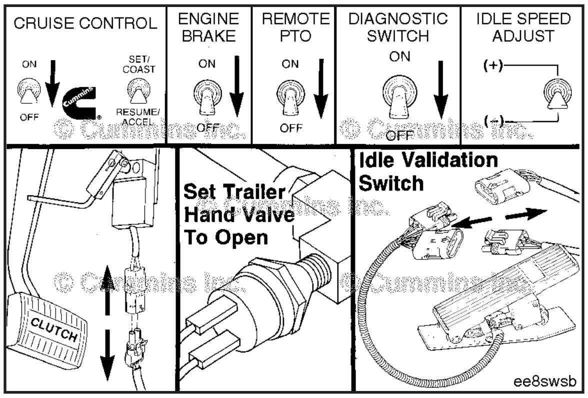


Check for Short Circuit to Ground

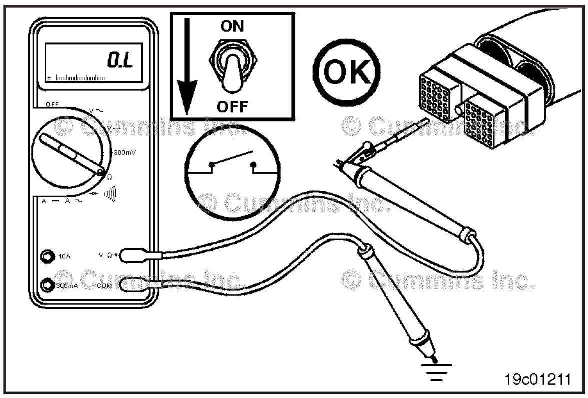
To isolate the diagnostic test mode switch signal circuit when checking for an electrical short, turn all cab panel switches to the OFF or neutral position.

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.

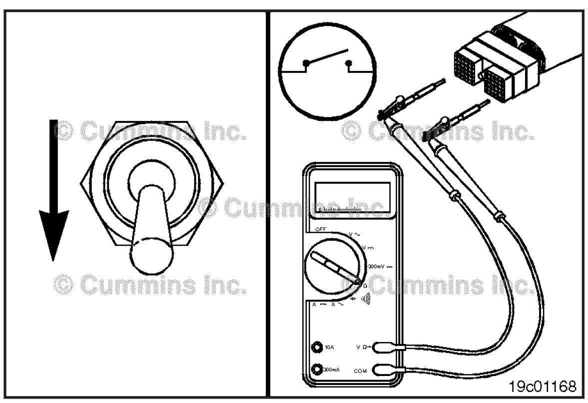


Disconnect the OEM harness connector from the electronic control unit. Set the diagnostic test mode switch to the OFF position.

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.

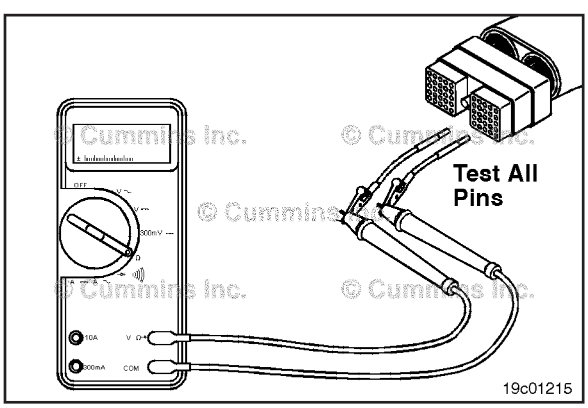
Touch the other probe to engine block or chassis ground.

The multimeter **must** show an open circuit (100k ohms or more).



Check for Short Circuit from Pin to Pin

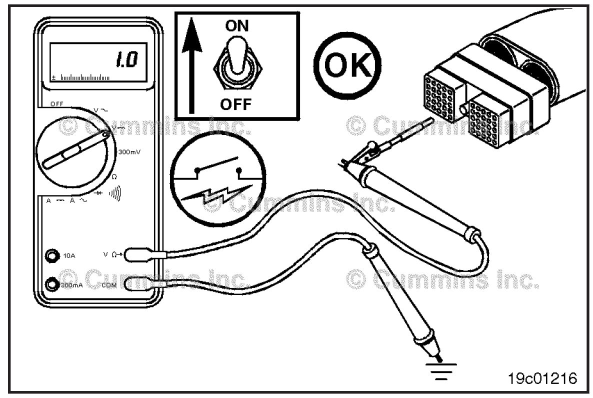
Check for a short circuit from pin-to-pin. Isolate the switch circuit by setting the cab panel switches as described in the previous section. Set the diagnostic test mode switch to the OFF position. Insert a test lead into the switch return pin of the OEM harness connector and connect it to the multimeter 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



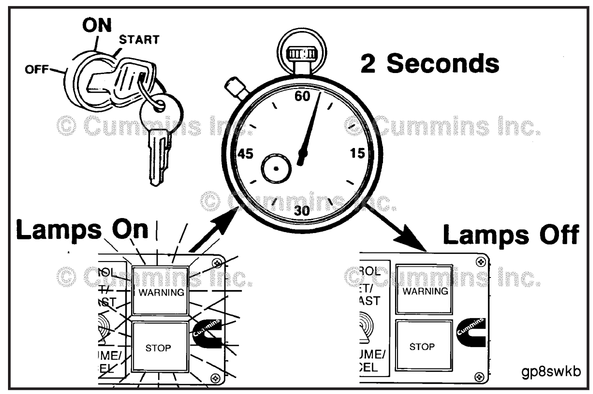
Turn the vehicle keyswitch to the ON position. Set the diagnostic test mode switch to ON. Adjust the multimeter to measure VDC. Insert a test lead into the diagnostic test mode switch signal pin of the OEM harness connector. Touch the other lead to the engine block or chassis ground. Measure the voltage. 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)

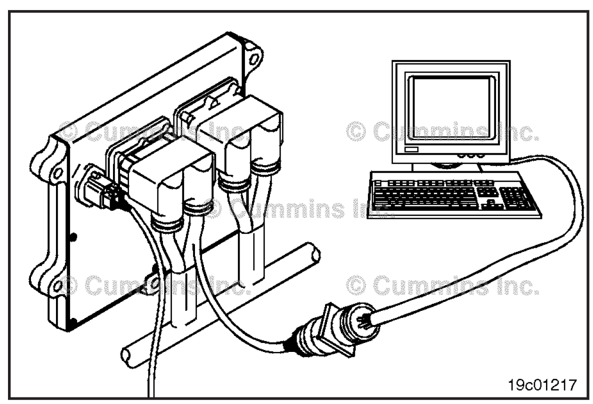
Initial Check



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.

NOTE: This applies to automotive and industrial **only**.



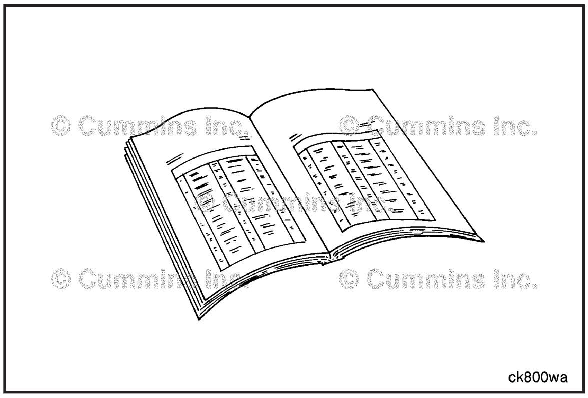
Turn the keyswitch to the OFF position.

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

Turn the keyswitch to the ON position.

Select the Monitor Mode on INSITE™ electronic service tool. INSITE™ electronic service tool **must** be able to communicate with the engine control module (ECM). If the ECM will **not** communicate with INSITE™ electronic service tool, reference the Communication Error - Electronic Service Tool or Control Device troubleshooting symptom tree in Section TS.

Preparatory Steps

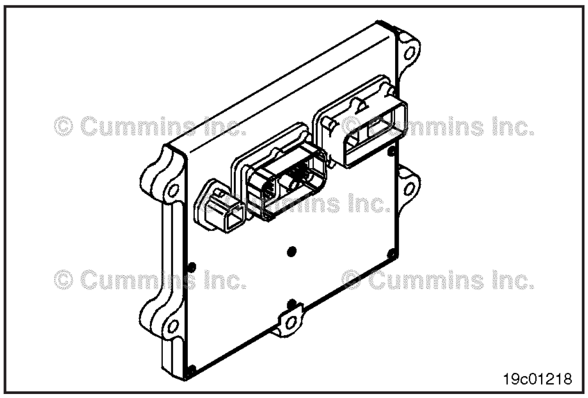


WARNING

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 connections. Refer to the original equipment manufacturer (OEM) service manual.

Remove

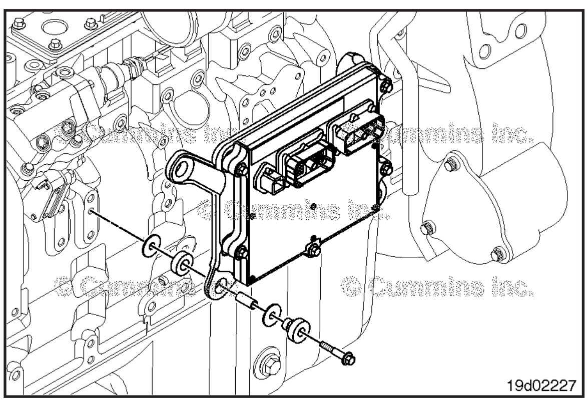


CAUTION

Record all programmable parameters, features, and calibration information from the old ECM before disconnecting the harness connectors. This information will be needed to program the new ECM.

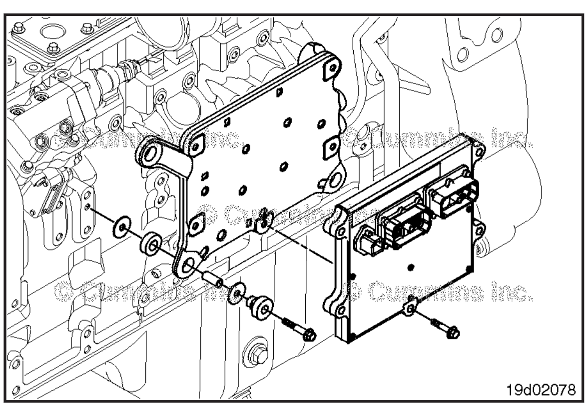
Disconnect the ECM power, engine, and OEM harness connectors from the ECM, if they are **not** already disconnected.

Marine Application: The OEM harness mounting plate **must** be removed first. To do so, remove the OEM harness connector, the unswitched power supply harness, and system integration module.



Remove the capscrews that secure the ECM to the engine block.

Install



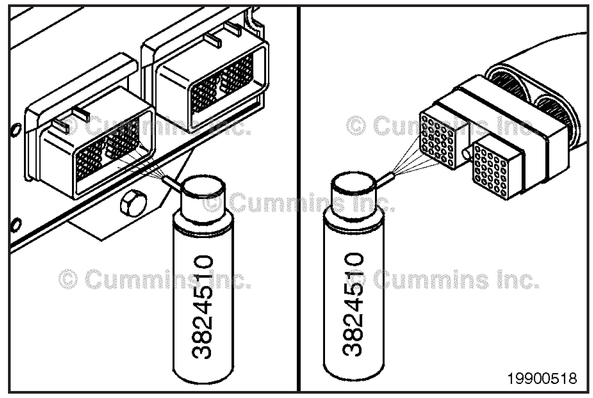
CAUTION

Do not paint the backside of the ECM. Make sure there is no grease or dirt between the ECM and the engine block.

Install the new ECM to the cooling plate.

Tighten the capscrews.

Torque Value: 18 N•m [159 in-lb]



⚠CAUTION⚠
Do not blow compressed air into the ECM ports or connectors. Compressed air can contain moisture due to condensation.

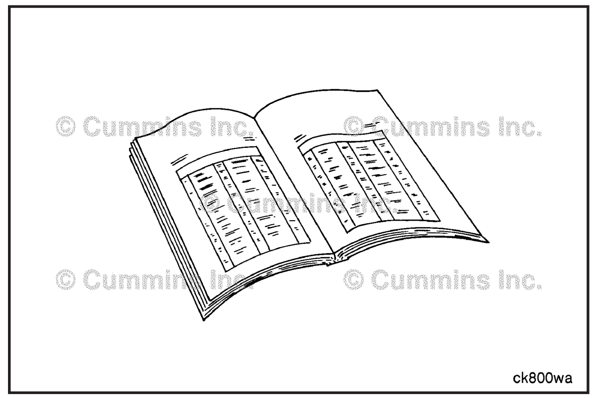
Use electrical contact cleaner, Part Number 3824510, to remove all dirt and moisture from the ECM connector ports and the harness connectors.

Connect the ECM power, engine, and OEM harness connectors to the ECM. Tighten the connector capscrews to the ECM.

Torque Value: 3 N•m [27 in-lb]

NOTE: When an ECM is replaced, the new ECM **must** be calibrated. Refer to Procedure 019-032 in Section 19.

Finishing Steps

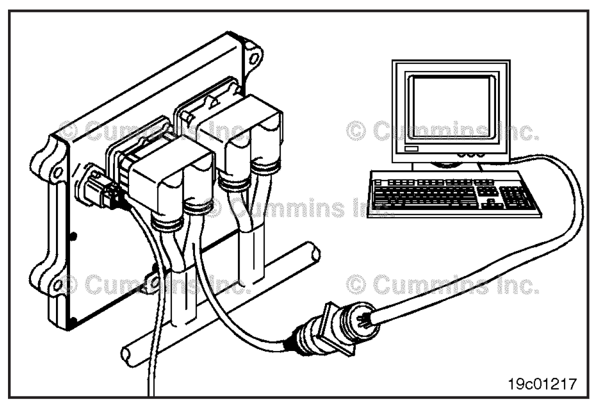


⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Connect the battery connections. Refer to the OEM service manual.
- Start the engine and check for proper operation.

Engine Control Module Calibration Code (019-032)

General Information

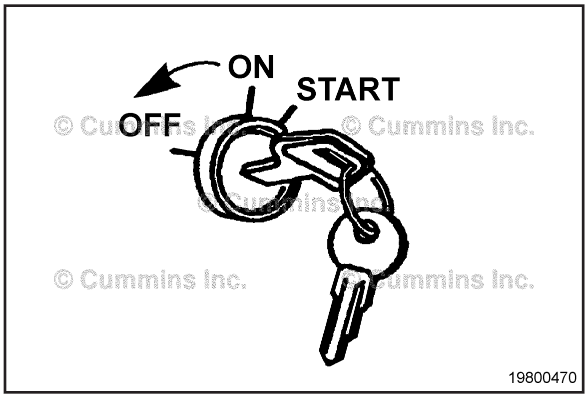


NOTE: Due to the number of various engine control module (ECM) configurations, this procedure has been written to be common. **Not** all illustrations within this procedure will represent the application that is being worked on.

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.

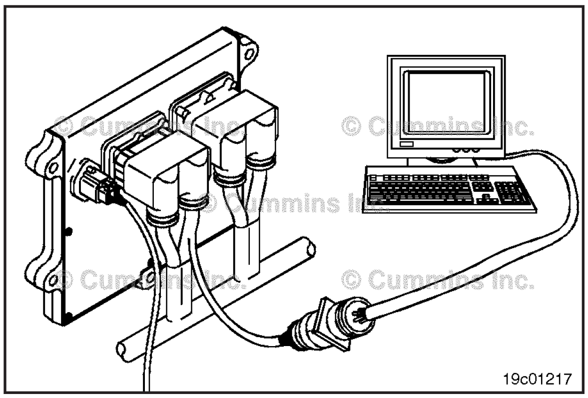
Record the values of ECM Distance Offset, ECM Time Offset, Engine Distance Offset, and Engine Time Offset prior to replacement or calibration of the ECM. These parameters can be found in the Trip Information section of Features and Parameters.



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.



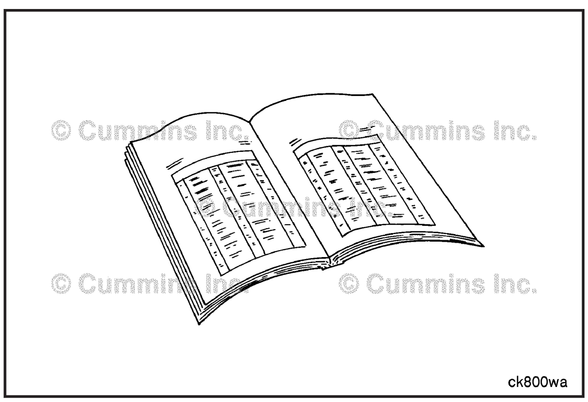
Preparatory Steps

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.

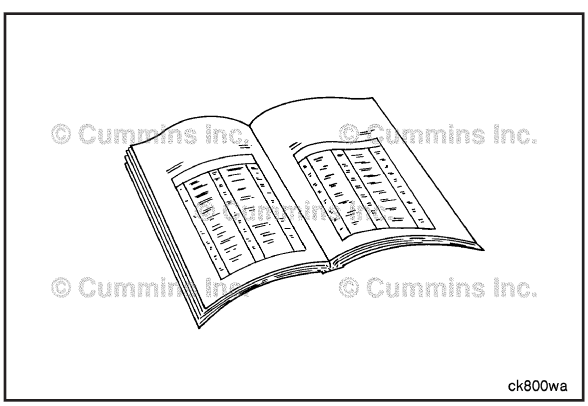
Input the values of ECM Distance Offset, ECM Time Offset, Engine Distance Offset, and Engine Time Offset prior to replacement or calibration of the ECM. These parameters can be found in the Trip Information section of Features and Parameters.



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.

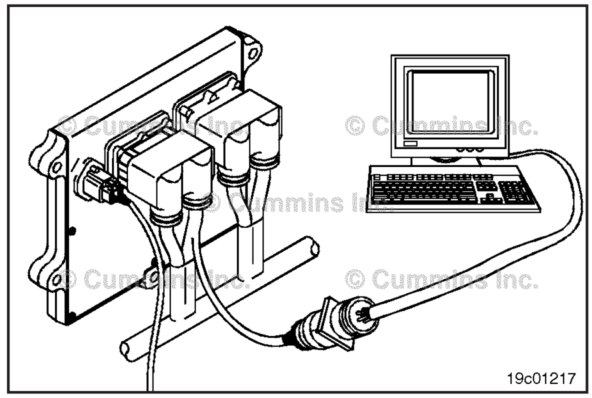


Inspect

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

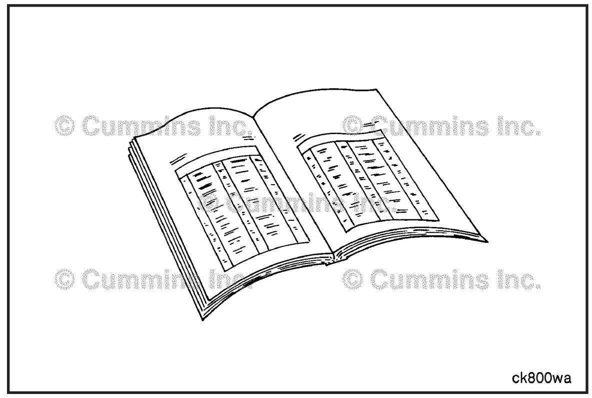
2 Select "My Applications"

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.



NOTE: The greater the number of parameters, the slower the rate at which they can be logged. Therefore, **only** log the minimum number of parameters if sample rate is important.

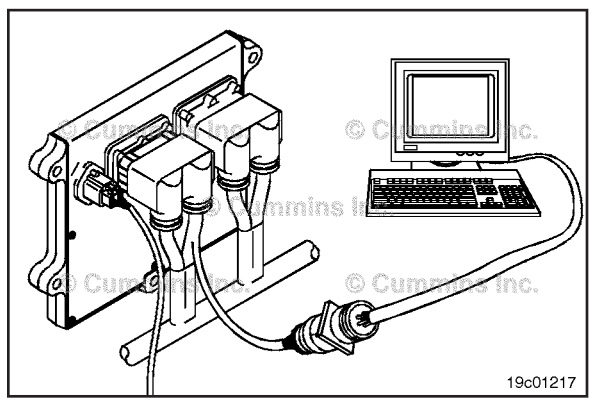
If no issue can be identified using the steps listed above, the following information should be collected to allow the issue to enter the technical escalation chain:

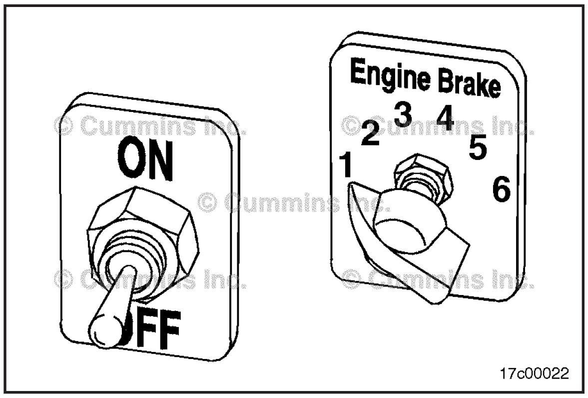
1 Engine specifics engine serial number (ESN), application, rating, engine hours, maintenance history, etc.)

2 ECM codes (the codes before and after, including revision numbers)

3 ECM images (before and after calibration downloads)

4 Data logs (utilize existing, pre-defined parameter groups, found in INSITE™ electronic service tool, or use the relevant wiring diagram to identify if multiple circuits utilize a common supply or ground, or monitor parameters which logically would be linked - i.e. User Fuelling State, Engine Speed, Commanded Fuel Rail Pressure, Measured Fuel Rail Pressure, etc.).



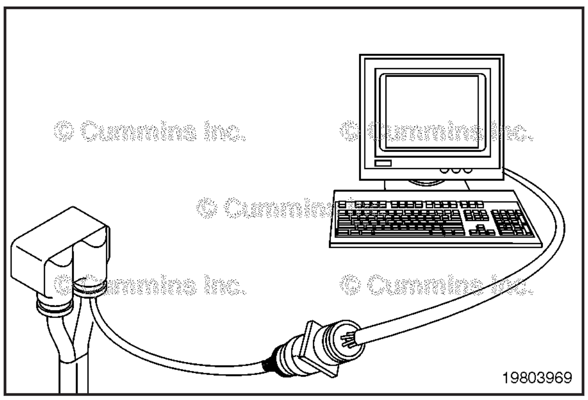


Engine Brake ON/OFF Switch (019-034)

General Information

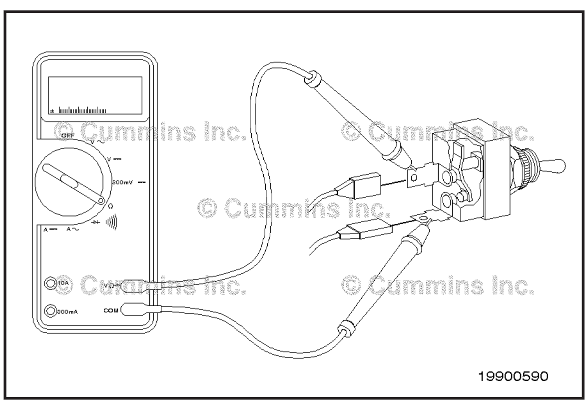
The engine brake ON/OFF switch circuit signals the system that the operator is requesting the engine brake system to be activated. The engine brake level switch determines what percentage of engine braking power will be used for engine braking. Three inputs to the electronic control module (ECM) from the engine brake level switch are used to communicate the setting to the ECM. Engine brake selector number 1 signal, engine brake selector number 2 signal, and engine brake selector number 3 signal in the original equipment manufacturer (OEM) connector are used. Various combinations of the three wires are used to represent the six switch positions.

After the ECM receives the signal from the engine brake ON/OFF switch and all other engine braking preconditions are met (engine RPM and road speed limits), the ECM will supply 12 VDC to the appropriate engine brake solenoids depending on how the 3 or 6 position engine brake level switch is set.



Resistance Check

If INSITE™ electronic service tool is available, monitor the engine brake ON/OFF switches for proper operation. If **not**, follow the troubleshooting procedures in this section.



Locate the engine brake ON/OFF switch. Remove the electrical connectors from the switch.

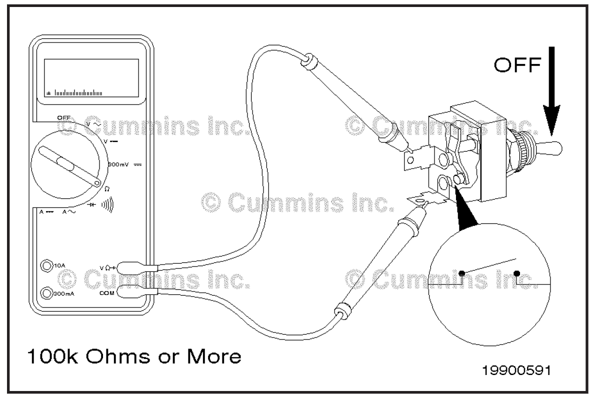
Label the wires with the location on the switch or the wire number. Remove the electrical connectors from the switch.

Adjust the multimeter to measure resistance.

Touch one multimeter probe to one of the terminals of the switch. Touch the other multimeter probe to the other terminal of the switch.

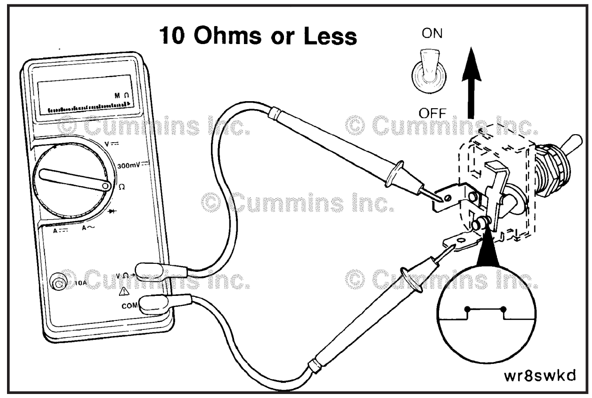
Move the switch to the OFF position. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed.

Refer to the OEM troubleshooting and repair manual for replacement procedures.



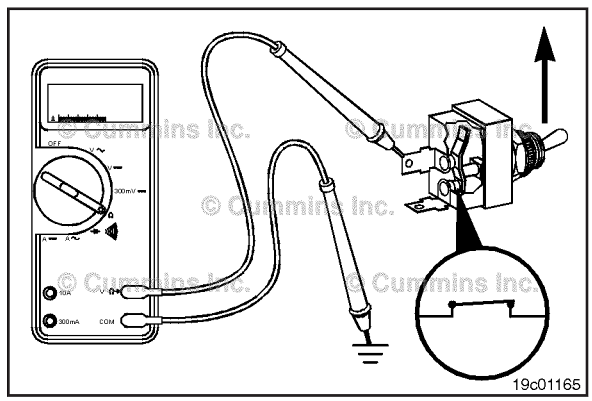
Place the switch in the ON position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed.

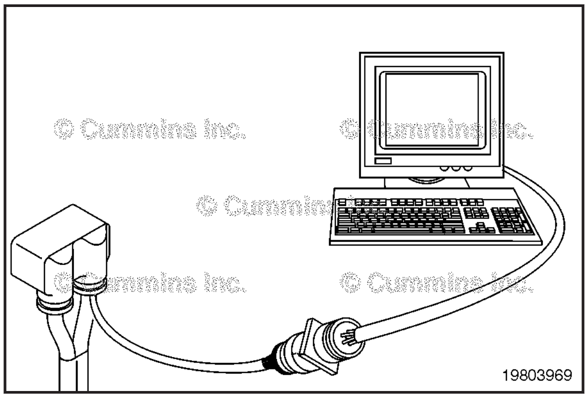
Refer to the OEM troubleshooting and repair manual for replacement procedures.



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.





Engine Brake ON/OFF Switch Circuit (019-035)

Resistance Check

⚠CAUTION⚠

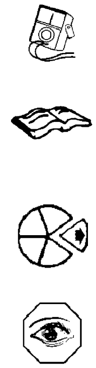
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

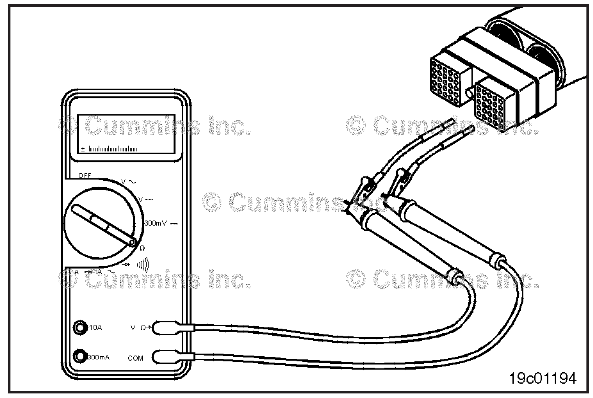
If INSITE™ electronic service tool is available, monitor the engine brake switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.

Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

Insert one of the test leads into the switch return of the OEM harness connector and connect the alligator clip to the multimeter probe. Insert the other lead into engine brake selector signal number 1 of the OEM harness connector and connect the alligator clip to the other multimeter probe.

Move the engine brake ON/OFF switch to the ON position. Move the engine brake level switch to position number 1 for a six-position switch or to position number 2 for a three-position switch. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the switch return and engine brake selector signal number 1 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 engine brake selector signal number 1 **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.





Remove the lead from engine brake selector signal number 1 and insert it into engine brake selector signal number 2 of the OEM harness connector.

Move the engine brake ON/OFF switch to the ON position. Move the engine brake level switch to position number 2 for a six-position switch or to position number 1 for a three-position switch.

The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect engine brake selector signal number 2 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, engine brake selector signal number 2 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.

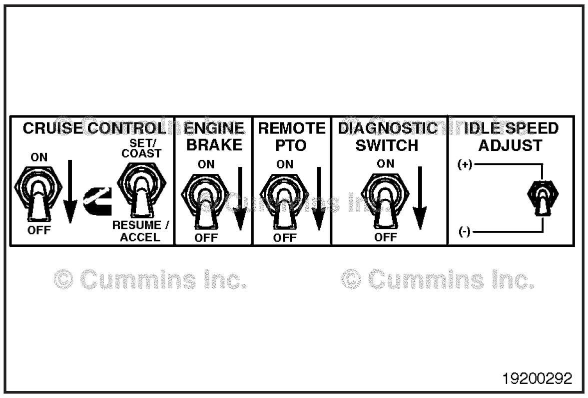
Remove the lead from engine brake selector signal number 2 and insert it into engine brake selector signal number 3 of the OEM harness.

Move the engine brake ON/OFF switch to the ON position. Move engine brake level switch to position number 3.

The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the engine brake selector signal number 3 wire for an open circuit, provided that the switch has been previously checked. Refer to the OEM troubleshooting and repair manual for repair procedures.

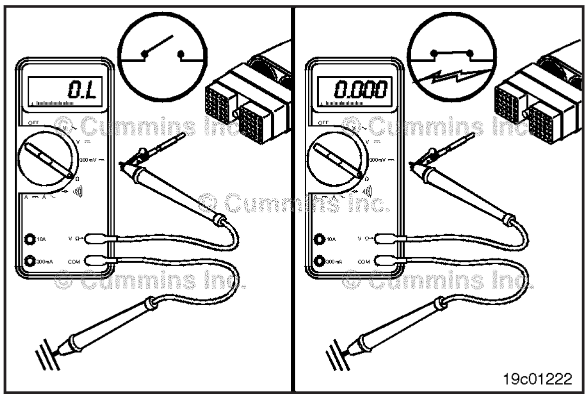
If the resistance is within the specification, the engine brake selector signal number 3 wire **must** be checked for a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.

Connect all components after completing the repair.



Check for Short Circuit to Ground

To isolate the engine brake circuit when checking for an electrical short, turn all cab panel switches to the OFF or neutral position.



Move the engine brake level switch to position number 1 for a six-position switch or position number 2 for a three-position switch.

Insert a test lead into engine brake selector signal number 1 pin of the OEM harness connector and connect it to a multimeter probe.

Touch the other multimeter probe to the engine block ground.

Switch the engine brake ON/OFF switch to the OFF position.

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 brake circuit, provided the engine brake ON/OFF switch and engine brake selector switch have been previously checked.

Repair or replace the wire connected to the switch return or engine brake selector signal number pin 1 in the OEM harness connector according to the vehicle manufacturer's procedures.

Remove the lead from engine brake selector signal number 1 pin and insert it into engine brake selector signal number 2 pin of the OEM harness connector.

Move engine brake level switch to position number 2 for a six-position switch or to position number 1 for a three-position switch.

Switch the engine brake ON/OFF switch to OFF.

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 brake circuit, provided the engine brake ON/OFF switch has been previously checked.

Repair or replace the wire connected to engine brake selector signal number 2 pin in the OEM harness according to the vehicle manufacturer's procedures.

Remove the lead from engine brake selector signal number 2 pin and insert it into engine brake selector signal number 3 pin of the OEM harness connector.

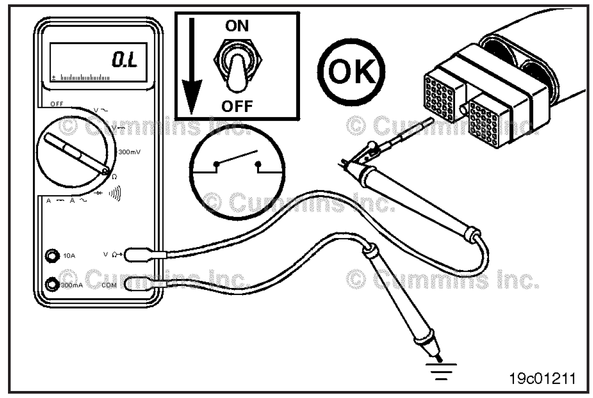
Move engine brake level switch to position number 3.

Switch the engine brake ON/OFF switch to the OFF position.

Measure the resistance with the multimeter.

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 brake circuit, provided the engine brake ON/OFF switch has been previously checked.

Repair or replace the wire connected to engine brake selector signal number 3 pin in the OEM harness according to the vehicle manufacturer's procedures.



Check for Short Circuit from Pin to Pin

Isolate the circuit by setting the cab panel switches as described in the previous section. Set the engine brake ON/OFF switch to the ON position. Place engine brake level to position number 6 for a six-position switch or position number 3 for a three-position switch.

Insert a test lead into the switch return of the OEM harness connector and check all pins except the switch return, engine brake selector signal number 1 pin, and engine brake selector signal number 3 pin.

Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the switch return and insert it into engine brake selector signal number 2 pin. Check all pins except the switch return engine, brake selector signal number 1 pin and engine brake selector signal number 3 pin. Measure the resistance.

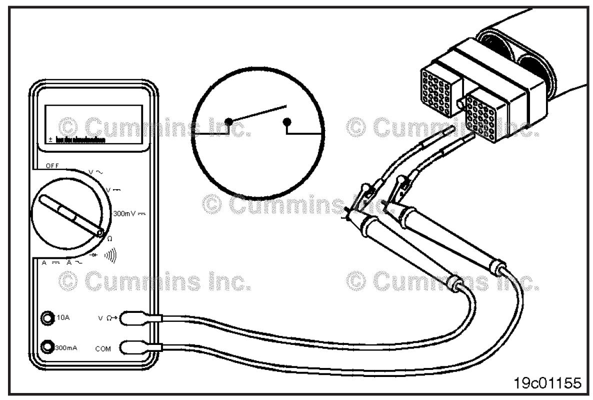
The multimeter **must** show an open circuit (100k ohms or more).

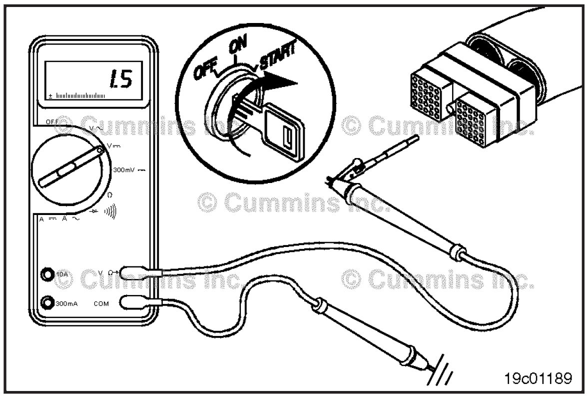
Remove the lead from engine brake selector signal number 2 pin and insert it into engine brake selector signal number 3 pin. Check all pins except the switch return. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the engine brake selector signal number 3 pin and inert it in the engine brake selector signal number 1 pin. Check all pins except the switch return. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).





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Check for Short Circuit to External Voltage Source

Turn the vehicle keyswitch to the ON position. Set the engine brake ON/OFF switch to the ON position.

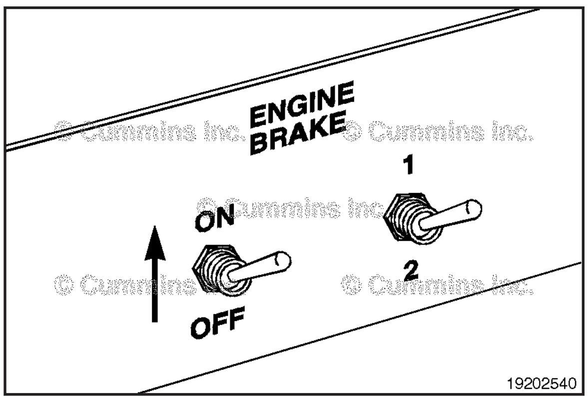
Adjust the multimeter to measure the VDC.

Insert a test lead into the switch signal pin of the OEM harness connector.

Disconnect the 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.

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 brake on/off 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.



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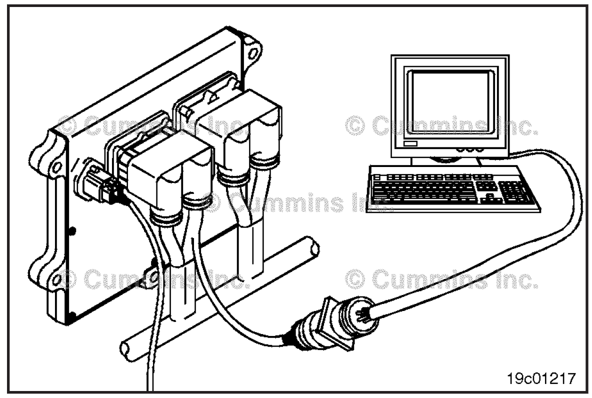
Engine Brake Level Switch (019-036)

General Information

The engine brake level switch determines the percentage of engine braking power that will be applied when the engine brakes are activated. The engine brake ON/OFF switch needs to be turned ON to activate the engine brake system. Vehicles can be wired with a 2 or 3 position switch.

Resistance Check



If INSITE™ is available, monitor the engine brake selector switch for proper operation. If INSITE™ is **not** available then follow the troubleshooting procedures for this section.

Label the wires with the location on the switch or the wire number. Disconnect the three electrical connectors from the switch.

Adjust the multimeter to measure resistance

Three Position Switch		
Switch Position	**Terminal A - Engine Brake Selector Signal Number 1**	**Terminal B - Engine Brake Selector Signal Number 2**
1	Closed	Open
1	Open	Closed
2	Open	Closed
2	Closed	Open
3	Closed	Closed

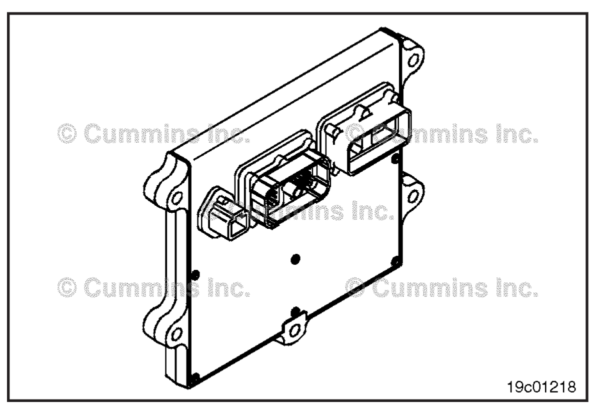
Two Position Switch		
Switch Position	**Terminal A - Engine Brake Selector Signal Number 1**	**Terminal B - Engine Brake Selector Signal Number 2**
1	Closed	Open
1	Open	Closed
2	Closed	Closed

Check the resistance for each position of the 2 or 3 position switch. An open circuit **must** have a resistance greater than 100k ohms. A closed circuit **must** have a resistance of 10 ohms or less.

If the multimeter does **not** show the correct values in both tests, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.

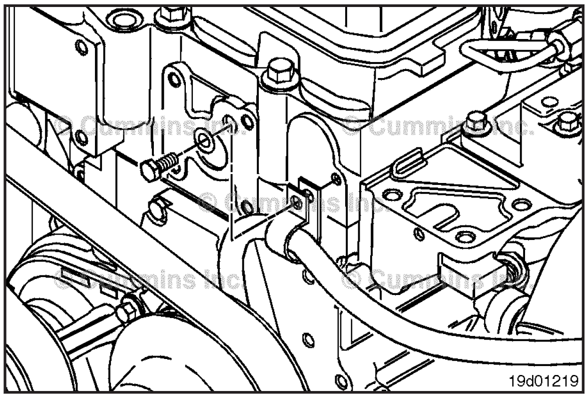
Engine Wiring Harness (019-043)

General Information



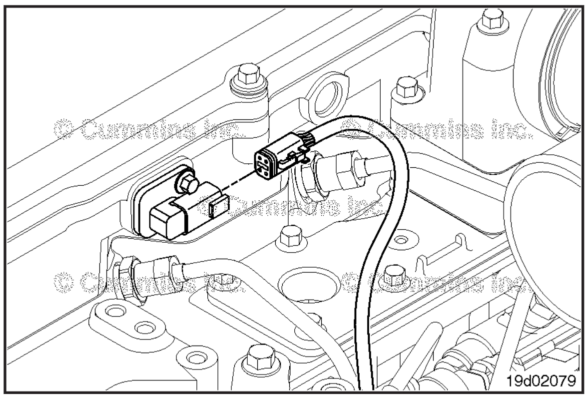
The engine uses three separate wiring harnesses to control the engine and some of the vehicle operations. Shown, left to right, are the ECM ports for the following:

1. 4-pin OEM power supply harness connector
2. 60-pin engine harness connector
3. 50-pin OEM harness connector.

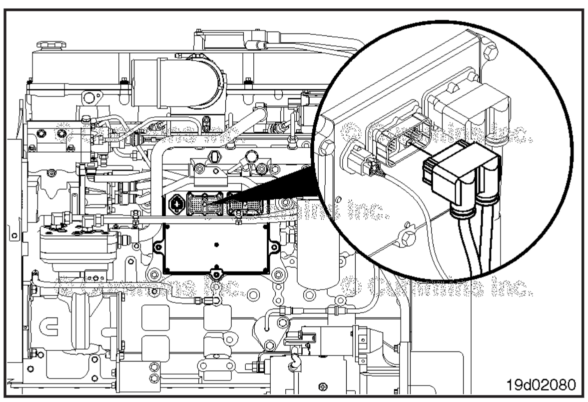


Remove

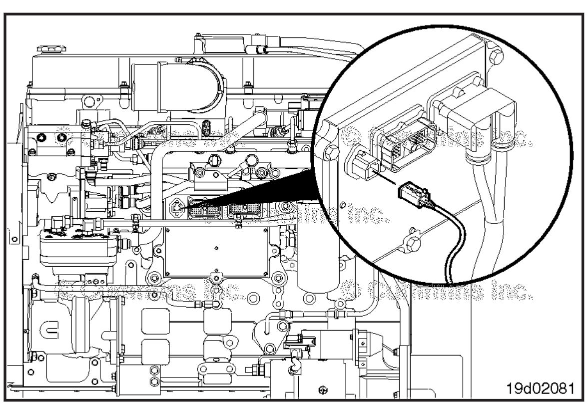
Remove the harness clamps from the engine block.



Disconnect the engine harness from the injector pass-through connectors.

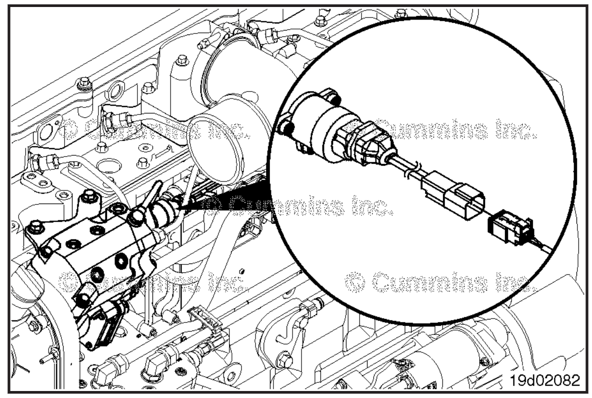


Disconnect the 60-pin engine harness connector from the ECM.



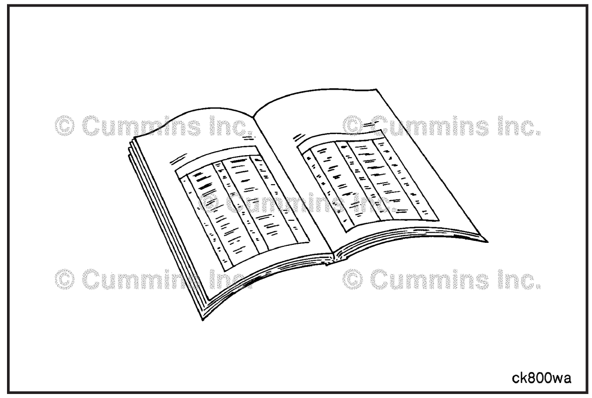
Disconnect the 4-pin power supply harness connector from the ECM.

Disconnect the electronic fuel control actuator from the engine harness.



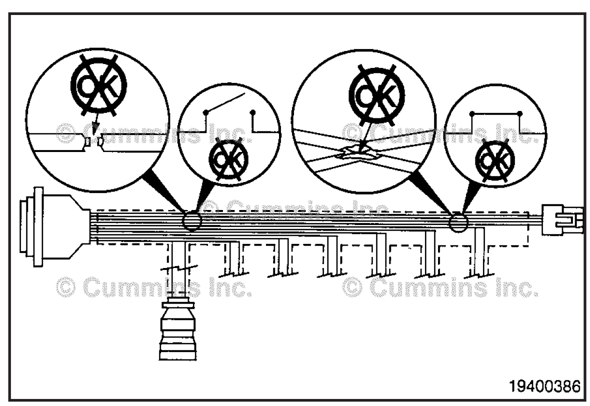
Disconnect the engine harness from the following :

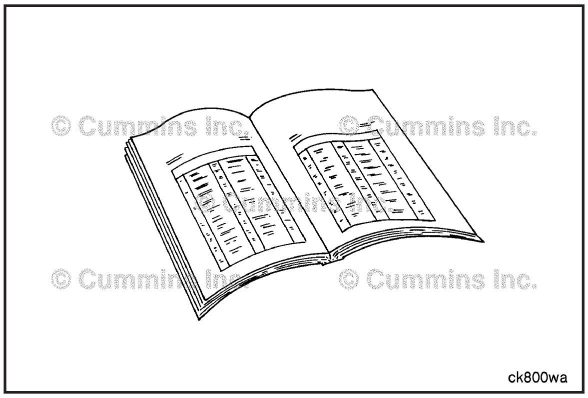
- Crankshaft position sensor. Refer to Procedure 019-365.
- Camshaft position sensor. Refer to Procedure 019-363.
- Intake manifold pressure sensor. Refer to Procedure 019-061.
- Intake manifold temperature sensor. Refer to Procedure 019-059.
- Barometric pressure sensor. Refer to Procedure 019-004, (this applies to automotive and industrial **only**).
- Oil pressure switch. Refer to Procedure 019-066.
- Engine coolant temperature sensor. Refer to Procedure 019-019.
- Turbocharger speed sensor. Refer to Procedure 019-390, (this applies to automotive and industrial **only**).
- Turbocharger compressor inlet temperature sensor. Refer to Procedure 019-395, (this applies to automotive and industrial **only**).
- Turbocharger control valve. Refer to Procedure 019-388, (this applies to automotive and industrial **only**).
- Rail fuel pressure sensor. Refer to Procedure 019-115.
- Water-in-fuel sensor. Refer to Procedure 019-127.
- Fuel lift pump.



Inspect for Reuse

Replace or repair the engine harness if there is an open circuit or a short circuit found under the protective covering of the harness body.

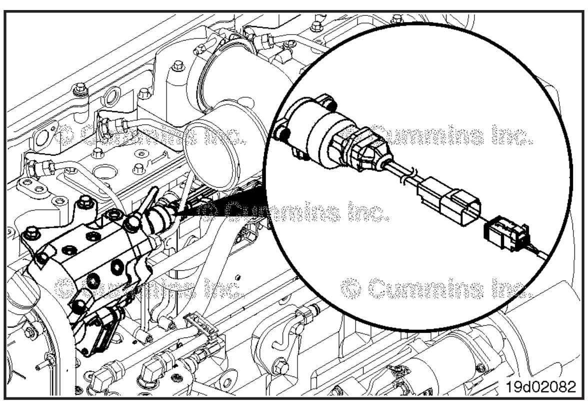




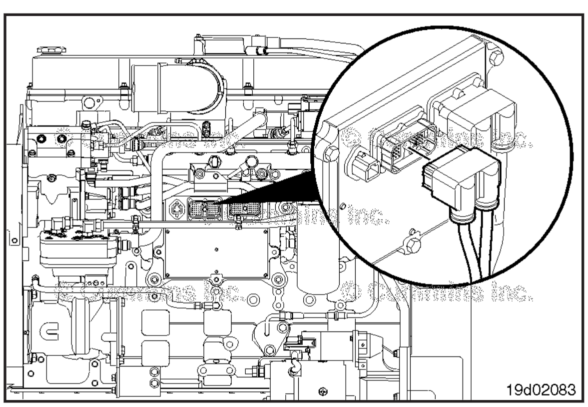
Install

Connect the engine harness to the following:

- Crankshaft position sensor. Refer to Procedure 019-365.
- Camshaft position sensor. Refer to Procedure 019-363.
- Intake manifold pressure sensor. Refer to Procedure 019-061.
- Intake manifold temperature sensor. Refer to Procedure 019-059.
- Barometric pressure sensor. Refer to Procedure 019-004, (this applies to automotive and industrial **only**).
- Oil pressure switch. Refer to Procedure 019-066.
- Engine coolant temperature sensor. Refer to Procedure 019-019.
- Turbocharger speed sensor. Refer to Procedure 019-390, (this applies to automotive and industrial **only**).
- Turbocharger compressor inlet temperature sensor. Refer to Procedure 019-395, (this applies to automotive and industrial **only**).
- Turbocharger control valve. Refer to Procedure 019-388, (this applies to automotive and industrial **only**).
- Rail fuel pressure sensor. Refer to Procedure 019-115.
- Water-in-fuel sensor. Refer to Procedure 019-127.
- Fuel lift pump.



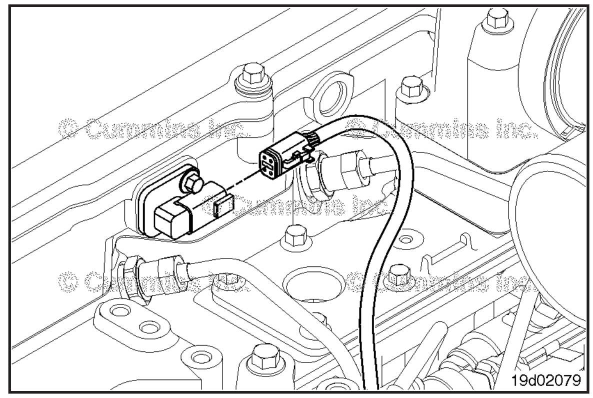
Connect the electronic fuel control actuator connector.



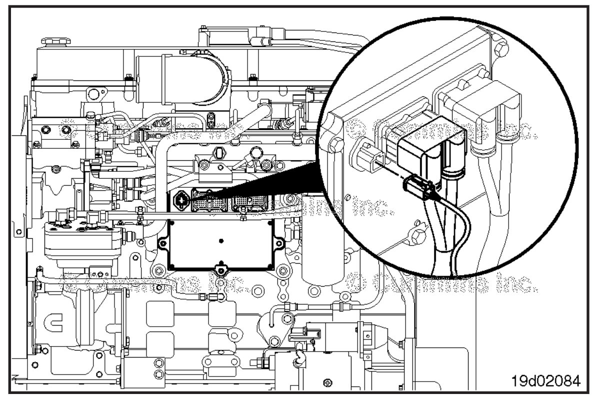
Connect the 60-pin engine harness connector to the ECM.

Torque Value: 3 N•m [27 in-lb]

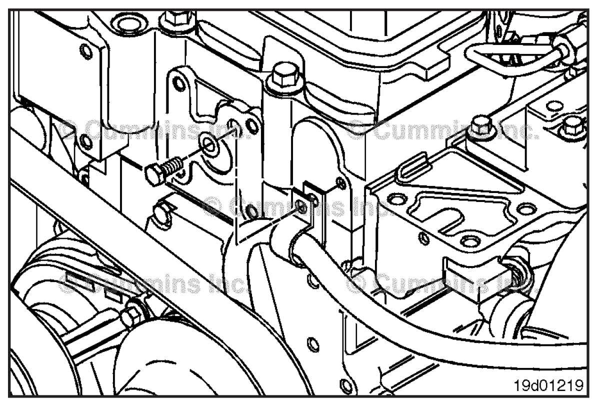
Connect the engine harness to the injector pass-through connectors.


19d02079

Connect the 4-pin OEM power supply harness connector to the ECM.


19d02084

Install the harness clamps that hold the engine harness to the engine block.

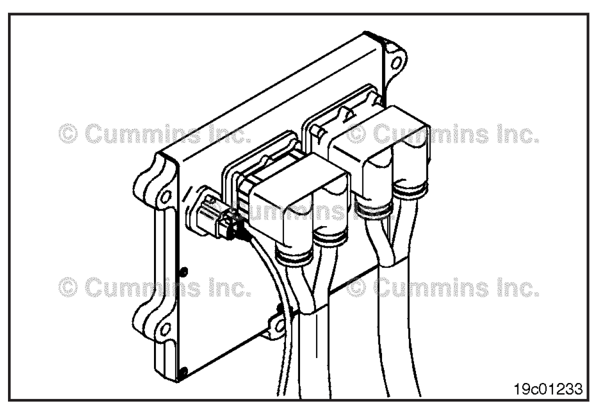

19d01219

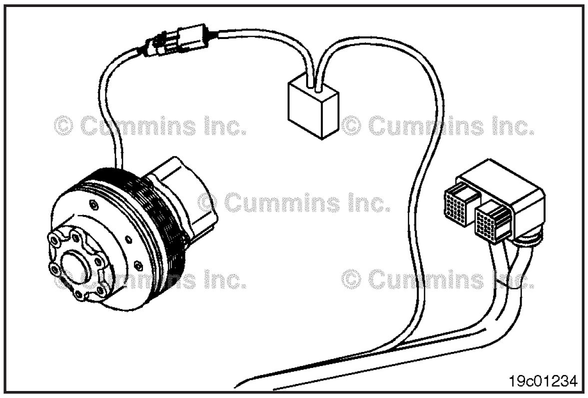
Fan Control Circuit (019-045)

General Information

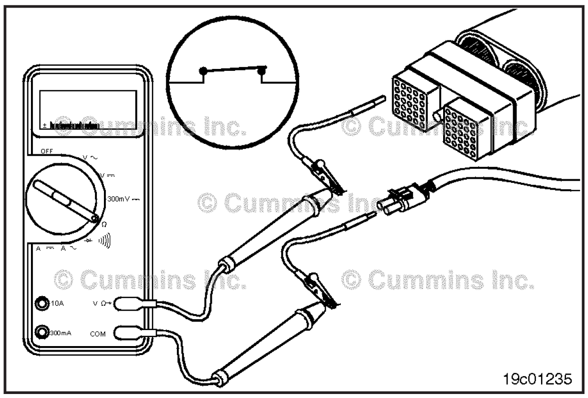
The CM850 control system can control the fan clutch activation. The ECM energizes the air valve solenoid or an electric fan clutch.

Refer to vehicle manufacturer's publications for more information on troubleshooting and repair of the fan clutch wiring.


19c01233



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 Part Number 3822758. The connector will be damaged. The leads must fit tightly in the connector without expanding the pins of the connector.

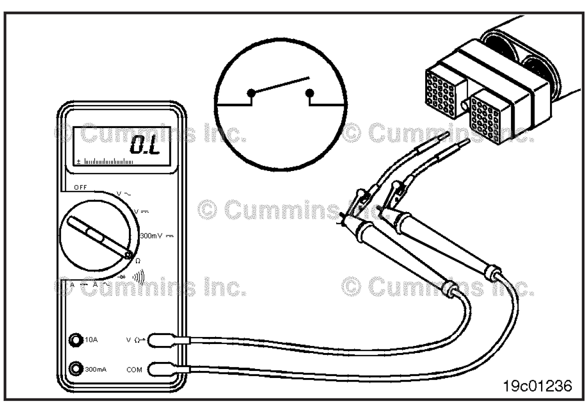
Disconnect the OEM harness connector from the ECM. Disconnect the OEM wiring at the fan control solenoid.

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 (more than 100k ohms).

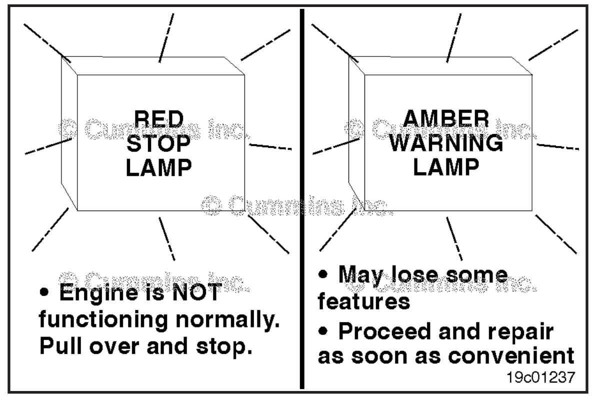
If the circuit is **not** open, there is a short circuit between the fan control signal pin and **any** pins that measured a closed circuit.

Repair or replace the OEM wiring harness.

Refer to Procedure 019-043 or 019-071.

Fault Lamp (019-046)

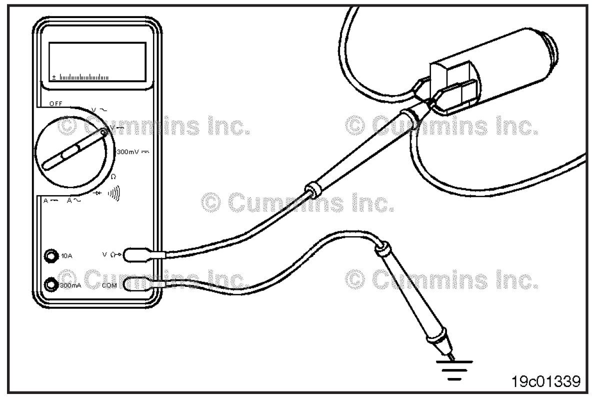
General Information



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.

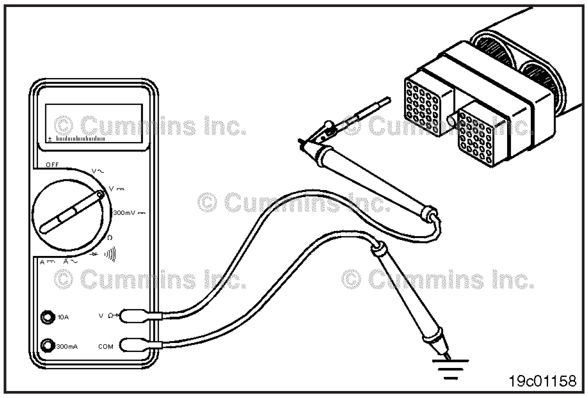
Touch the negative (-) multimeter probe to chassis ground.

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.


19c01158

Fault Lamp Circuit (019-047)

Voltage Check

CAUTION

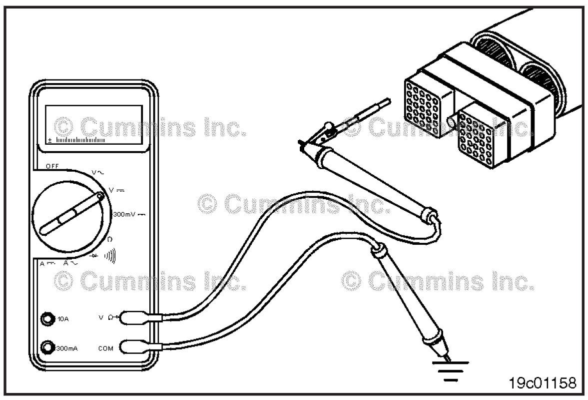
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

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.

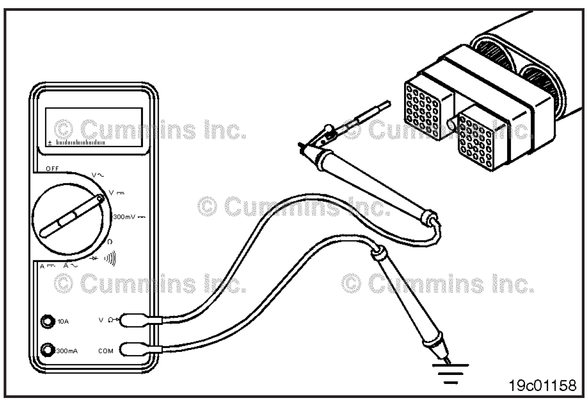
Refer to the OEM troubleshooting and repair manual for repair procedures.


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

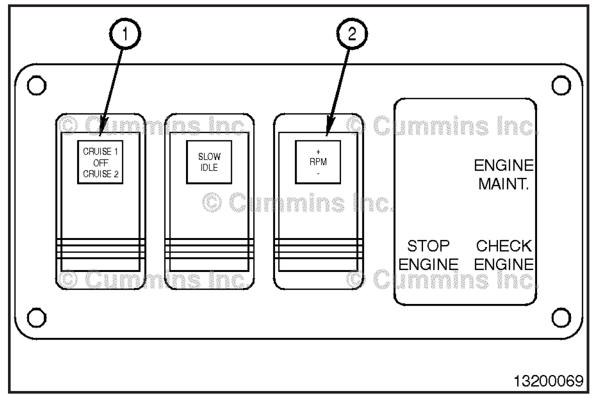
Remove the lead from the malfunction indicator lamp (MIL) signal pin and insert it into the red stop lamp signal pin. Touch the other multimeter probe to the engine block.

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.

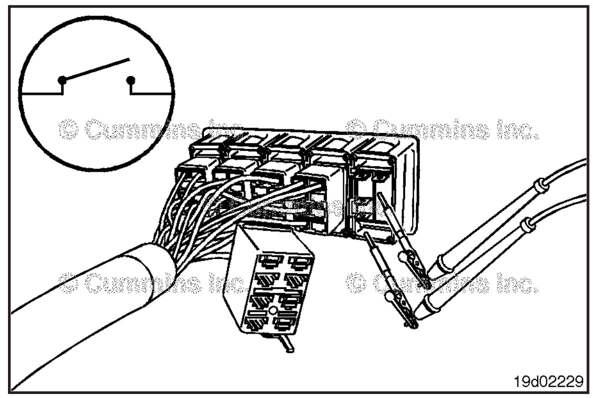
Idle Adjust Switch (019-052)

General Information



The idle adjust switch is located on the control panel and has three settings, RPM+, RPM-, and OFF. The rocker switch is used to activate or disable the idle adjust operation. The idle adjust circuit consists of the RPM+ and RPM- signal lines, switch common ground and the rocker switch.

Resistance Check



If INSITE™ is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate and remove the idle adjust switch from the connector.

Adjust the multimeter to measure resistance.

Touch the multimeter probes to the RPM+ signal switch prong (3) and the battery ground prong switch prong (2).

Turn the switch to the OFF position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

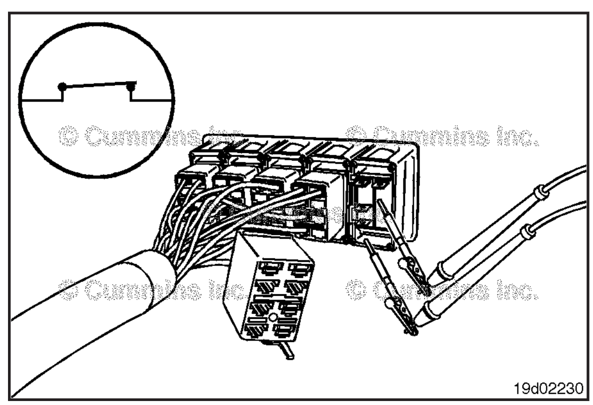
If the circuit is **not** open, the switch has failed. Replace the switch.

Touch the multimeter probes to the RPM- signal switch prong (1) and the battery ground prong switch prong (2).

Turn 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. Replace the switch.

Check for Short Circuit to Ground



Touch the multimeter probes to the RPM+ signal switch prong (3) and the battery ground prong switch prong (2).

Hold the switch depressed to the RPM+ position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

Touch the multimeter probes to the RPM- signal switch prong (1) and the battery ground prong switch prong (2).

Hold the switch depressed to the RPM- position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

Check for Short Circuit from Pin to Pin

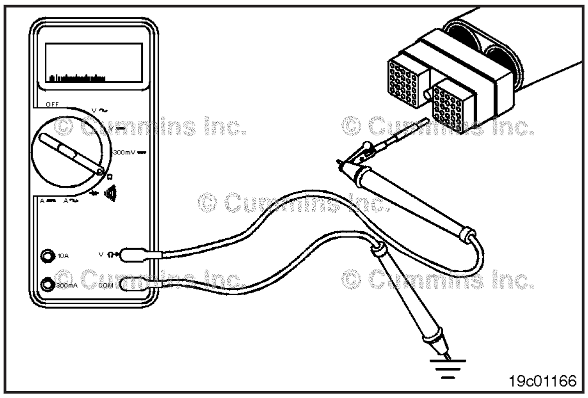
Check for a short circuit from pin to pin.

Touch the multimeter probe to the RPM+ switch signal prong (3). Touch the other multimeter probe to the RPM- switch signal prong (1).

Turn the cruise control switch to the OFF position.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the RPM+ and RPM- signal lines. Replace the switch.



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).

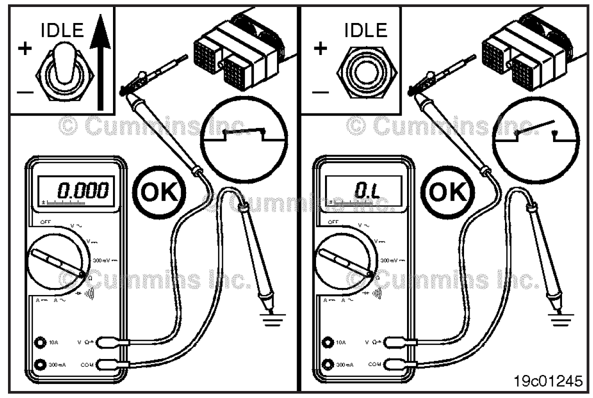
Insert the pin of the test lead into the cruise control/PTO set/coast switch signal in the OEM harness connector. Measure the resistance from the cruise control/PTO set/coast switch signal to the engine block.

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.

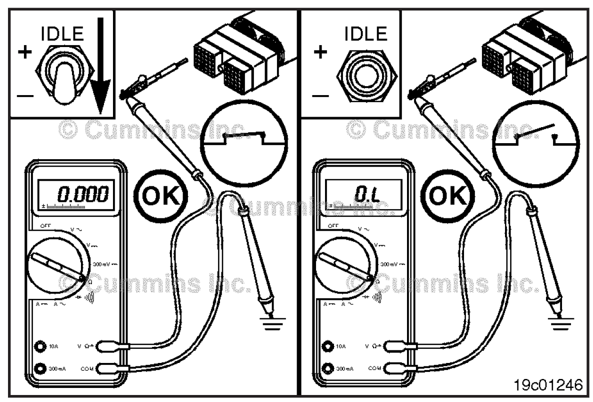
If the resistance values are **not** correct, make sure the return wire and the cruise control/PTO set/coast switch signal wire are properly installed on the idle adjust switch. If both wires are correctly installed, inspect the return wire and the cruise control/PTO set/coast switch signal wire for 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.

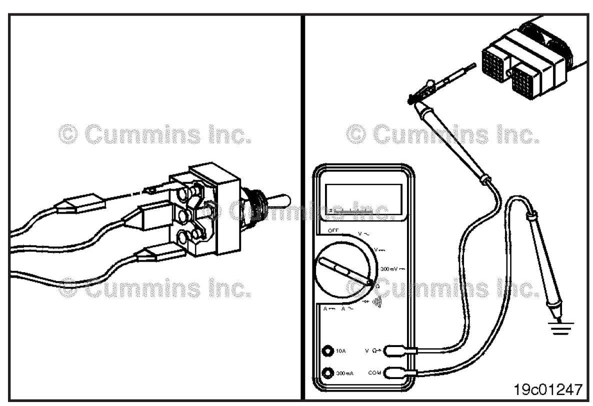
If the resistance values are **not** correct, make sure the cruise control/PTO resume/accelerator switch signal wire is properly installed on the idle adjust switch. If the cruise control/PTO resume/accelerator switch signal wire is properly installed on the idle adjust switch, inspect the cruise control/PTO resume/accelerator switch signal wire for an open circuit, provided the idle adjust switch has been previously checked for short circuits to ground.

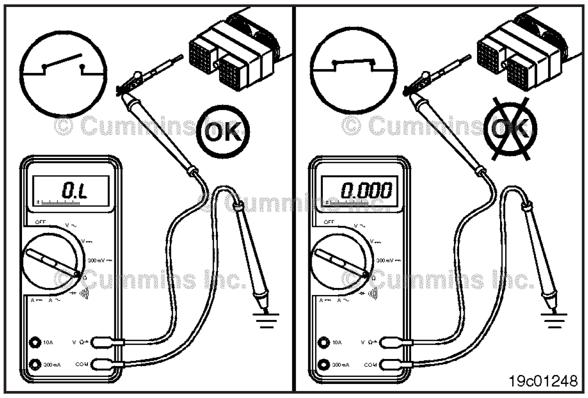


Check for Short Circuit to Ground

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.

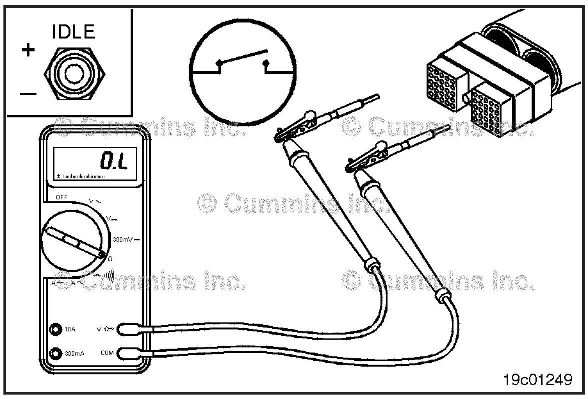




The multimeter **must** show an open circuit (100K ohms or more). If the circuit is **not** open, there is a short circuit to ground in the cruise control/PTO resume/accelerator switch signal circuit, provided the idle adjust switch has been previously checked.

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 the to cruise control/PTO set/coast switch signal) for short circuits to ground, follow the same procedure as described above for the idle/diagnostic decrement wire.



Check for Short Circuit from Pin to Pin

Measure the resistance from the cruise control/PTO resume/accelerator switch signal of the OEM harness connector to all other pins in the connector. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the wire connected to the cruise control/PTO resume/accelerator switch signal and any pin that measured less than 100k ohms.

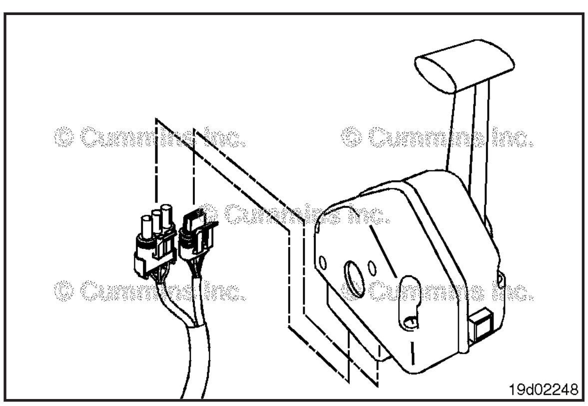
Repair or replace the wires in the OEM harness according to the vehicle manufacturer's instructions.

Remove the lead from the cruise control/PTO resume/accelerator switch signal of the OEM harness connector and insert it into the cruise control/PTO set/coast switch signal of the connector. Measure the resistance from the cruise control/PTO set/coast switch signal to all other pins in the connector. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the wire connected to the cruise control/PTO set/coast switch signal and any pin that measured less than 100k ohms, provided the idle adjust switch has been previously checked.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's instructions.

Connect all components after completing the repair.



Idle Validation Switch (019-054)

General Information

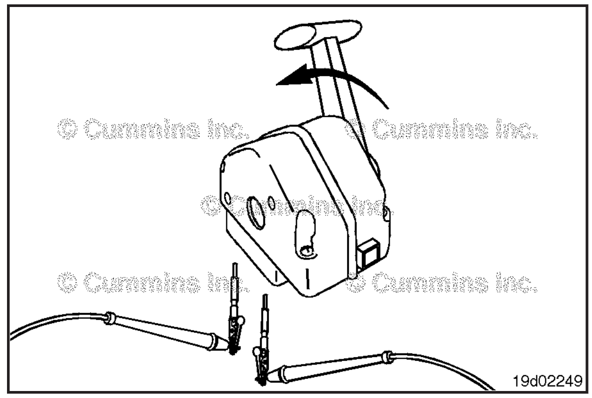
Marine Applications

WARNING

Do not use DSES lubricant on throttle connectors.

The idle validation switch is located on the throttle assembly and is activated by moving the throttle to or from the idle position. The idle validation switch circuit consists of the Idle Validation Idle Switch Input, the Idle Validation Off Idle Switch Input, the Idle Validation Return and the Idle Validation Switch.

Resistance Check



If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Locate the throttle assembly and disconnect the Idle Validation Switch connector from the Idle Validation Switch.

Adjust the multimeter to measure resistance.

Touch the multimeter probes to the idle validation idle switch input pin and idle validation return pin of the idle validation switch connector.

Move the throttle out of the idle position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

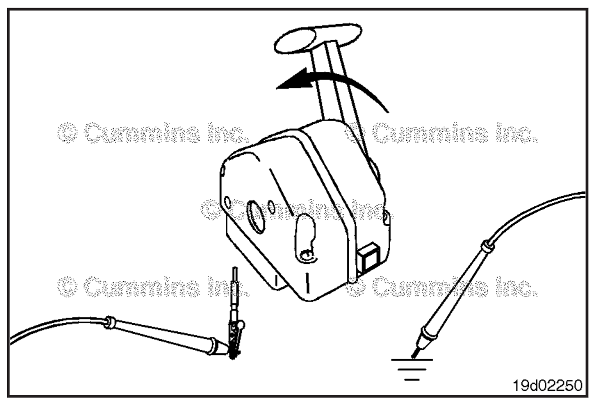
If the circuit is **not** open, the switch has failed. Replace the switch.

Touch the multimeter probes to the idle validation off idle switch input pin and the idle validation return pin of the idle validation switch connector.

Move the throttle to the idle position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Replace the switch.

Check for Short Circuit to Ground



Touch the multimeter probes to the idle validation idle switch input line and the idle validation return line of the idle validation switch.

Move the throttle into the idle position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

Touch the multimeter probes to the idle validation off idle switch input line and the idle validation return line of the idle validation switch.

Move the throttle out of the idle position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

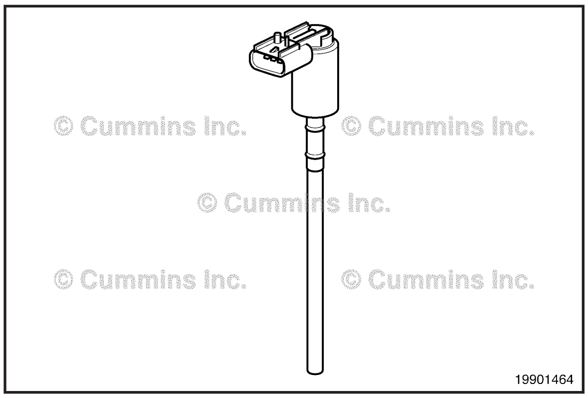
Check for Short Circuit from Pin to Pin

Check for a short circuit from pin to pin.

Touch the multimeter probe to the idle validation idle switch input line. Touch the other multimeter probe to the idle validation off idle switch input line.

Move the throttle into the idle position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

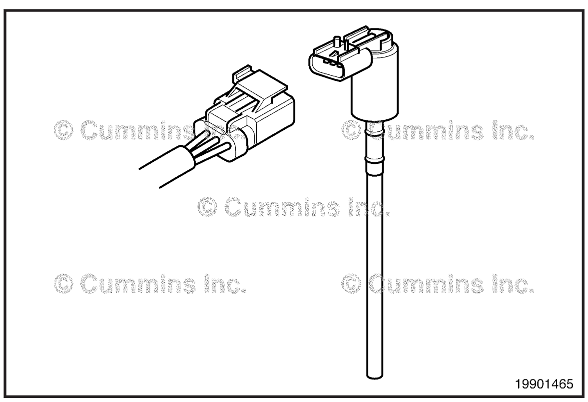
If the circuit is **not** open, there is a short circuit between the idle validation idle switch input and idle validation off idle switch input lines. Replace the switch.



Lubricating Oil Level Sensor (019-056)

General Information

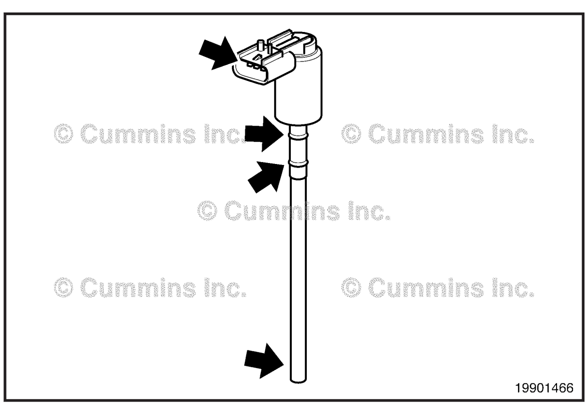
The lubricating oil level sensor is used to monitor the engine lubricating oil level. The sensor is integrated into the dipstick tube on the engine.



Remove

Lift up on the locking tab and pull the electrical connectors apart.

Remove the lubricating oil level sensor from the dipstick tube.



Clean and Inspect for Reuse

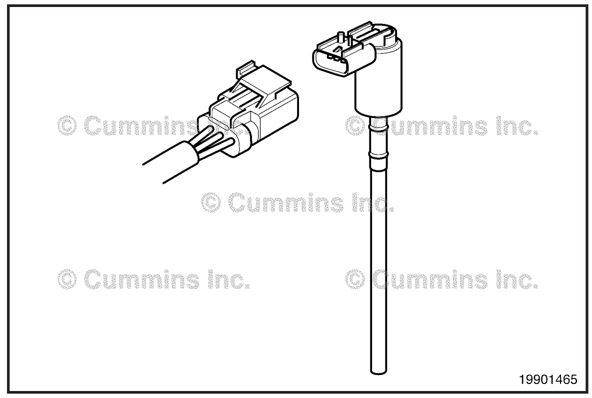
Visually inspect the lubricating oil level sensor for damage to wiring or body.

Inspect the o-rings for damage.

Install

Install the sensor into the dipstick tube.

Push the sensor and sensor harness connectors together until they lock.

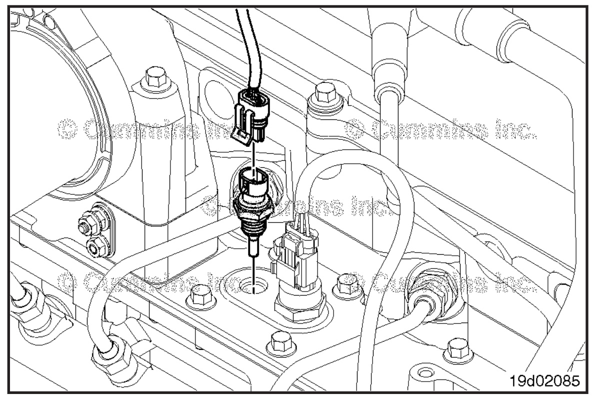


Intake Manifold Air Temperature Sensor (019-059)

Remove

Disconnect the wiring harness connector from the sensor.

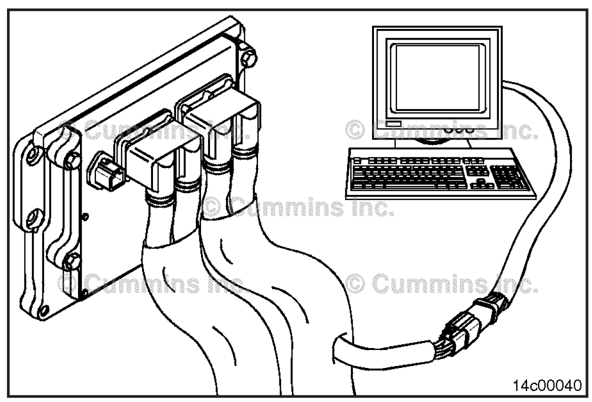
Remove the intake manifold air temperature sensor from the intake manifold cover.



Inspect for Reuse

Use the electronic service tool to monitor the air temperature sensor.

Perform a rationale check to see if the sensor is reading an appropriate reading.



Install

Install the sensor and tighten the capscrew.

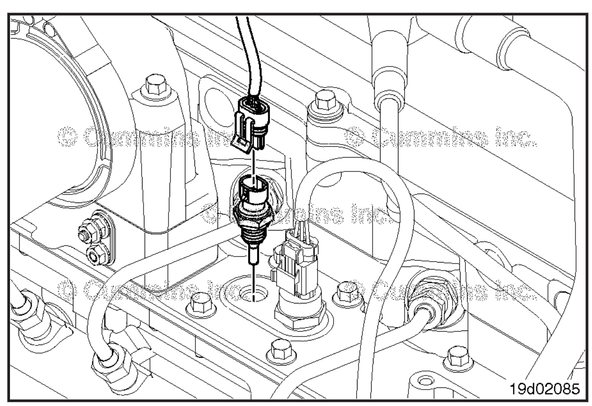
Torque Value: 23 N•m [17 ft-lb]

Connect the wiring harness connector to the sensor.

Turn the keyswitch ON.

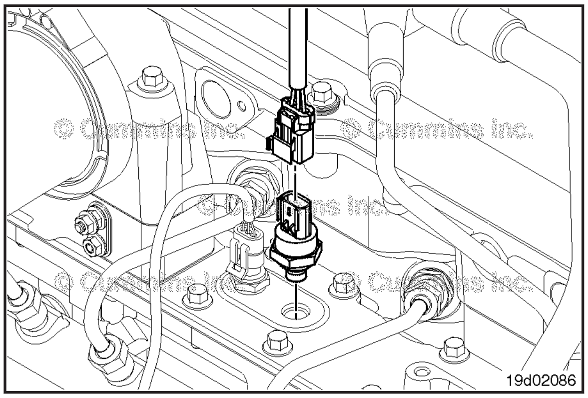
Use the electronic service tool to monitor the temperature sensor to make sure it is working correctly.

Refer to the resistance charts on the wiring diagram for sensor resistance values.



Intake Manifold Pressure Sensor (019-061)

Remove



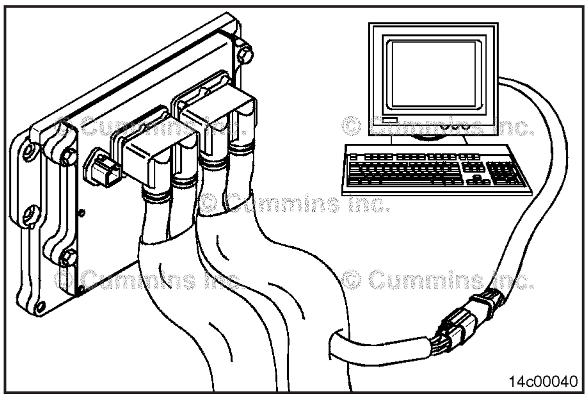
Slide the locking tab on the top side of the connector to the unlock position.

Press down on the tab near the end of the harness connector where the harness wires lead into the connector.

Pull outward on the connector away from the sensor to disconnect.

Use a socket or combination wrench to remove the sensor.

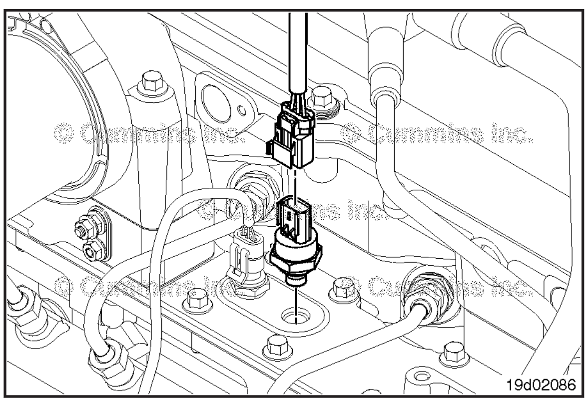
Inspect for Reuse



The sensor is located on the intake air manifold. Use the electronic service tool to monitor the sensor.

To validate this reading, a multimeter with a pressure transducer can be used to measure the pressure.

Install



Install the sensor and tighten the capscrew.

Torque Value: 23 N•m [17 ft-lb]

Connect the wiring harness connector to the sensor and slide the locking tab to the lock position.

Turn the keyswitch ON.

Use the electronic service tool to monitor the intake manifold pressure sensor to ensure it is working correctly.

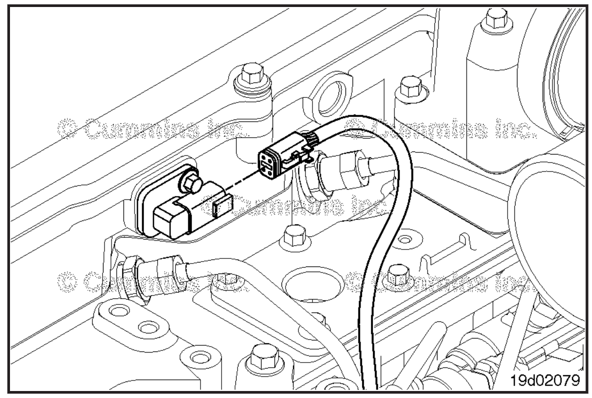
Internal Actuator Wiring Harness (019-063)

Remove

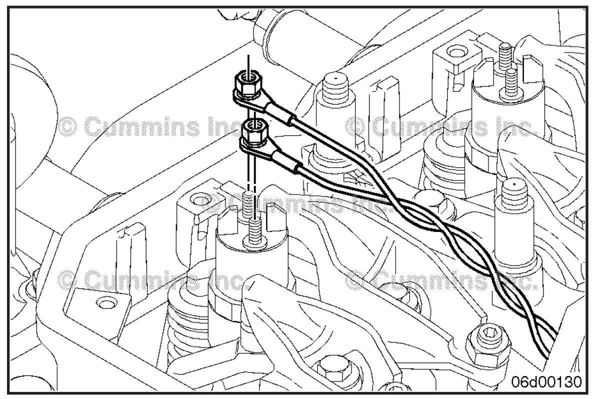
Disconnect the three Deutsch 4-pin connectors on the engine harness from the pass-through connector.

Remove the crankcase breather tube. Refer to Procedure 003-018 in Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting and Repair Manual, ISB^{e}, ISB, and QSB5.9 Engines, Bulletin 4021271.

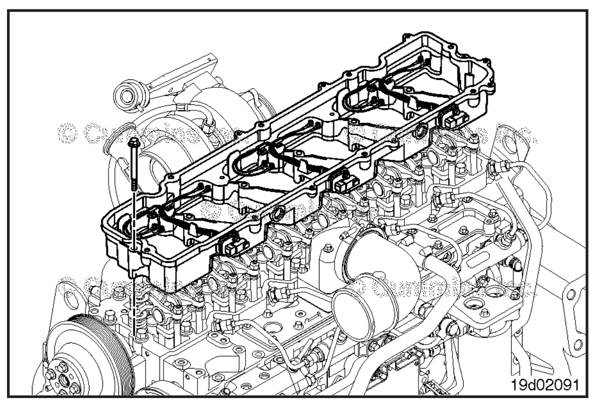
Remove the rocker lever cover. Refer to Procedure 003-011 in Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting and Repair Manual, ISB^{e}, ISB, and QSB5.9 Engines, Bulletin 4021271.

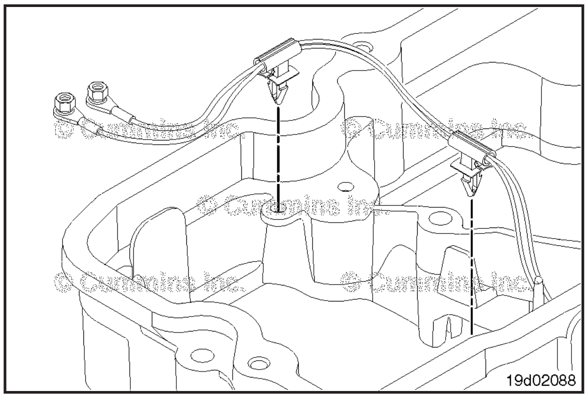


Remove the pigtail capscrews from all injector solenoids.

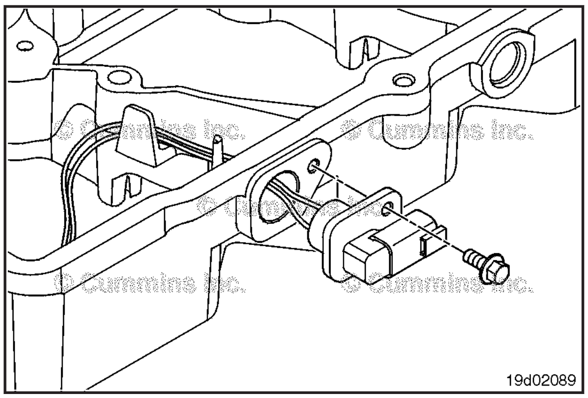


Remove the rocker housing. Refer to Procedure 003-013 in Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting and Repair Manual, ISB^{e,} ISB, and QSB5.9 Engines, Bulletin 4021271.

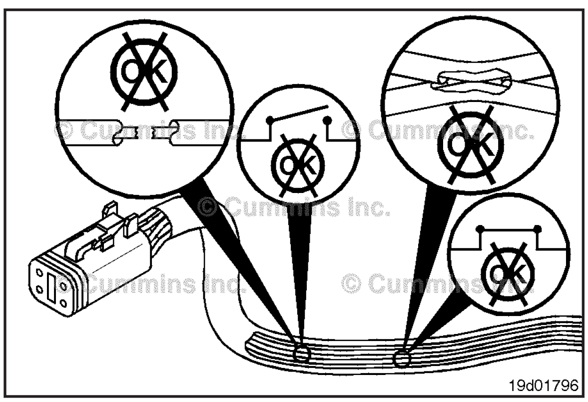




Remove the internal injector harness and the plastic clips from the rocker lever housing.



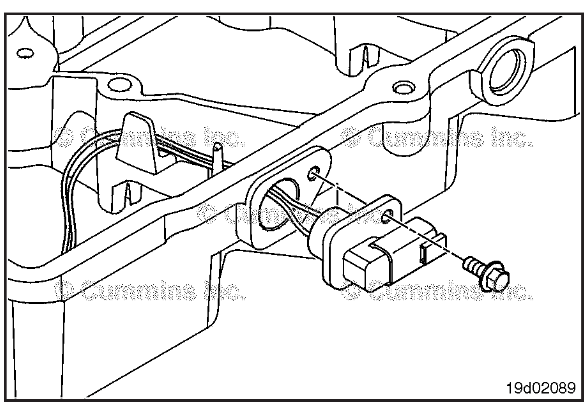
Remove the pass-through connector from the rocker housing.



Inspect for Reuse

Inspect for damaged or exposed wires, bent or broken pins, or damaged connectors.

Replace, if necessary.



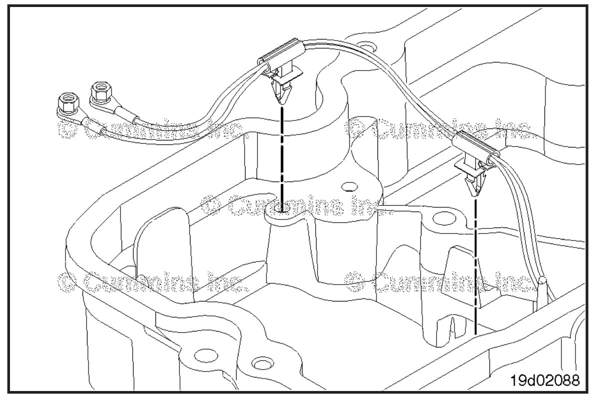
Install

Install the pass-through connector into the rocker housing.

Torque Value: 10 N•m [89 in-lb]

Route the injector wiring around the metal tabs to the injectors.

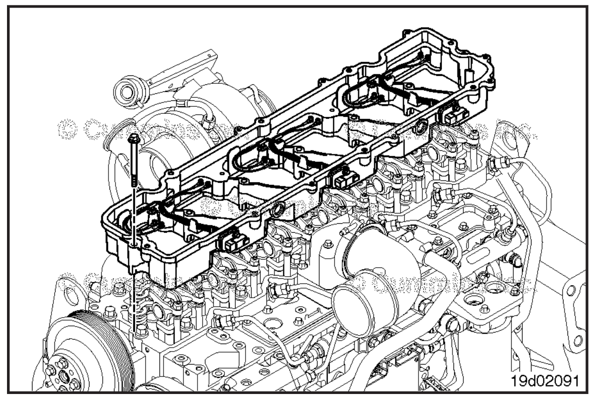
Install new plastic clips into the rocker housing.



Install the rocker lever housing. Refer to Procedure 003-013 in Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting and Repair Manual, ISB^{e}, ISB, and QSB5.9 Engines, Bulletin 4021271.

NOTE: Verify that the internal injector harness does **not** rest on any sharp corners.

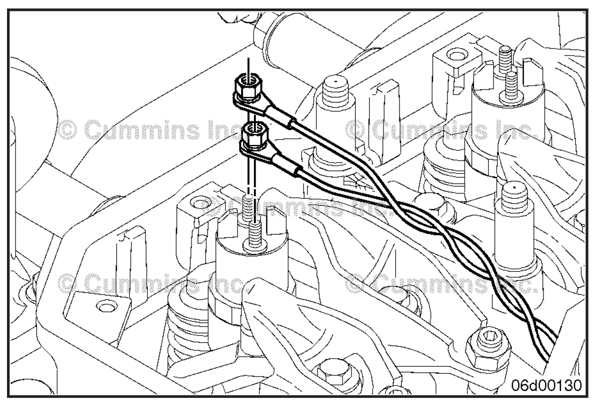
NOTE: Verify that the pigtail wires are **not** “crossed over” to the wrong injectors.



Install pigtail nuts on injectors.

Torque Value: 1.25 N•m [11 in-lb]

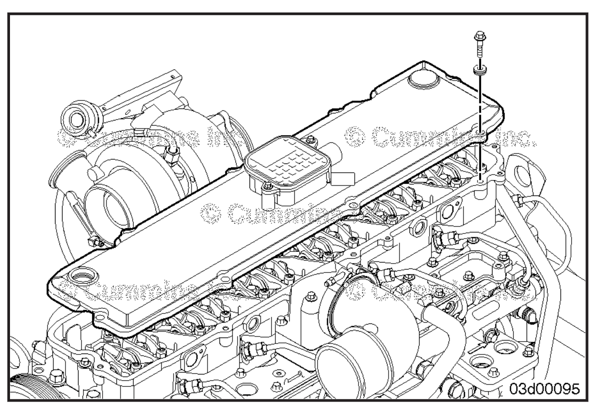
NOTE: Injector wire to injector orientation is **not** significant.



Install the rocker lever cover. Refer to Procedure 003-011 in Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting and Repair Manual, ISB^{e}, ISB, and QSB5.9 Engines, Bulletin 4021271.

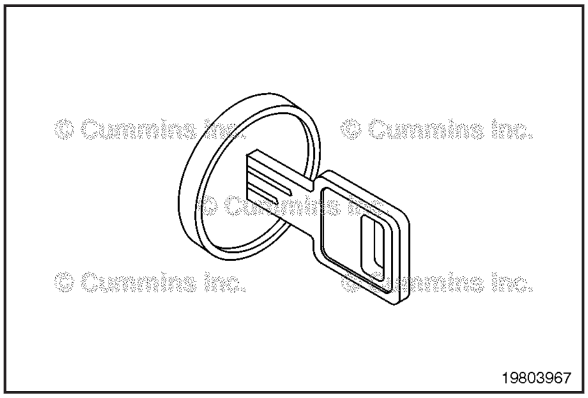
Connect the engine harness to the pass-through connector.

Install the crankcase breather tube. Refer to Procedure 003-018 in Troubleshooting and Repair Manual, ISC, QSC8.3, ISL and QSL9 Engines, Bulletin 4021418 or Troubleshooting and Repair Manual, ISB^{e}, ISB, and QSB5.9 Engines, Bulletin 4021271.



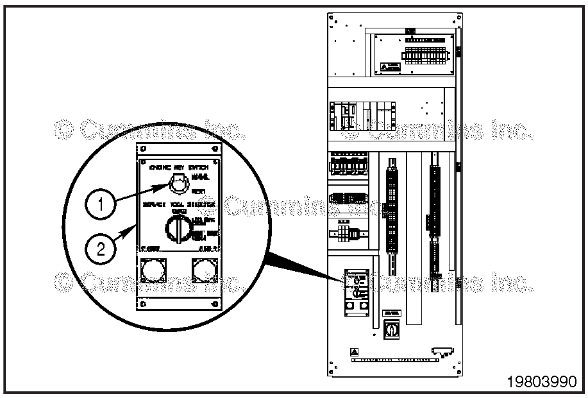
Key Switch Battery Supply Circuit (019-064)

Voltage Check



19803967

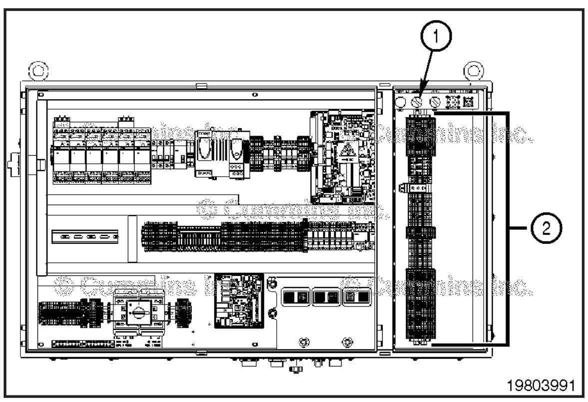
The vehicle keyswitch supplies an input signal to the electronic control module (ECM) which turns the ECM on or off.



19803990

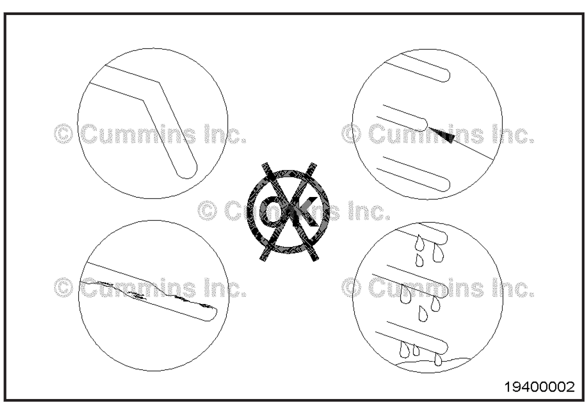
The Generator Set ECM Keyswitch supplies an input signal to all generator set electronic control modules (ECMs) which turns to ECM on or off.

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.

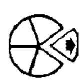


19803991

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).



19400002



Turn the keyswitch to the OFF position.

Disconnect the Actuator harness connector from the ECM.

Inspect the connector pins.

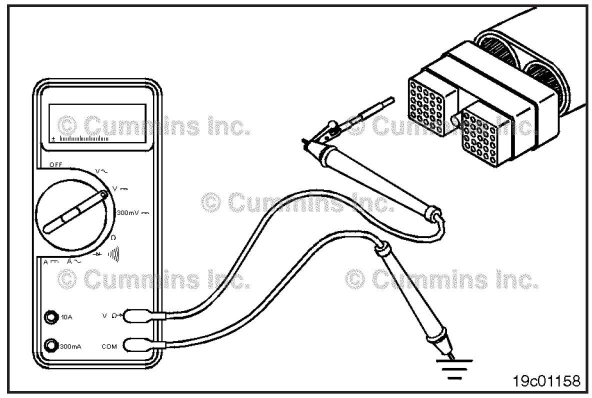
⚠CAUTION⚠
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

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.



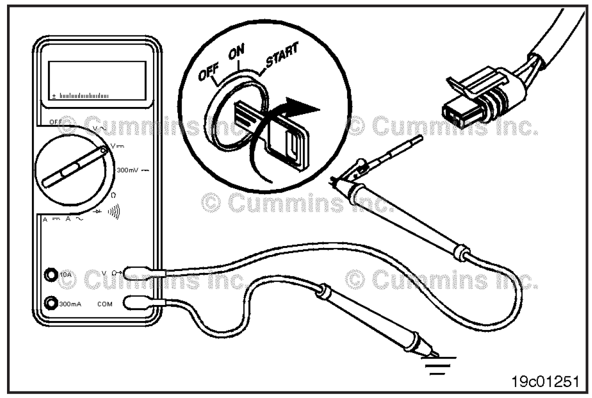
Disconnect the bulkhead connector.

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.

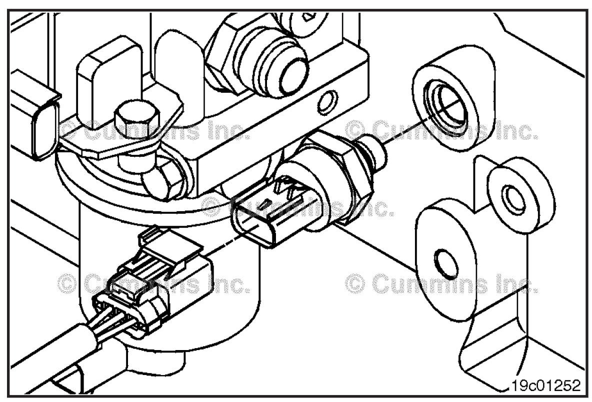


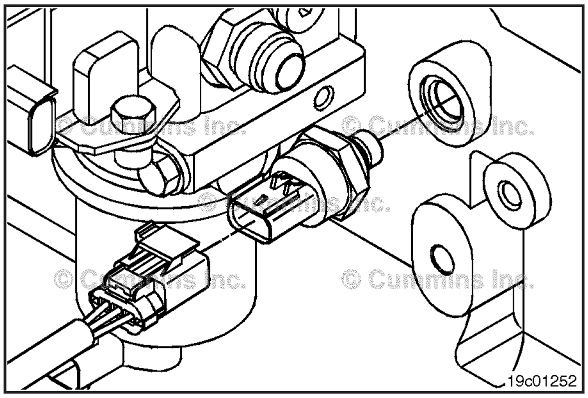
Engine Oil Pressure Sensor/Switch (019-066)

Remove

Disconnect the engine wiring harness from the engine oil pressure sensor.

Remove the engine oil pressure sensor.





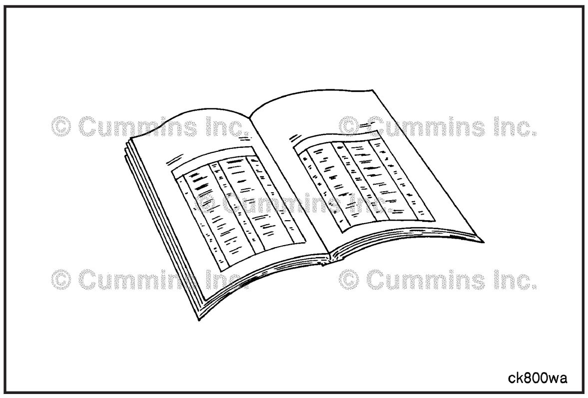
Install

Verify the o-ring is installed on the sensor.

Install the engine oil pressure sensor.

Torque Value: 23 N•m [17 ft-lb]

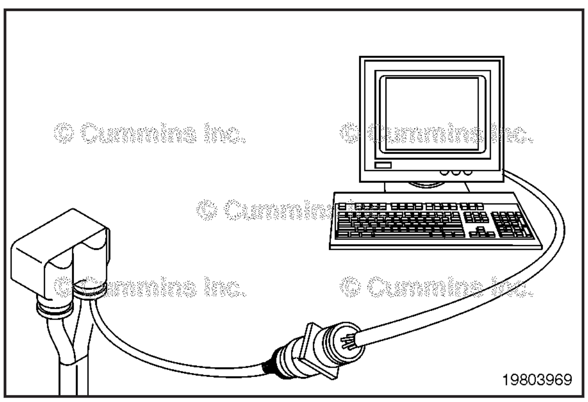
Connect the engine wiring harness to the engine oil pressure sensor. An audible click will be heard when the connector locks in place.



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.

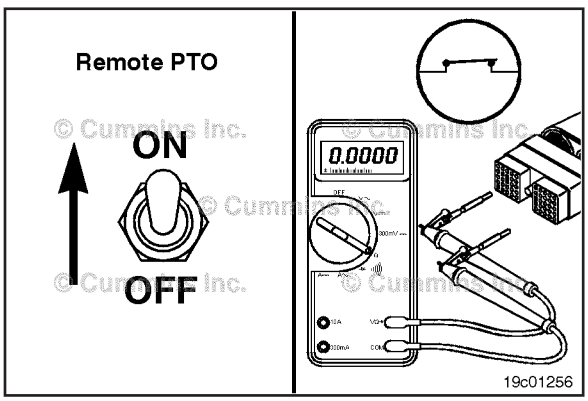
Consult the appropriate electronic service tool manual to adjust the parameters or features.

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 **not** correct or vehicle exceeding road speed governor set speed	Vehicle speed parameters **not** correct.	Make sure the following are correct: tire size, rear axle ratio, vehicle speed sensor type, and gear teeth per revolution.
Trip information mileage readings are **not** correct	The tire size parameter was changed without resetting the trip information system.	Set the trip information system again whenever the tire size parameter is changed.
Can **not** obtain maximum vehicle speed with semiautomatic transmission	The gear-down protection parameters are **not** correct.	Change the top gear ratio parameter to be equal to the first gear-down ratio, **not** the top gear ratio. For example, on a transmission with a 0.75, 0.87, and 1.0 ratio set, the top gear ratio parameter **must** be set to 0.87.
Engine won't start	Antitheft password active.	Enter antitheft personal identification number (PIN) using RoadRelay™ or delete password with Zap-It.
Low power in lower gears or top gear	Power train protection parameters set too low.	Change power train protection torque limits to match torque capability of the vehicle's transmission.
Semiautomatic transmission will **not** shift into top gear	Top gear ratio setting does **not** match top gear of transmission.	Using INSITE™ electronic service tool, set the proper top gear ratio.
	Centinel™ feature has been turned on but vehicle has a Spicer Top 2™ transmission.	Turn off the Centinel™ feature and turn on the Top 2 feature using INSITE™ electronic service tool.
Engine recently started overheating because the fan will **not** turn on	Fan control feature is **not** set properly.	Verify all fan control feature parameters are properly set for the vehicle.
Fan will **not** turn off	Fan control feature is **not** set properly.	Verify all fan control feature parameters are properly set for the vehicle.
Fan control switch will **not** turn on the fan	Fan control 1 accessory switch control is turned off.	Turn on fan control 1 accessory switch control using INSITE™ electronic service tool.
Unable to obtain maximum vehicle speed	Cruise control maximum vehicle speed or accelerator maximum vehicle speed **not** set high enough.	Verify or change settings using INSITE™ electronic service tool.
	Driver reward system is penalizing the driver with reduced top vehicle speed or cruise control maximum speed for poor fuel economy or extended idle time.	Explain feature to the driver or change parameter settings to more appropriate values.
Accelerator pedal has no effect on engine speed	Vehicle is in PTO mode and PTO accelerator override is turned on in the ECM.	Turn off PTO accelerator override using INSITE™ electronic service tool.
	Vehicle has a multiplexed throttle pedal and the multiplexing feature has been turned off.	Verify that the throttle pedal is multiplexed. Turn on the multiplexing feature for the throttle pedal using INSITE™ electronic service tool.

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 **not** operate	5 A or 15 A Power fuse in engine harness blown.	Check fuses and verify the ECM is getting power on the keyswitch wire.
	Vehicle has multiplexed lamps and the multiplexing feature has been turned off.	Verify that the lamps are multiplexed. Turn on the multiplexing feature for the lamps using INSITE™ electronic service tool.
Engine brakes do **not** operate	Vehicle has multiplexed engine brake switches and the multiplexing feature has been turned off.	Verify that the engine brake switches are multiplexed. Turn on the multiplexing feature for the engine brake switches using INSITE™ electronic service tool.
Engine will **not** respond to one or all of the operator's switch(es)	Vehicle has multiplexed switches and the multiplexing feature has been turned off.	Verify that the switches are multiplexed. Turn on the multiplexing feature for the switches using INSITE™ electronic service tool.



Remote PTO Switch Circuit (019-079)

Resistance Check

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

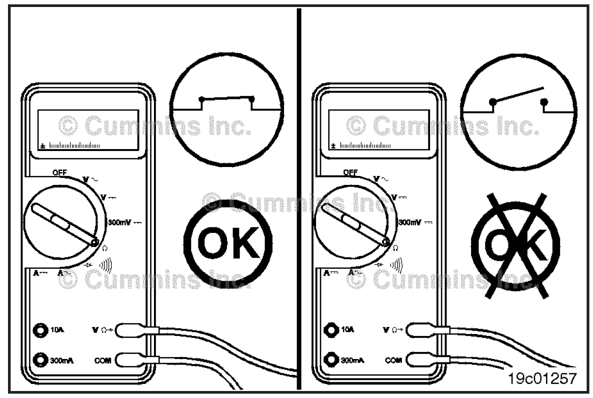
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).

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.

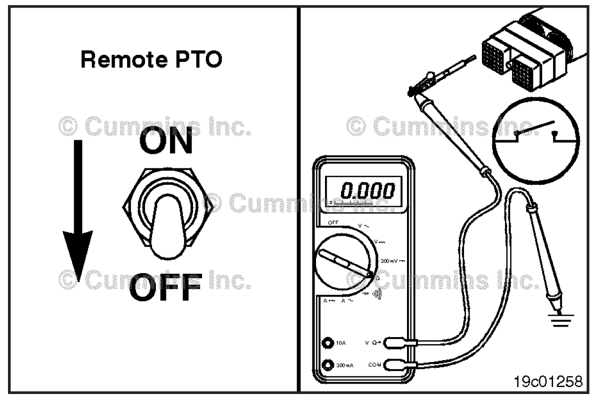
Disconnect the OEM harness from the ECM.

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.

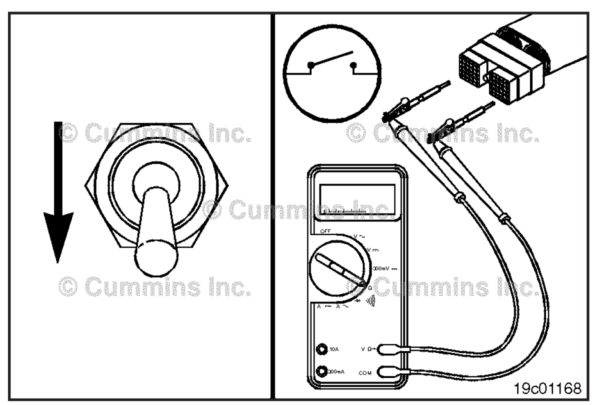
The multimeter **must** show an open circuit (100k ohms or more).

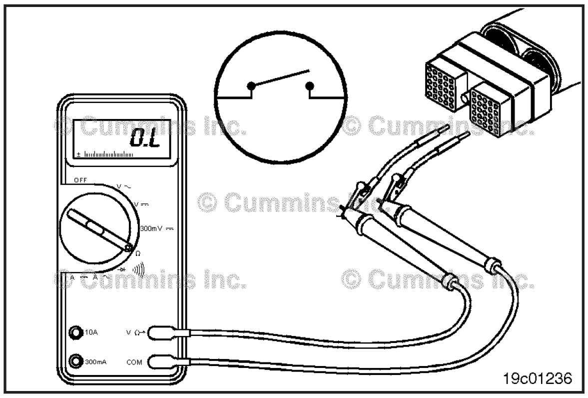
If the resistance values are **not** correct, make sure the remote PTO switch signal wire and the ground wire are properly installed on the switch. If both wires are correctly installed, inspect the wires for a short to ground circuit, provided the remote PTO switch has been previously checked.



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).

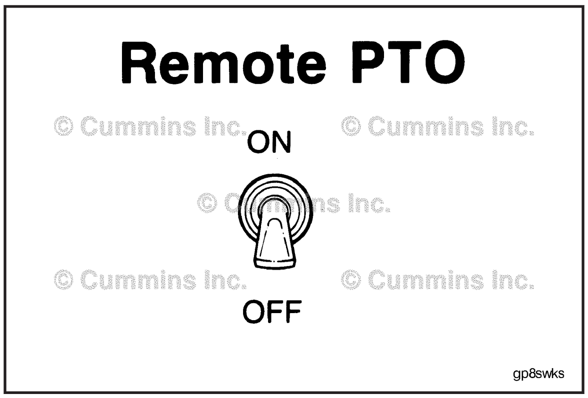




Remove the lead from the remote PTO switch return pin and insert it into the remote PTO switch signal pin of the harness connector. With the other test lead, check all other pins in the connector. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

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.

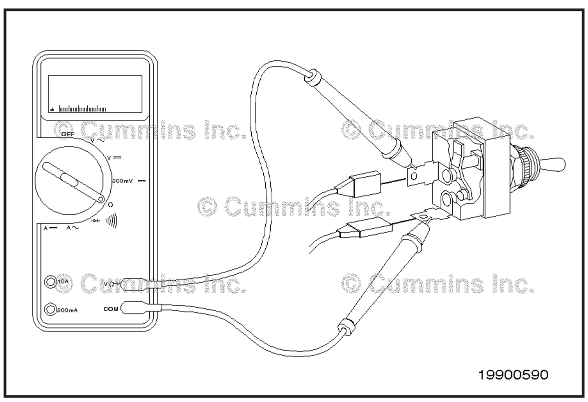


Remote PTO Switch (019-080)

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.

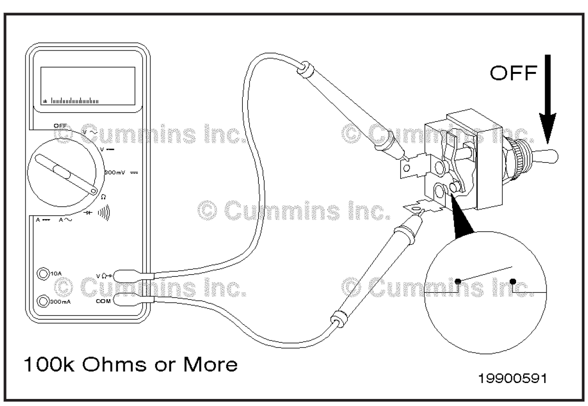


Resistance Check

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.



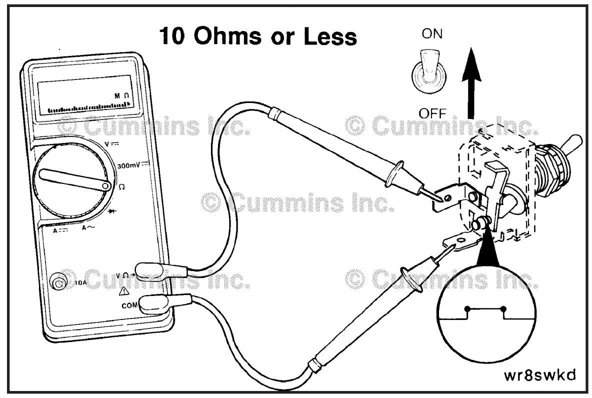
Move the switch to the OFF position and measure the resistance. The multimeter **must** show 100k ohms or more (open circuit). If the circuit is **not** open, the switch has failed.

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.

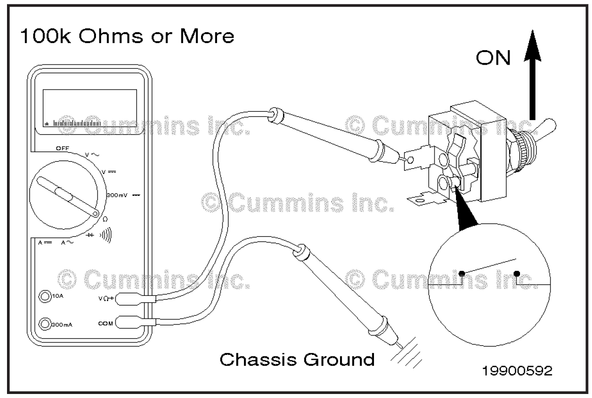
Replace the switch. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

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.

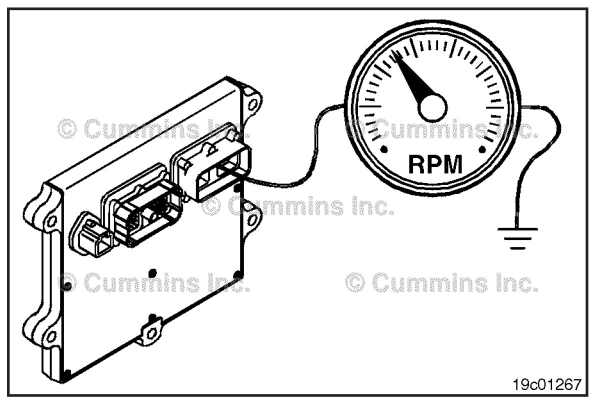


Tachometer Circuit (019-083)

General Information

The ECM can supply an output signal to operate the vehicle tachometer.

The circuit is the tachometer signal wire and a return line in the OEM harness.



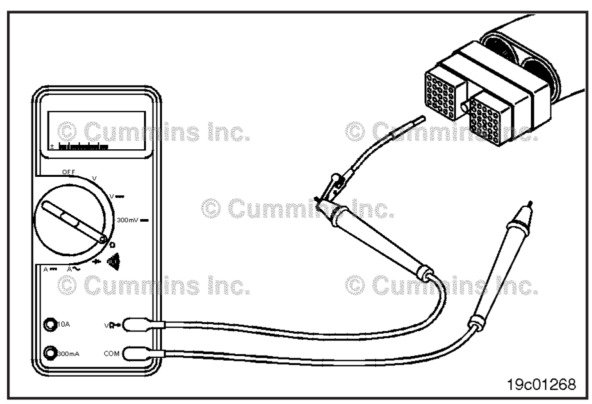
Resistance Check

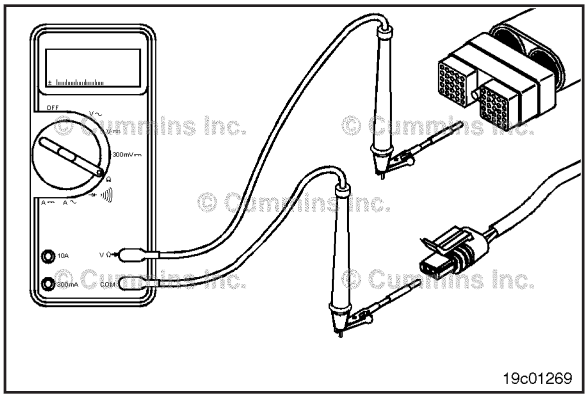
CAUTION

Do not use probes or leads other than Part Number 3822758. The connector will be damaged. The leads must fit tightly in the connector without expanding pins in the connector.

Disconnect the OEM harness from the ECM. Disconnect the tachometer from the OEM harness.

Insert the test lead into the tachometer signal pin of the OEM harness connector and connect it to the multimeter probe.



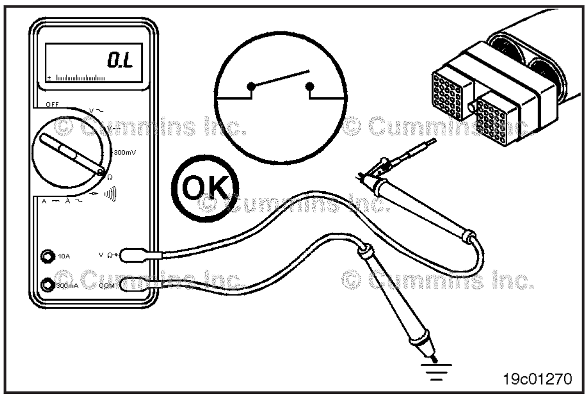


Locate the tachometer connector of the OEM harness.

Connect the other lead to the multimeter probe and connect it to the tachometer signal pin of the tachometer connector that is coming from the engine ECM. Consult the OEM troubleshooting and repair manual for wiring schematics.

Adjust the multimeter to the resistance setting. Measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, there is an open circuit or the wires in the tachometer connector are reversed. Repair or replace the wire connected to the tachometer signal pin in the OEM harness according to the vehicle manufacturer's procedures.



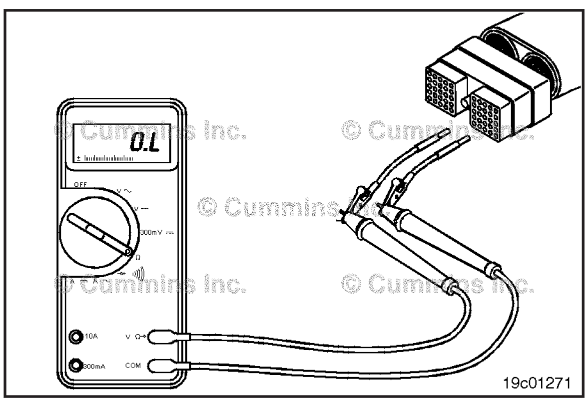
Check for Short Circuit to Ground

Disconnect the tachometer from the OEM harness.

Insert the test lead into the tachometer signal pin of the OEM harness connector and connect it to the multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open in either of the prior checks, repair the wires which have incorrect readings. Refer to the OEM troubleshooting and repair manual for the repair procedures.



Check for Short Circuit from Pin to Pin

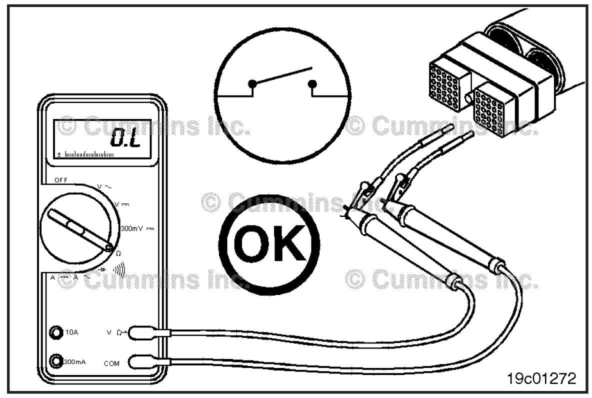
Disconnect the tachometer from the OEM harness. Insert the test lead into the tachometer signal pin of the OEM harness connector and connect it to the multimeter probe. Insert the other lead into any pin, except the tachometer switch return, of the OEM harness connector, and connect it to the other multimeter probe, and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Measure the resistance from the tachometer signal pin to all other pins in the OEM connector. The multimeter **must** show an open circuit.

Remove the test lead from the last tested pin, insert it into the tachometer switch return pin. Measure the resistance from the tachometer switch return pin to the tachometer signal pin in the OEM harness connector.

The multimeter **must** show an open circuit (100k ohms or more) at all pins. If any pin-to-pin check 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. Refer to Procedure 019-071 for harness replacement.



19c01272

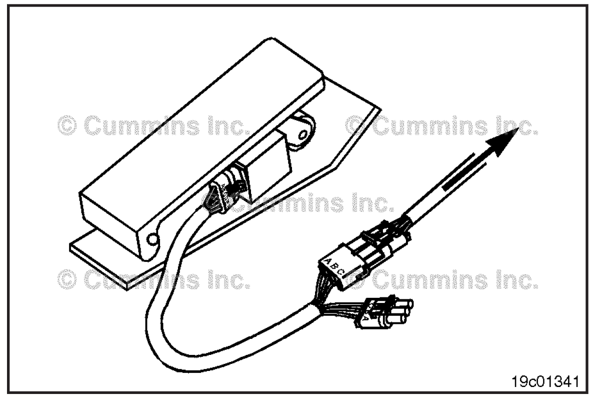
Accelerator Pedal or Lever Position Sensor (019-085)

General Information

Automotive and Industrial

The accelerator pedal 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 position sensor.

The accelerator pedal position sensor sends a signal to the ECM when the operator pushes on the accelerator pedal. The accelerator position circuit consists of the accelerator pedal position sensor, the ECM, accelerator pedal position +5 volt, accelerator pedal position signal, and accelerator pedal position return wires.

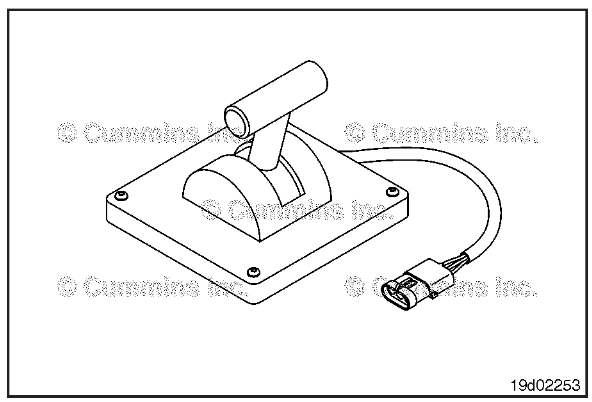


19c01341

Marine Applications

The 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 lever position sensor.

The accelerator lever position sensor sends a signal to the ECM when the operator pushes on the accelerator lever. The accelerator position circuit consists of the accelerator lever position sensor, the ECM, accelerator lever position +5 volt, accelerator lever position signal, and accelerator lever position return wires.



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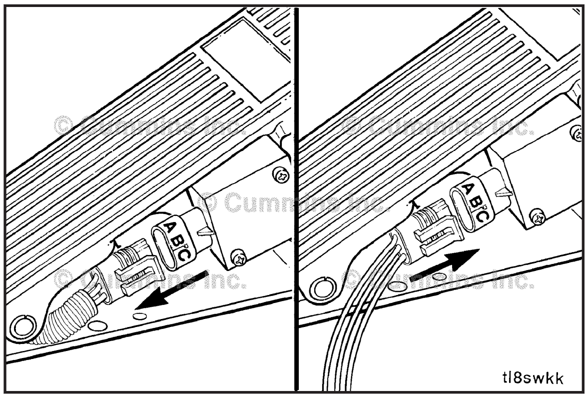


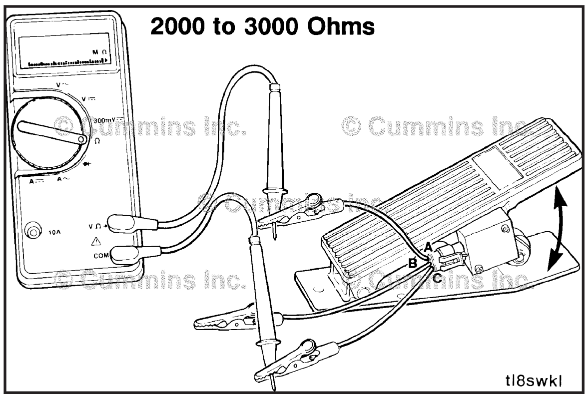
Resistance Check

Automotive and Industrial

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.

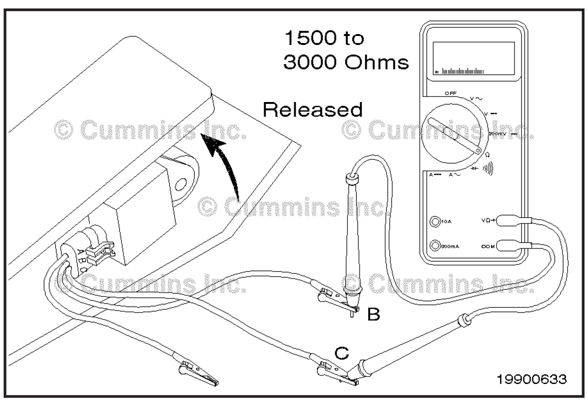
Connect the test connector.



Connect the multimeter positive (+) test lead to the accelerator pedal position +5 volt supply test connector wire. Connect the negative (-) multimeter test probe to the accelerator pedal position return test connector wire.

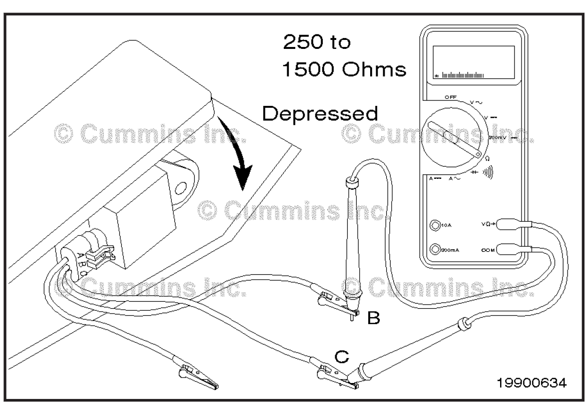
Measure the resistance. The multimeter **must** show between 2000 and 3000 ohms when the accelerator pedal is released (idle position) or depressed (full-fuel position).

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 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.



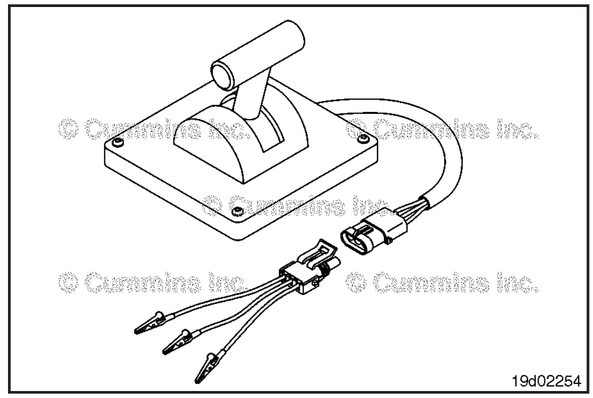
Depress the accelerator pedal assembly (full-fuel position) and measure the resistance. The multimeter **must** show between 250 and 1500 ohms. This resistance value **must** be at least 1000 ohms lower than the resistance value of 1500 to 3000 ohms measured in the above check. If the resistance values 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.

Marine Applications

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.

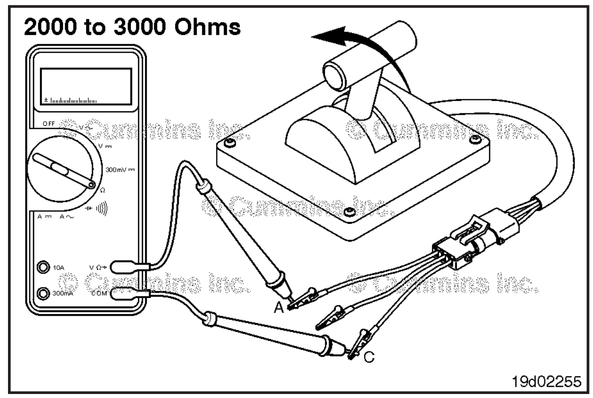
Connect the test connector.



Connect the multimeter positive (+) test lead to the accelerator lever position +5 volt supply test connector wire. Connect the negative (-) multimeter test probe to the accelerator lever position return test connector wire.

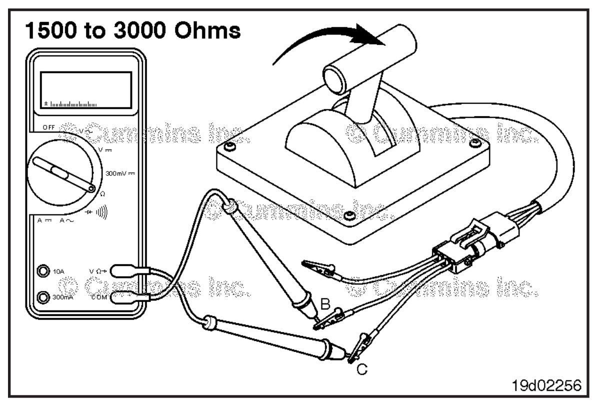
Measure the resistance. The multimeter **must** show between 2000 and 3000 ohms when the accelerator lever is released (idle position) or depressed (full-fuel position).

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.

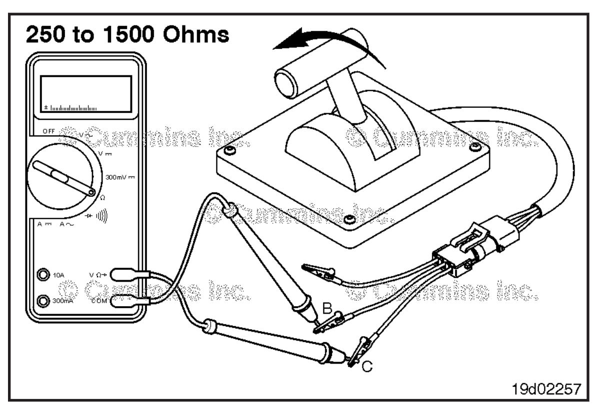


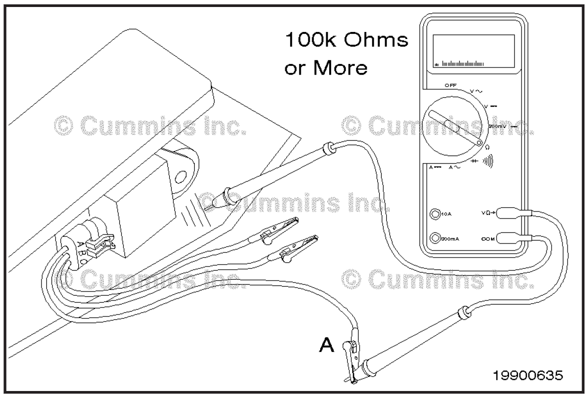
Remove the multimeter probe from the accelerator lever position +5 volt supply test connector wire and connect it to the accelerator lever position signal test connector wire.

When the accelerator lever is in the released (idle) position, measure the resistance. The multimeter **must** show between 1500 and 3000 ohms.



Depress the accelerator lever 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.



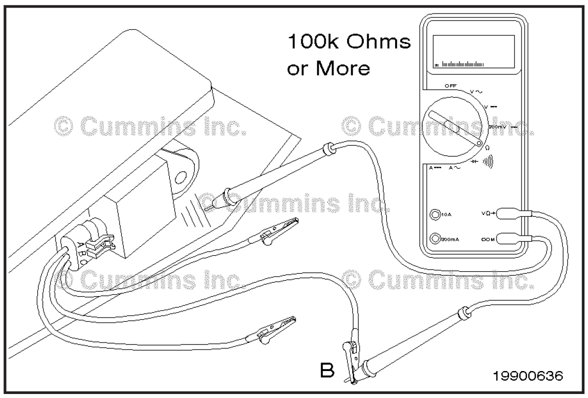


Check for Short Circuit to Ground

Automotive and Industrial

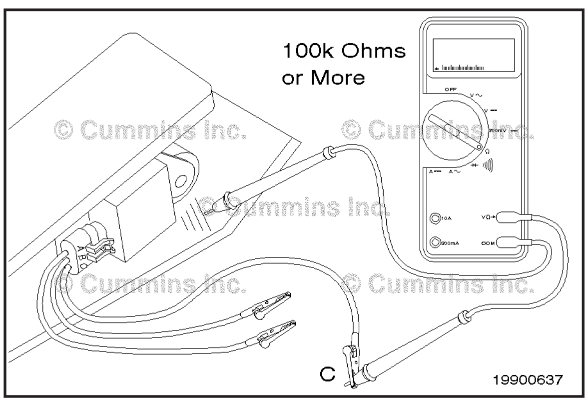
Connect the multimeter positive (+) probe to the accelerator pedal position return test connector wire. Touch the negative (-) multimeter probe to the chassis ground and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).



Remove the multimeter positive (+) probe from accelerator pedal position return test connector wire and connect it to the accelerator pedal position signal test connector wire. Measure the resistance.

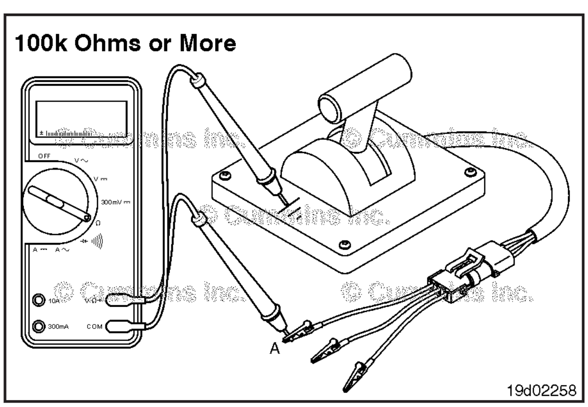
The multimeter **must** show an open circuit (100k ohms or more).



Remove the multimeter positive (+) probe from the accelerator pedal position signal test connector wire and connect it to the accelerator pedal 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.



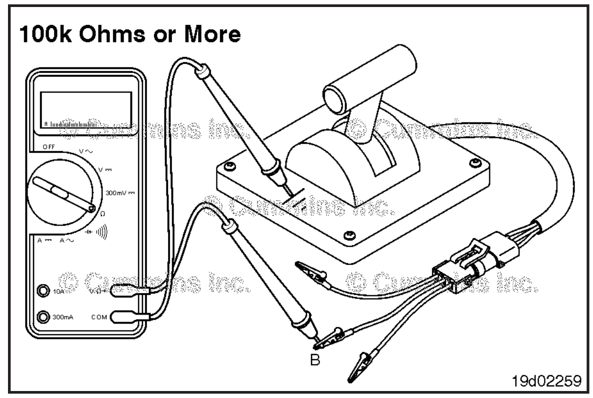
Marine Applications

Connect the multimeter positive (+) probe to the accelerator 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 lever position return test connector wire and connect it to the accelerator lever position signal test connector wire. Measure the resistance.

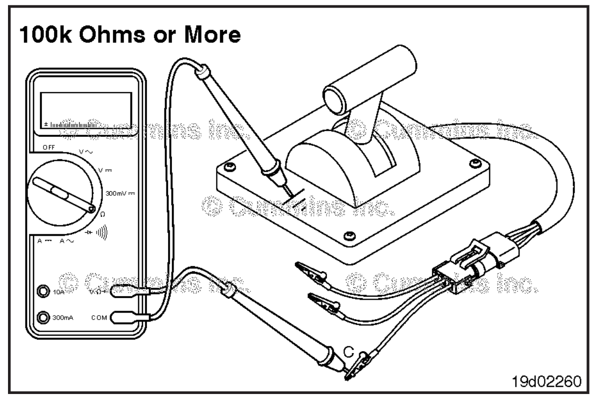
The multimeter **must** show an open circuit (100k ohms or more).



Remove the multimeter positive (+) probe from the accelerator lever position signal test connector wire and connect it to the accelerator 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.



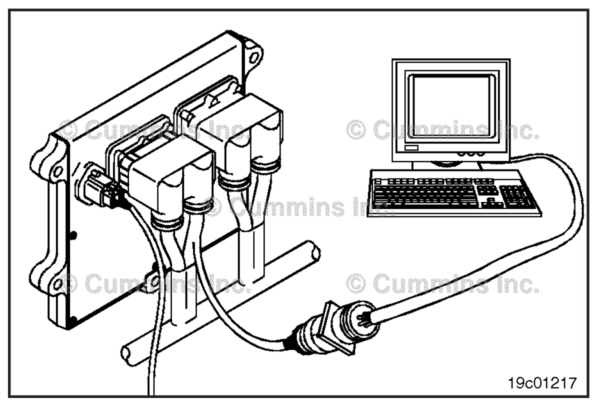
Accelerator Pedal or Lever Position Sensor Circuit (019-086)

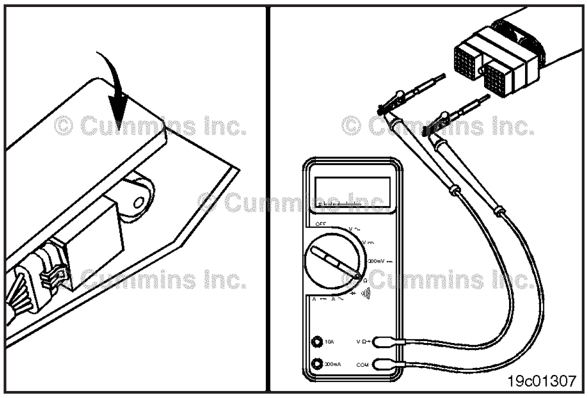
Initial Check

⚠CAUTION⚠

Do not use probes or leads other than Part Number 3822758. The OEM connector will be damaged. The leads must fit tightly in the connector without expanding the pins in the connector.

If INSITE™ electronic service tool is available, monitor the accelerator position sensor circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.





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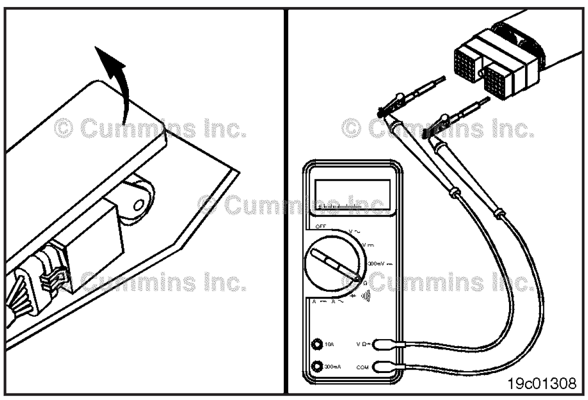
Resistance Check

Disconnect the OEM harness connector from the ECM. Make sure the sensor is connected to the OEM harness. Insert a test lead into the accelerator pedal/lever position +5 volt supply pin of the OEM harness connector and connect it to the multimeter probe. Insert the other lead into the accelerator pedal/lever position return of the connector and connect it to the other multimeter probe.

With the accelerator pedal depressed, measure the resistance. The multimeter **must** show 2000 to 3000 ohms when the accelerator pedal is down. If the resistance is **not** within the specification, there is a problem with the accelerator pedal/lever position +5 volt supply wire or the accelerator pedal/lever position return wire in the OEM harness, provided the accelerator position sensor has been previously checked. Repair the OEM harness according to the manufacturer's procedures.



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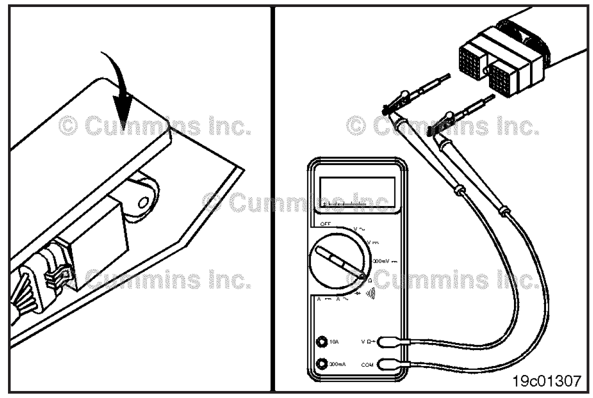
Repeat the check with the accelerator pedal in the released position. Measure the resistance. The multimeter **must** show 2000 to 3000 ohms when the accelerator pedal is up. If the resistance is **not** within the specification, there is a problem with the accelerator pedal/lever position +5 volt supply wire or the accelerator position pedal/lever return wire in the OEM harness, provided the accelerator position sensor has been previously checked. Repair the OEM harness according to the manufacturer's procedures.

Remove the test lead from the accelerator pedal/lever position return pin and insert it into the accelerator pedal/ lever position signal pin.

Make sure the foot pedal is in the released (idle) position.

Measure the resistance. The multimeter **must** show 1500 to 3000 ohms.



Depress the accelerator pedal assembly (full-fuel) and measure the resistance again.

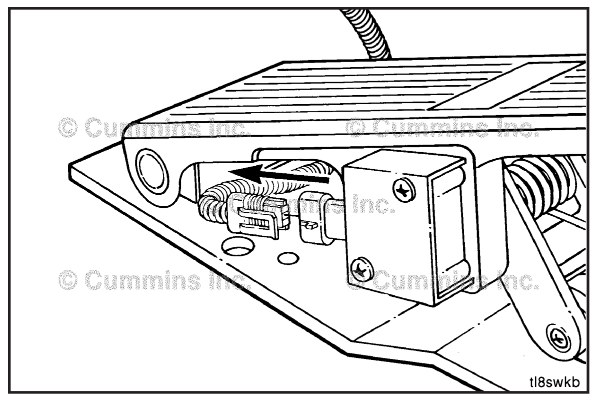
The multimeter **must** show 200 to 1500 ohms. This resistance value **must** be at least 1000 ohms lower than the resistance value of 1500 to 3000 ohms measured in the above check. If the resistance values are **not** within the specification, there is a problem with the accelerator pedal/lever position +5 volt supply or the accelerator position pedal/lever signal wire in the OEM harness.

Repair the OEM harness according to the manufacturer's procedures.

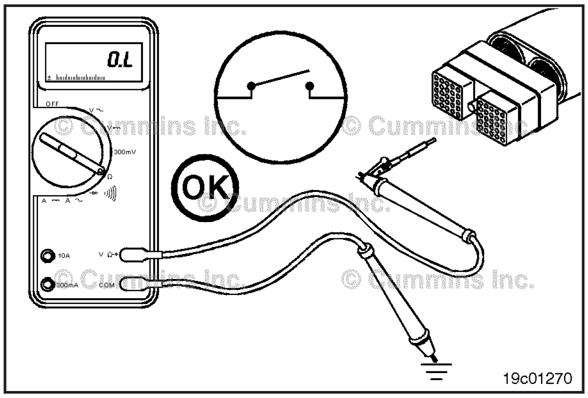
If the resistance values in the two previous checks are within the specification, the accelerator pedal/lever position +5 volt supply, the accelerator pedal/lever position return, and the accelerator pedal/lever position signal wire **must** still be checked for a short circuit to ground, a short circuit from pin to pin, and a short circuit to battery supply.

NOTE: When checking the OEM harness, inspect the bulkhead connector and other connectors in the circuit for corrosion or damage to the accelerator position sensor wire terminals.

Check for Short Circuit to Ground



Disconnect the accelerator pedal/lever position sensor and assembly from the OEM harness at the accelerator pedal/lever position sensor and assembly.



Insert a test lead into the accelerator pedal/lever position +5 volt supply pin of the OEM harness connector and connect it to the multimeter positive probe. Touch the multimeter negative probe to the engine block ground and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

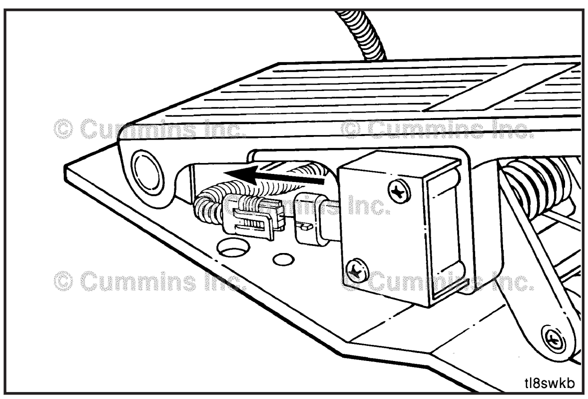
Remove the lead from the accelerator pedal/lever position +5 volt supply pin and insert it into the accelerator pedal/lever position return pin of the OEM harness connector. Touch the multimeter negative probe to the engine block ground and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the accelerator pedal/lever position return and insert it into the accelerator pedal/lever position signal pin. Touch the multimeter negative probe to the engine block ground and measure the resistance.

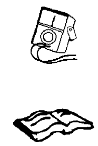
The multimeter **must** show an open circuit (100k ohms or more).

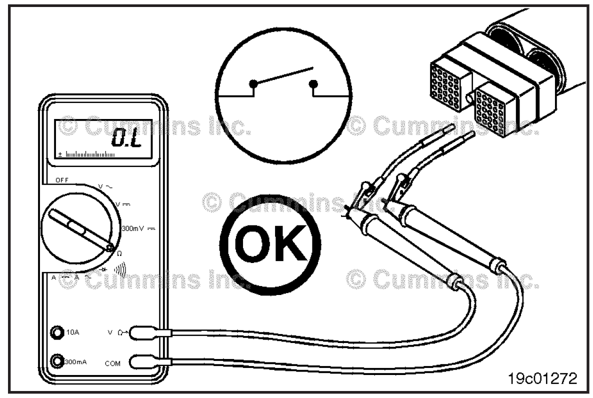
If **any** of these three resistance measurements are **not** open, there is a short circuit to ground between the wires connected to the accelerator pedal/lever position +5 volt supply, the accelerator pedal/lever position return, or the accelerator pedal/lever position signal wire. Repair the OEM harness. Refer to the OEM troubleshooting and repair manual for the procedures.



Check for Short Circuit from Pin to Pin

Disconnect the accelerator pedal/lever position sensor and assembly from the OEM harness at the accelerator pedal/lever position sensor and assembly.





Insert the test lead into the accelerator pedal/lever position +5 volt supply pin of the OEM harness connector. Insert the other lead into the idle validation on-idle signal pin of the accelerator pedal assembly connector. Connect the clips to the multimeter probes and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the idle validation on-idle signal pin and test all other pins in the OEM harness connector, one at a time.

The multimeter **must** show an open circuit (100k ohms or more) at all pins.

If the multimeter did **not** indicate an open circuit at every pin, there is a short circuit between the accelerator pedal/lever position +5 volt supply wire and any other wire that did **not** measure an open circuit. Repair or replace the OEM harness. Refer to Procedure 019-071 for harness replacement.

Remove the lead from the accelerator pedal/lever position +5 volt supply pin and insert it into the accelerator pedal/lever position return pin. Insert the other lead into the idle validation on-idle signal pin in the OEM harness connector and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from idle validation idle signal pin and test all other pins in the OEM harness connector, one at a time.

The multimeter **must** show an open circuit (100k ohms or more) at all pins.

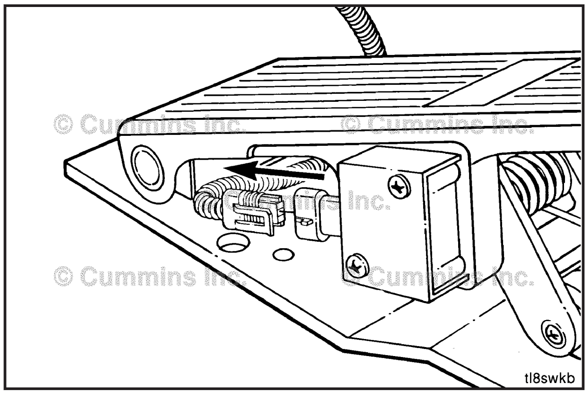
Remove the lead from the accelerator pedal/lever position return pin and insert it into the accelerator pedal/lever position signal pin. Insert the other lead into the first pin in the OEM harness connector and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the first pin in the OEM harness connector and test all other pins in the connector, one at a time.

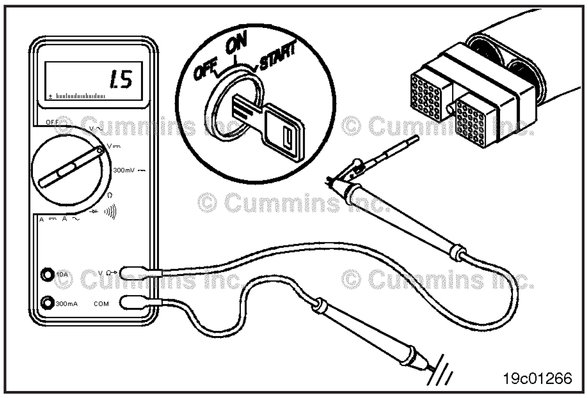
The multimeter **must** show an open circuit (100k ohms or more) in all pins.

If the multimeter did **not** indicate an open circuit on every pin, there is a short circuit between the accelerator pedal/lever position signal wire and any other wire that did **not** indicate an open circuit. Repair the OEM harness according to the vehicle manufacturer's procedures.



Check for Short Circuit to External Voltage Source

Disconnect the accelerator pedal/lever position sensor assembly from the OEM harness at the accelerator pedal/lever position sensor assembly.



Turn the keyswitch to the ON position. Adjust the multimeter to measure VDC.

Insert a test lead into the accelerator pedal/lever position return pin. Touch the multimeter negative probe to the engine block ground and measure the voltage.

The voltage **must** be 1.5 VDC or less.

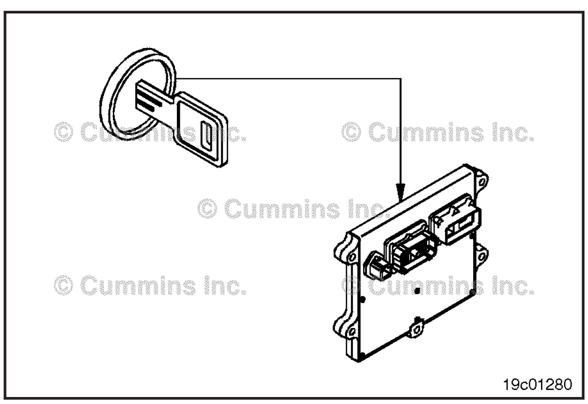
Remove the lead from the accelerator pedal/lever position return pin and insert it into the accelerator pedal/lever position signal pin. Touch the multimeter negative probe to the engine block and measure the voltage.

The voltage **must** be 1.5 VDC or less.

If more than 1.5 VDC is measured at any pin, there is a short circuit from the accelerator pedal/lever position +5 volt supply, the accelerator pedal/lever position return, or the accelerator pedal/lever position signal to a wire carrying power in the OEM harness.

NOTE: An external voltage source is any wire in the OEM harness that carries voltage.

Replace the OEM harness. Refer to Procedure 019-071. Connect all components after completing the repair.



Unswitched Battery Supply Circuit (019-087)

General Information

The ECM receives constant voltage from the batteries through the ECM battery supply positive (+) wire that is connected directly to the positive (+) battery post. There is one in-line 30-amp fuse (marine has 25-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 supply negative (-) wire is connected directly to the negative (-) battery post.

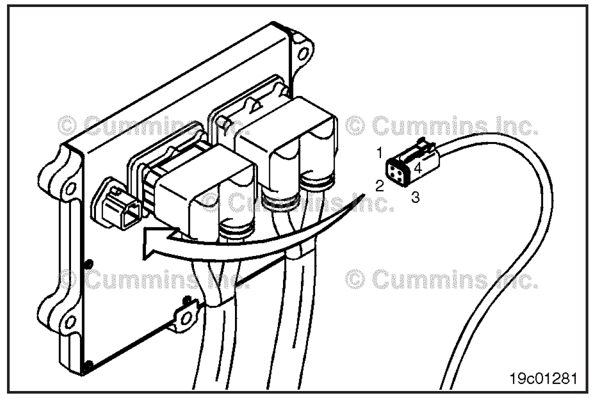
The ECM battery supply positive (+) wire and the ECM battery supply negative (-) wire are in the ECM power harness.

Always check the ECM battery supply fuse when troubleshooting the ECM and power supply circuit.

Check the battery voltage. Refer to Procedure 019-008.

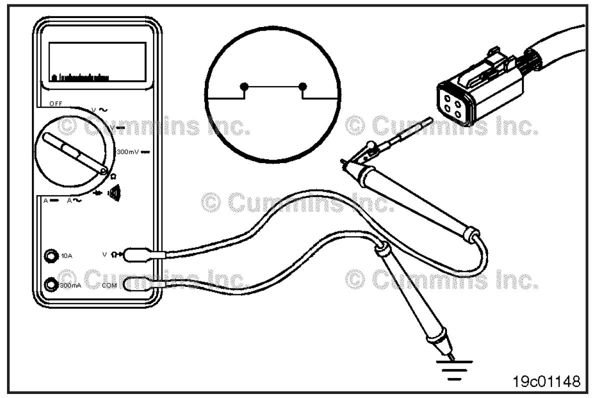
Resistance Check

Disconnect the ECM power harness connector from the ECM.



Adjust the multimeter to measure resistance.

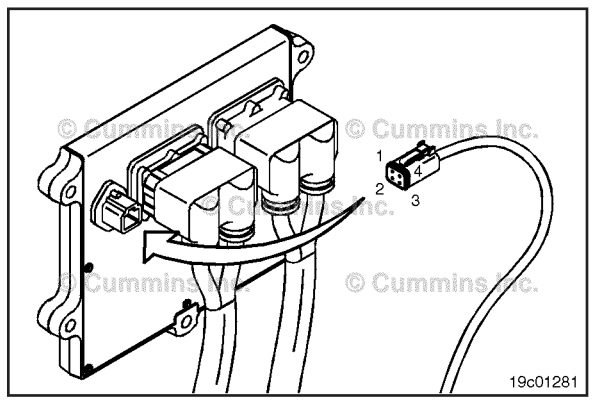
Insert a test lead into the ECM battery supply negative (-) pin of the ECM power connector. Attach it to a multimeter probe. Touch the other multimeter probe to the engine block ground and measure the resistance. The multimeter **must** show 10 ohms or less.



If the resistance value is **not** correct, check the ECM power harness.

Repair or replace the ECM power harness.

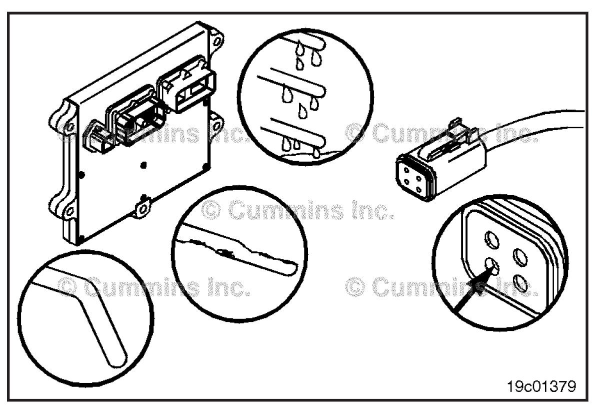
When the checks have been completed, connect the ECM power harness connector.

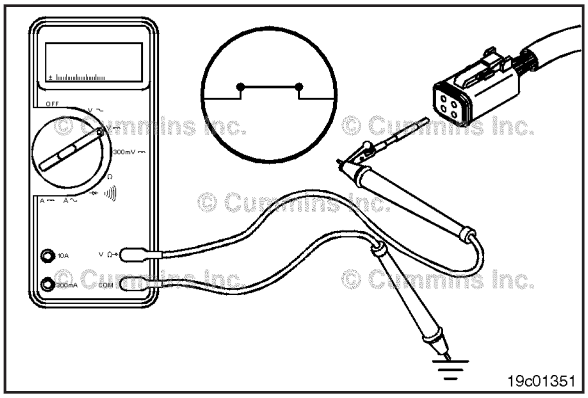


NOTE: Some OEM applications have the ECM power harness with all 4 pins in the connector populated.

Check the battery return wire in the ECM power harness for proper grounding. Disconnect the harness from the ECM. Check for damaged pins in the ECM and the harness.

Repair or replace any damaged pins.




19c01351

Voltage Check

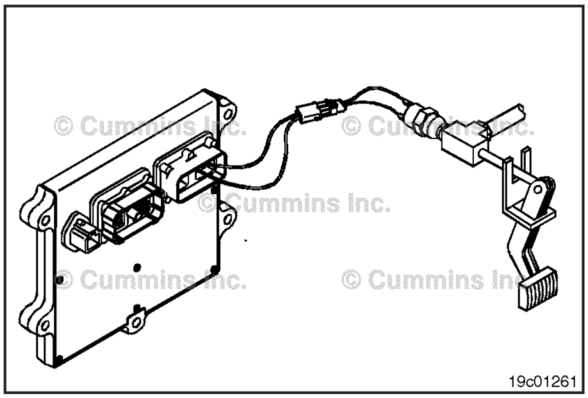
Check the battery voltage supply at the ECM battery supply positive (+) pin of the ECM power connector.

Turn the keyswitch to the OFF position. Disconnect the 4-pin ECM power harness connector from the ECM. Set the multimeter to measure VDC.

Measure the voltage from the ECM battery supply positive (+) to ground.

The voltage **must** read battery voltage at this pin.

If the voltage is **not** correct, repair or replace the ECM power harness.


19c01261

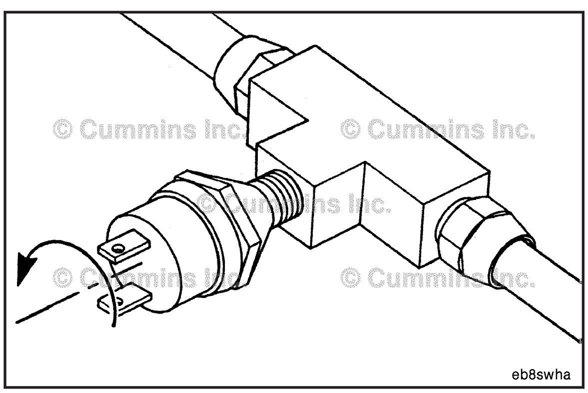
Brake Pedal Position Switch (019-088)

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.


eb8swha

Remove

WARNING

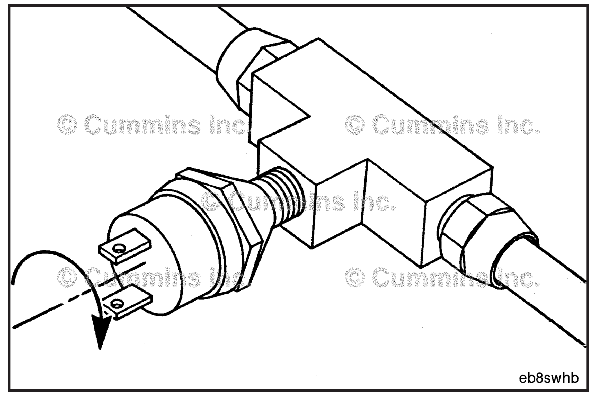
To avoid personal injury or death, do not apply the vehicle brakes when the switch is removed from the brake line fitting.

Disconnect the OEM harness from the brake pedal position switch.

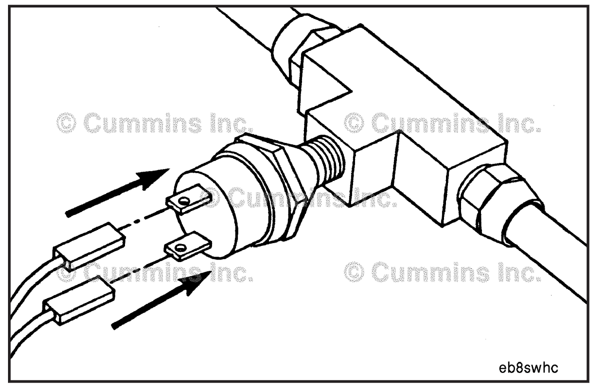
Remove the brake pedal position switch from the fitting.

Install

Install the new brake pedal position switch into the fitting according to the vehicle manufacturer's procedures.



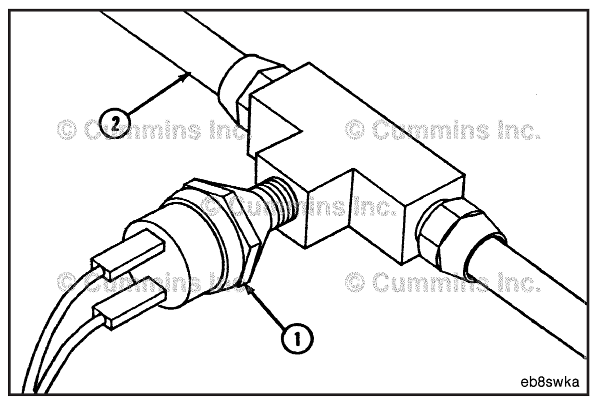
Connect the two wire connectors to the brake pedal position switch.



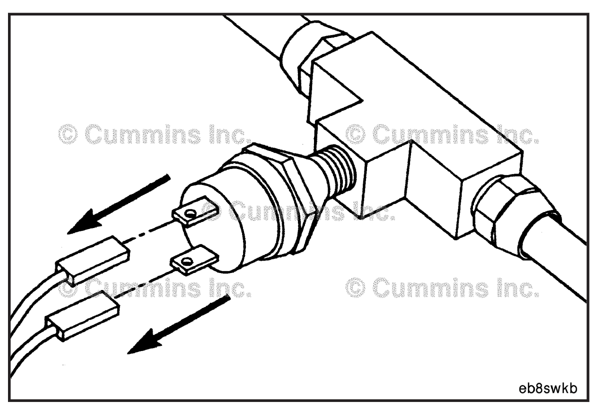
Resistance Check

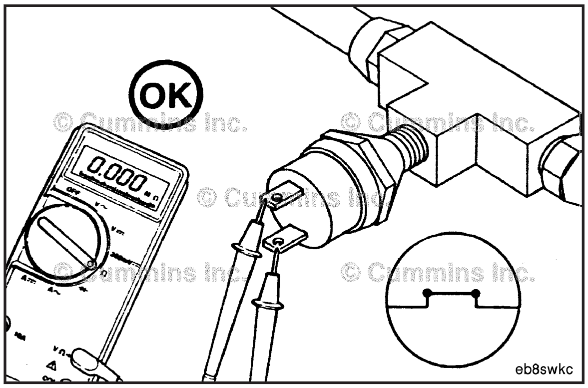
If INSITE™ is available, monitor the brake pedal position switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

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.

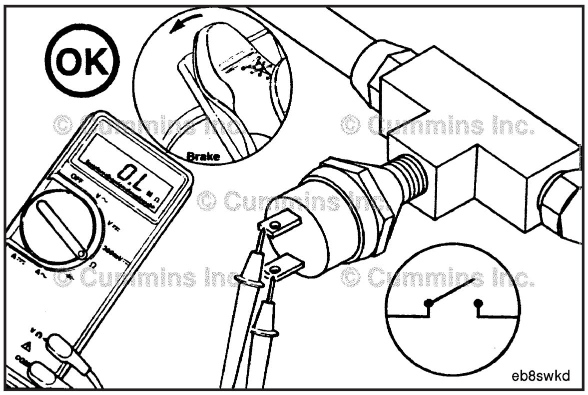




Connect the probes of the multimeter to the brake pedal position switch terminals.

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.

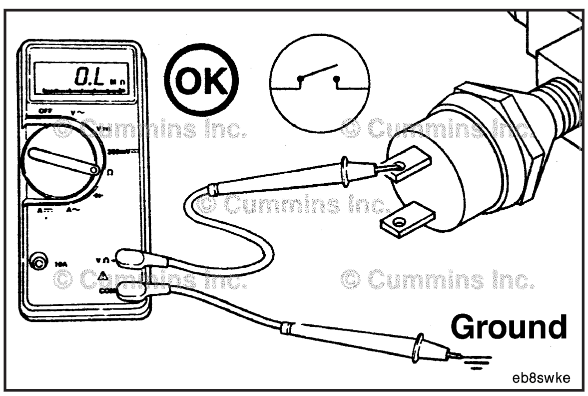


CAUTION

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.



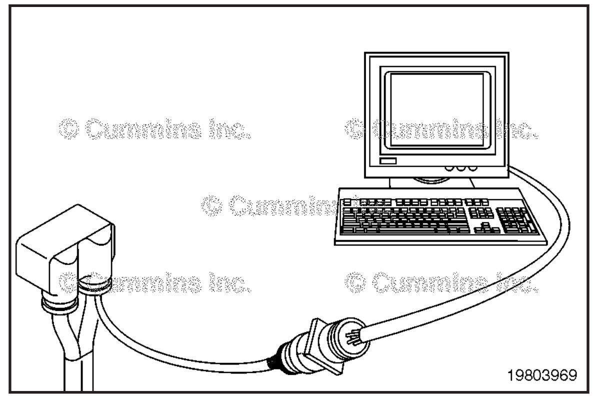
Check for Short Circuit to Ground

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

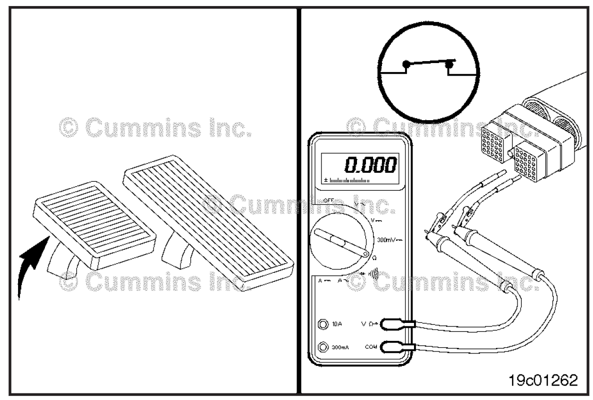


⚠CAUTION⚠

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.

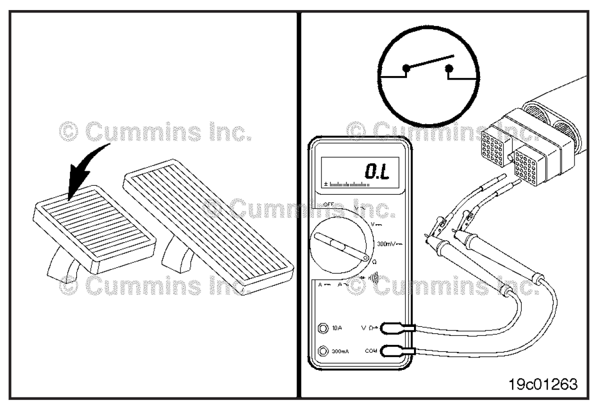
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM).



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.

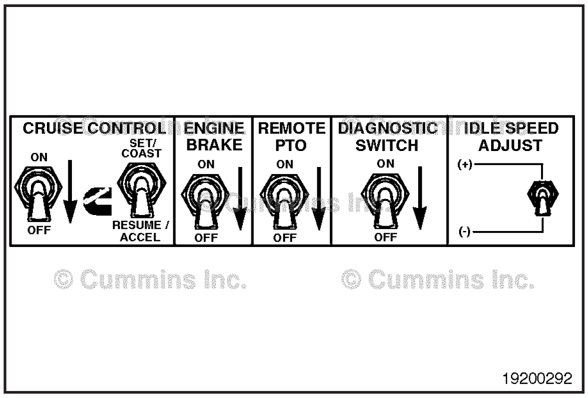


⚠CAUTION⚠

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.



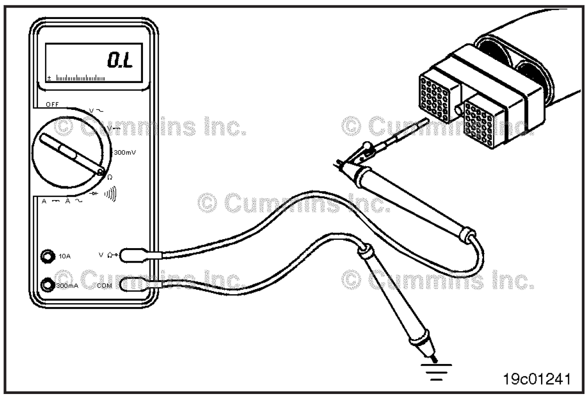
Check for Short Circuit to Ground

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.

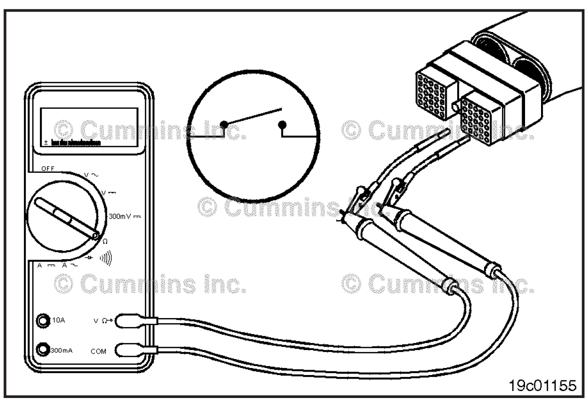


Insert a test lead into the brake pedal position switch signal pin of the OEM harness connector. Connect the lead to the multimeter probe. Remove the alligator clip from the other multimeter probe and touch the probe to the engine block.

The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the brake pedal position switch signal wire, provided that the switch has been previously checked.

Repair or replace the wire connected to the brake pedal position switch signal pin in the OEM harness according to the vehicle manufacturer's procedures.

Measure the resistance.



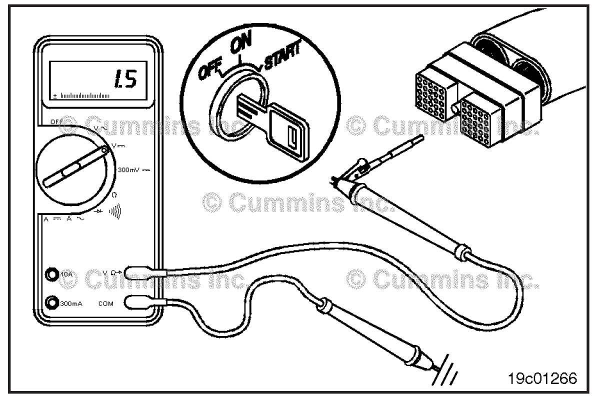
Check for Short Circuit from Pin to Pin

Isolate the brake pedal position switch circuit by disconnecting the brake pedal position switch connector and the OEM harness connector at the ECM. Insert a test lead into the brake pedal position switch signal pin of the OEM harness connector. Insert the other test lead into the switch return pin of the OEM harness connector. Connect the alligator clips to the multimeter probes. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

Remove the lead from the switch return pin and test all other pins in the connector. The multimeter **must** show an open circuit (100k ohms or more) at all pins. If the circuit is **not** open, there is a short circuit between the wire connected to the service brake switch signal pin and any pin that did **not** show an open circuit.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's procedures.

Check for Short Circuit to External Voltage Source



Disconnect the brake pedal position switch from the OEM harness and disconnect the OEM harness from the ECM. Turn the vehicle keyswitch to the ON position. Adjust the multimeter to measure VDC. Insert a test lead into the brake pedal position switch signal pin and connect it to the positive multimeter probe. Remove the lead from the negative multimeter probe and touch the probe to the engine block ground. Measure the voltage. The voltage **must** be 1.5 VDC or less.

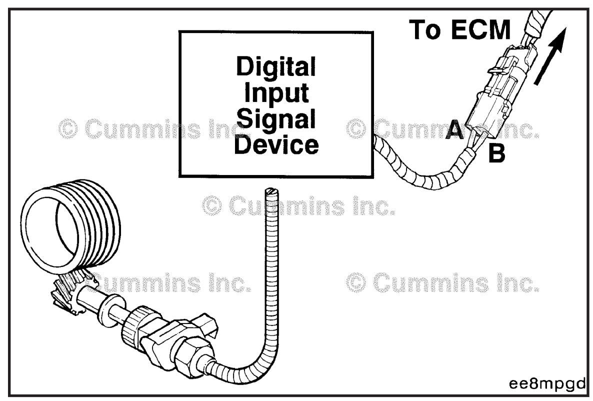
NOTE: An external voltage source is any wire in the OEM wiring that carries voltage.

If the voltage is more than 1.5 VDC, there is a short circuit between the wire connected to the brake pedal position switch signal pin and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.

Connect all components after completing the repair.

Vehicle Speed Sensor, Digital Input (019-090)

General Information

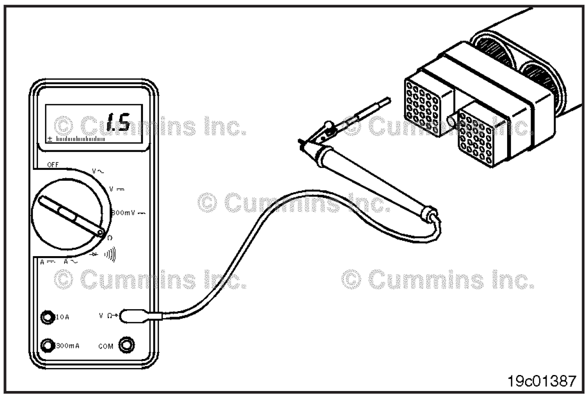


The digital input signal device is an OEM optional part. It changes the signal pulses from AC to DC. This part is near the transmission or in the vehicle cab. The DC voltage pulses are then sent to the ECM and computed into miles per hour.

The digital vehicle speed sensor circuit consists of the speed sensor, the digital vehicle speed sensor +5 volt supply wire, the digital vehicle speed sensor signal wire, and the digital vehicle speed sensor return wire.

⚠CAUTION⚠

When the OEM-supplied signal conditioner is internally grounded, do not connect the vehicle speed sensor signal negative (-) wire to the ECM. This will create a ground loop in the system that will inject unwanted electrical noise into the system. Only the digital vehicle speed sensor +5 volt supply wire is required in this case.



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Resistance Check

⚠CAUTION⚠

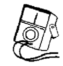
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

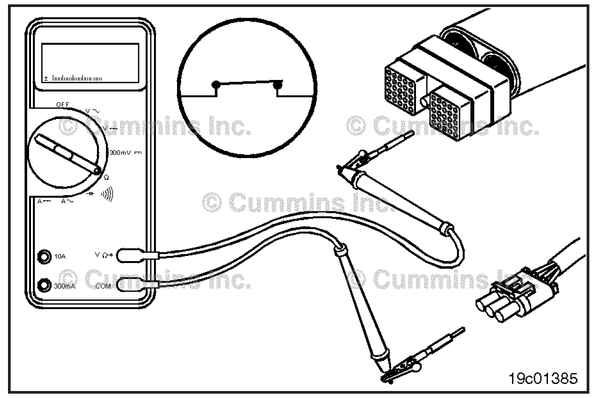
Disconnect the OEM harness connector from the ECM connector.

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).

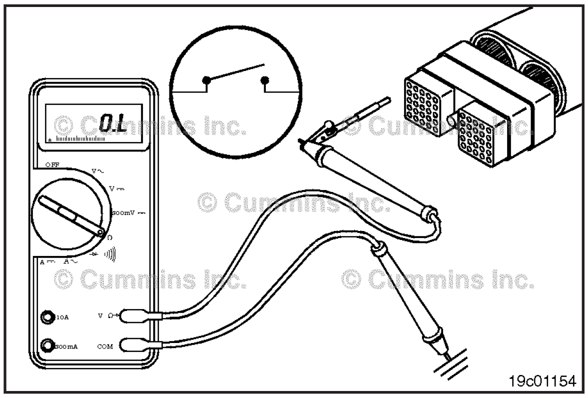
If the circuit is **not** closed, there is an open circuit. Repair or replace the wire connected to the vehicle speed sensor signal pin in the OEM harness according to the vehicle manufacturer's procedures.

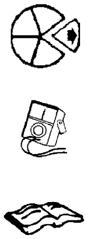
Remove the lead from the digital vehicle speed sensor signal pin and insert it into the digital vehicle speed sensor return pin of the OEM harness connector. Remove the multimeter lead from the digital vehicle speed sensor signal pin at the speed sensor connector and connect it to the digital vehicle 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).

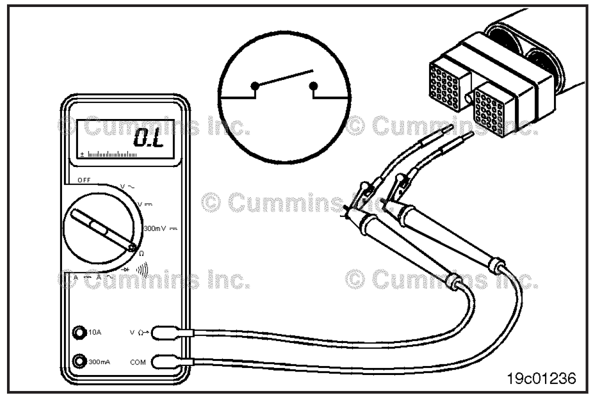
Remove the test lead from the digital vehicle speed sensor signal +5 volt supply pin and insert it into the digital vehicle speed sensor signal pin of the OEM harness connector. Touch the other multimeter probe to the engine block ground. Measure the resistance.

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.

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 connecter.

Insert one test lead into the digital vehicle speed sensor +5 volt supply pin of the OEM harness connector, and connect it to the multimeter probe. Connect the other test lead to the other multimeter probe and check all pins in the OEM harness connector.Measure the resistance.

The multimeter **must** show an open circuit at all pins (100k ohms or more).

Remove the test lead from the digital vehicle speed sensor +5 volt supply pin, and insert it into the digital vehicle speed sensor signal return pin.

Use the other test lead to check all pins in the connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

Remove the test lead from the digital vehicle speed sensor return pin, and insert it into the digital vehicle speed sensor signal signal pin.

Use the other test lead to check all pins in the connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

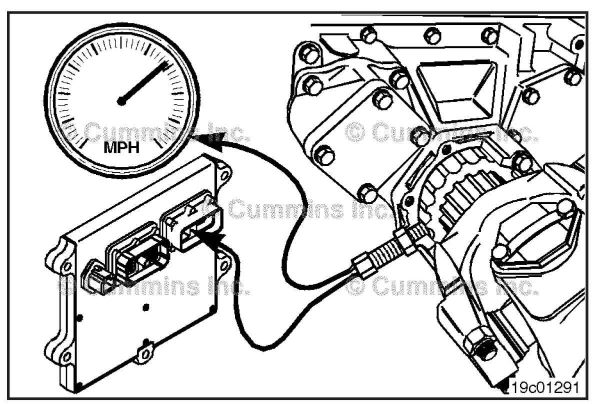
If the circuit is **not** open in any of the checks, repair the wires that have the short circuit according to the vehicle manufacturer's procedures.

NOTE: If the values are correct for all of the circuit checks in Procedure 019-090, the vehicle speed sensor circuit is good.

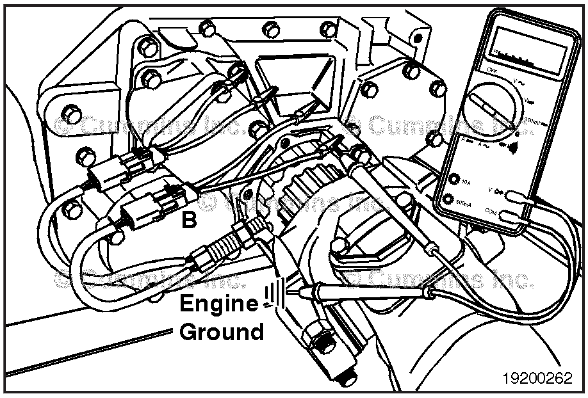
The problem is in the vehicle speed sensor. Repair or replace the vehicle speed sensor according to the vehicle manufacturer's procedures.

Vehicle Speed Sensor, Magnetic Pick Up (019-091)

General Information



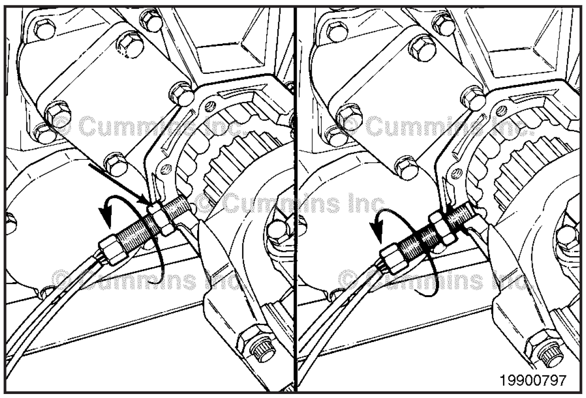
The vehicle speed sensor (VSS) senses the speed of the output shaft of the transmission. The vehicle's road speed is computed from this data by the electronic control module (ECM). The ECM uses programmed gearing and tire size data to compute the road speed.



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.

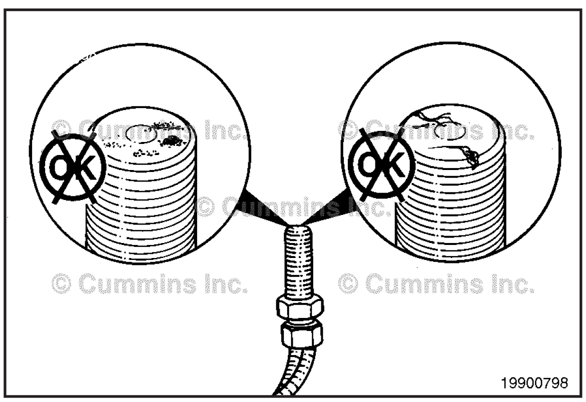
NOTE: Vehicle speed sensor design varies with the application. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual to understand which type of vehicle speed sensor is being used in a given location.



Remove

Disconnect the engine harness from the vehicle speed sensor.

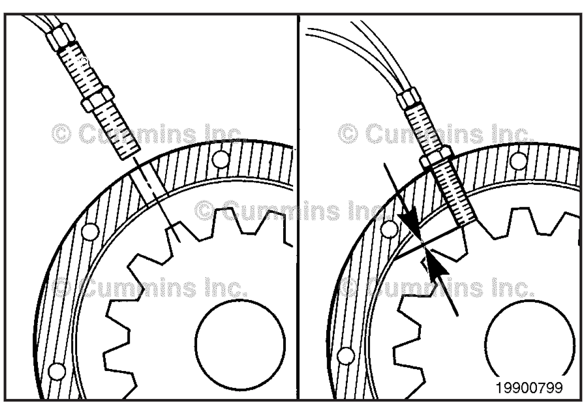
Loosen the locknut. Turn the vehicle speed sensor out of the transmission housing.



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.



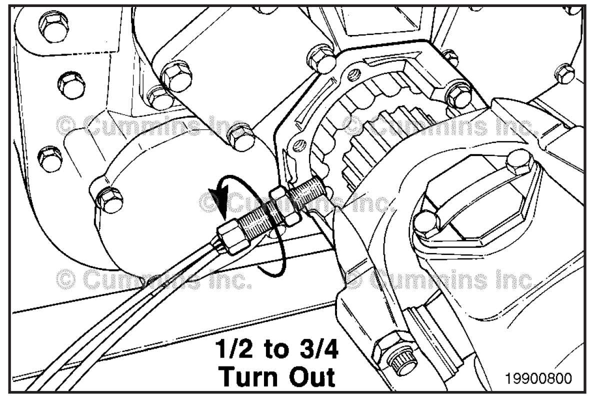
Install

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.

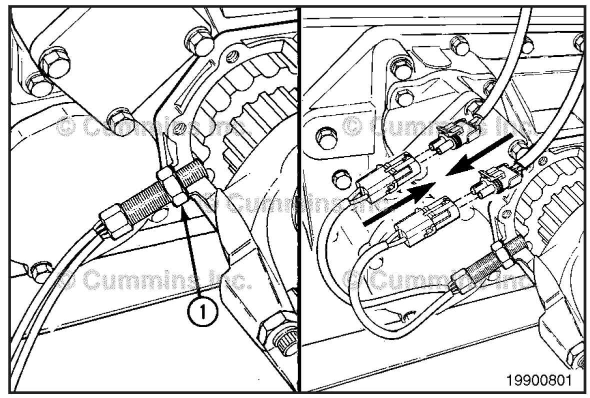
Turn the vehicle speed sensor out 1/2 to 3/4 of a turn.



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.

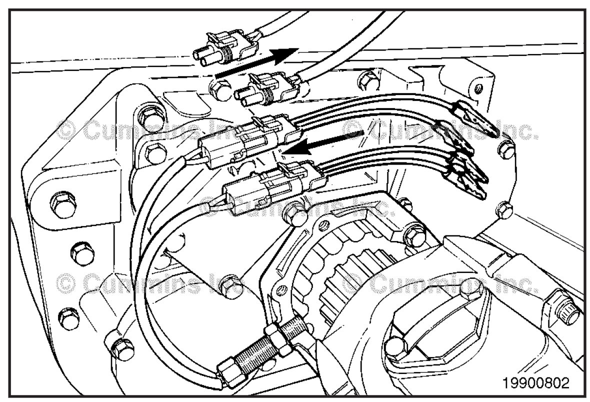
Install both of the connectors together until connectors "snap" into position. The connectors can be interchanged with each other without changing the performance of the system.



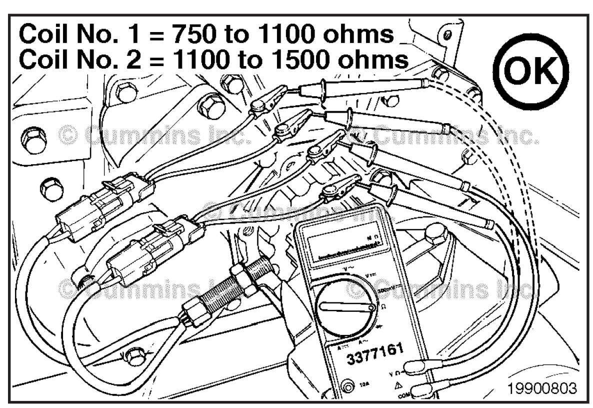
Resistance Check

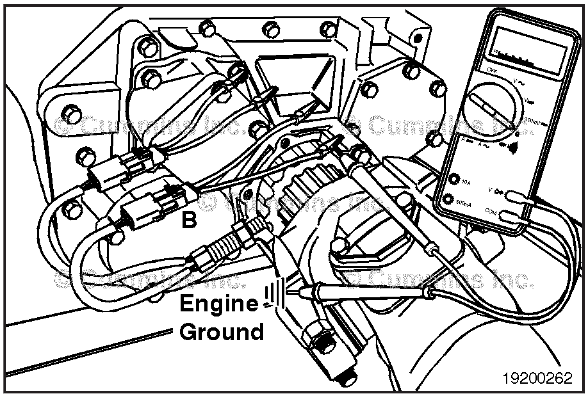
Lift the tab on the connectors and pull them apart.

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.



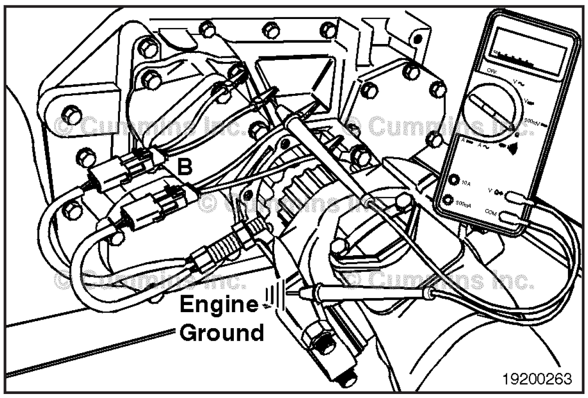
Use a multimeter to measure the resistance between the two pins of each connector on the vehicle speed sensor. Refer to the OEM troubleshooting and repair manual for detailed procedures. If the resistance is **not** correct, replace the vehicle speed sensor. If the resistance value is correct, the vehicle speed sensor **must** still be checked for a short circuit to ground and a short circuit between coils.



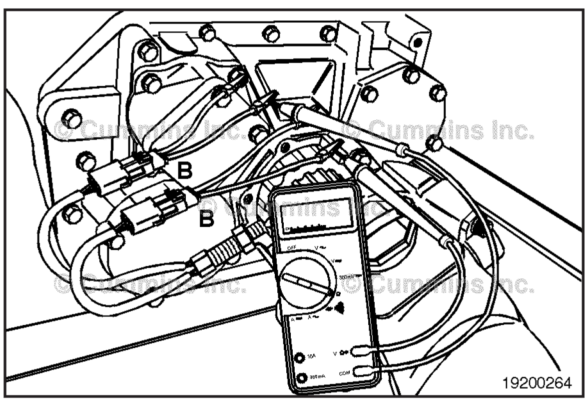


Check for Short Circuit to Ground

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.

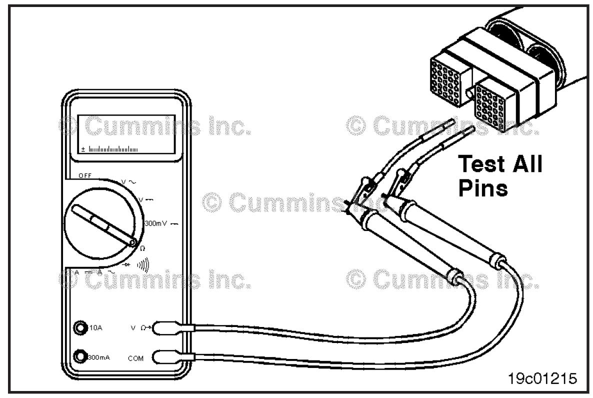


Check for a short circuit between coils

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.

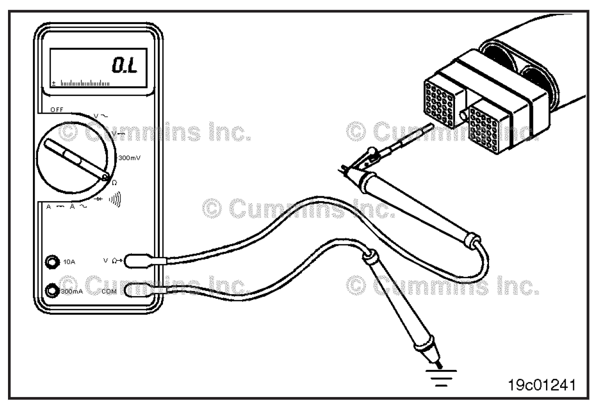
Insert a test lead into the magnetic vehicle speed sensor signal positive (+) pin in the OEM harness connector. Insert the other lead into the magnetic vehicle speed sensor signal negative (-) pin of the connector.

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.

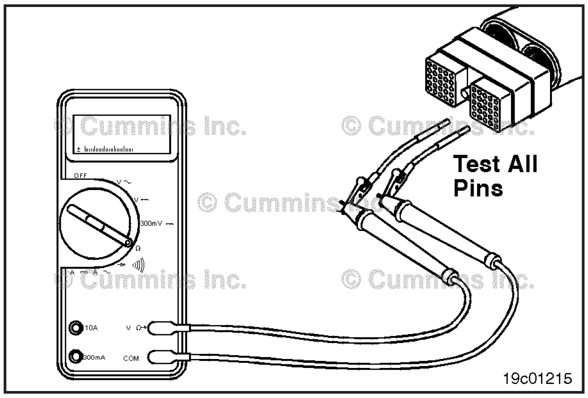
Check for Short Circuit to Ground



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.

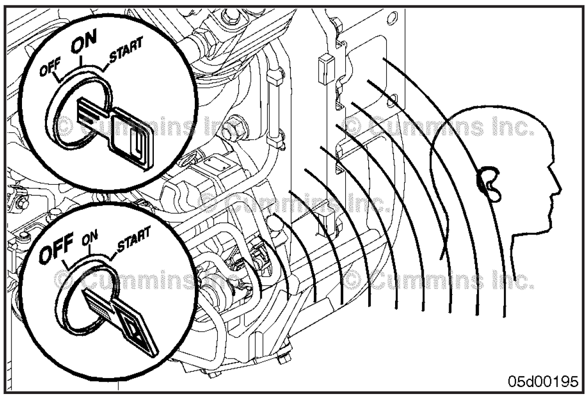
Repair the wires which are shorted in the circuit according to the vehicle manufacturer's procedures.



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).

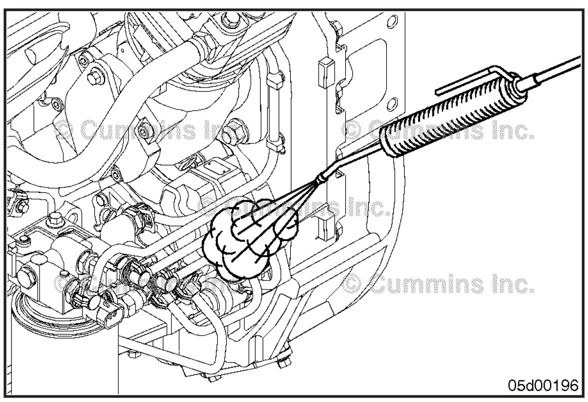


Fuel Control Valve (019-102)

Initial Check

Check the electronic fuel control actuator for an audible click after a key-on-key-off cycle. If no audible click is heard at key-off, measure the resistance of the electronic fuel control actuator valve.

NOTE: The electronic fuel control (EFC) actuator can also be checked using an INSITE™ electronic service tool. Refer to the OEM service manual for instructions.

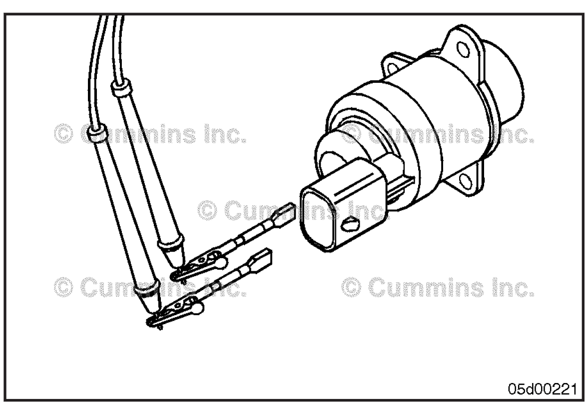


WARNING
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

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.

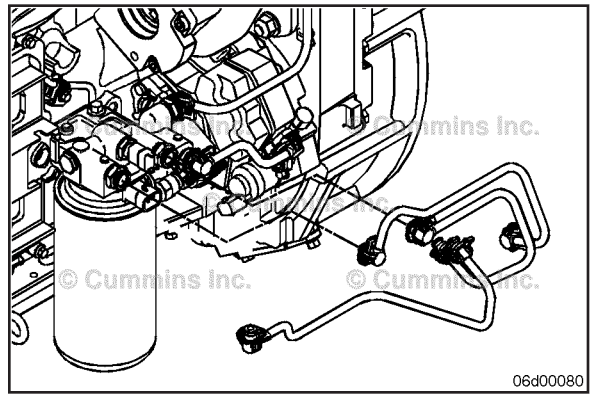


Measure

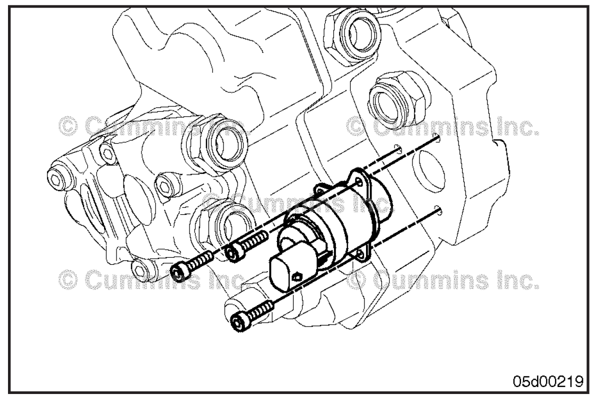
Measure the resistance of the electronic fuel control actuator valve. The maximum resistance is 5 ohms.

Remove

Remove the low-pressure supply lines. Refer to Procedure 006-024.



Remove the capscrews and electronic fuel control actuator.



Install

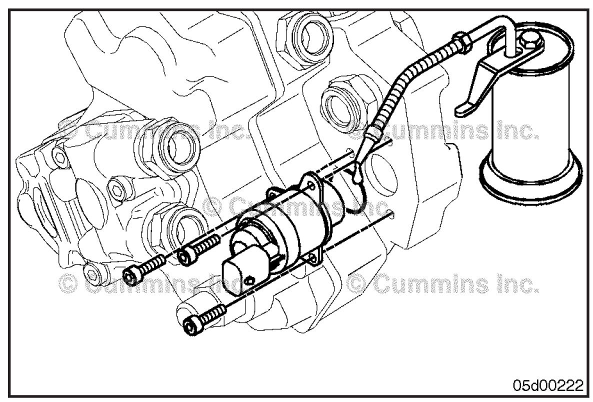
CAUTION

Do not pause more than two minutes between Torque Steps 1 and 2. This can cause the capscrews not to maintain their torque value. Leakage or engine damage can result.

NOTE: Lubricate the new o-ring with clean oil before installation.

Install a new o-ring on the electric fuel control actuator.

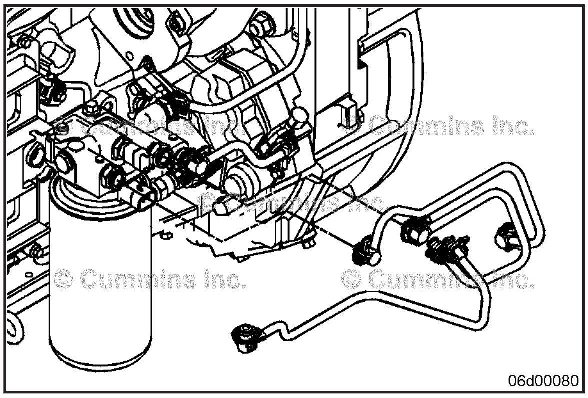
Install the electronic fuel control actuator and capscrews, and tighten.



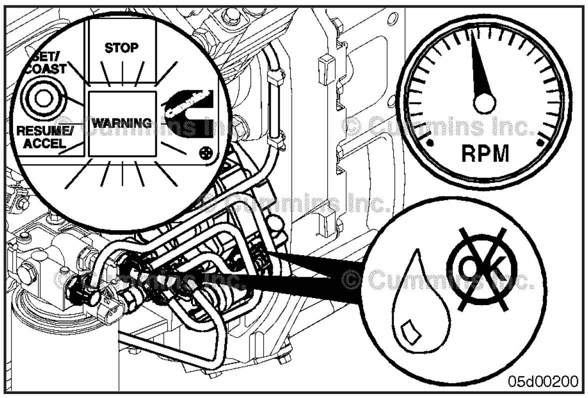
Torque Value:	Step1	3 N•m	[27 in-lb]
	Step2	7 N•m	[62 in-lb]

NOTE: Be sure that the electronic fuel control actuator flange is flush with the mounting surface on the fuel pump.

NOTE: New capscrews **must** be used each time the electronic fuel control actuator is installed. The capscrews are coated with an encapsulated thread sealant that is activated in Step 1 of the tightening procedure.



Install the low-pressure fuel supply lines. Refer to Procedure 006-024.

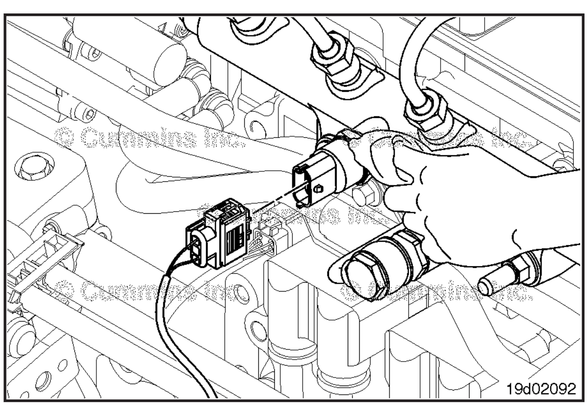


Operate the engine and check for leaks or fault codes.

Rail Fuel Pressure Sensor (019-115)

General Information

The fuel pressure sensor is located on the fuel rail mounted on the inlet manifold.

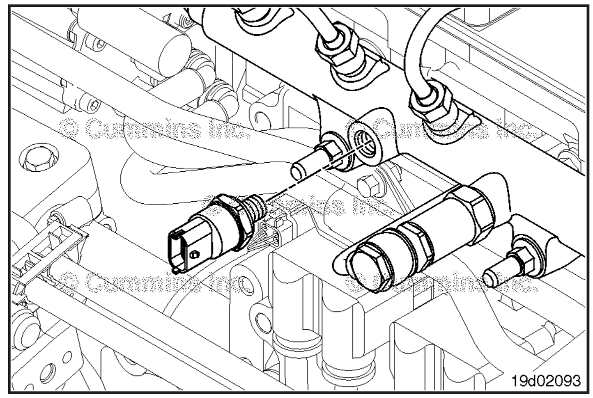


Remove

Clean the area around the fuel pressure sensor.

Disconnect the pressure sensor connector from the engine harness.

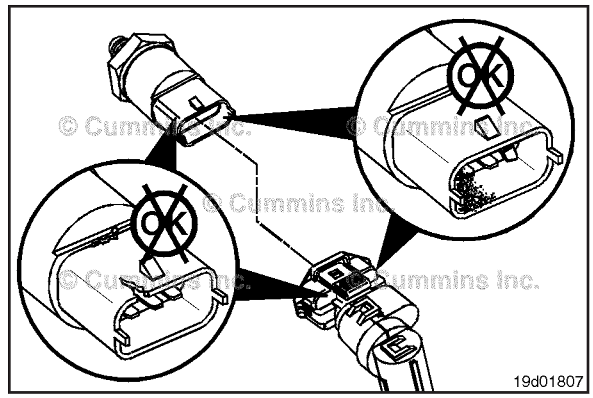
Remove the fuel pressure sensor.



Inspect for Reuse

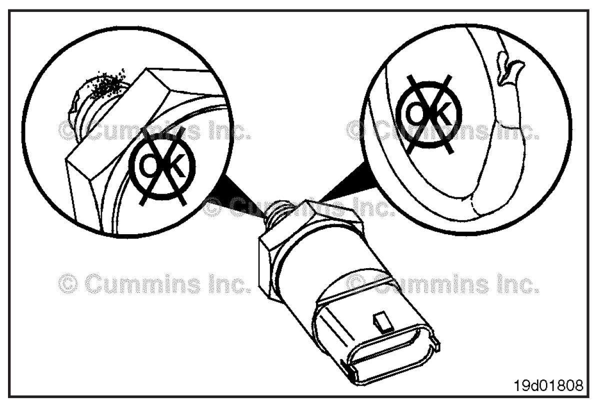
Inspect the engine harness connector and the fuel pressure sensor for the following:

- 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.



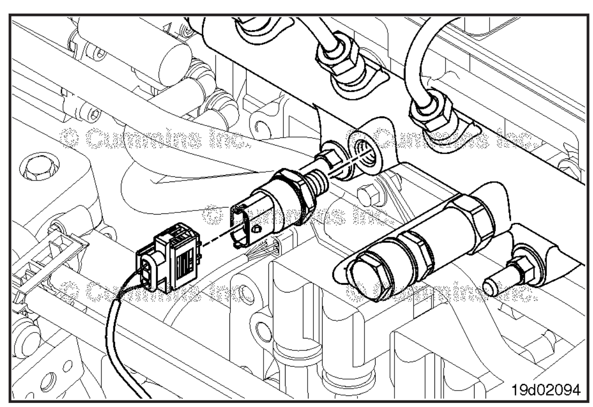
Install

Install a new fuel pressure sensor.

Torque Value: 70 N•m [52 ft-lb]

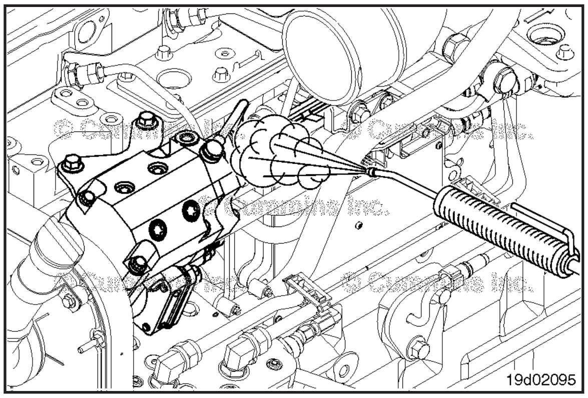
Connect the engine harness to the fuel pressure sensor.

Start the engine and check for leaks.



Fuel Pump Actuator (019-117)

Initial Check



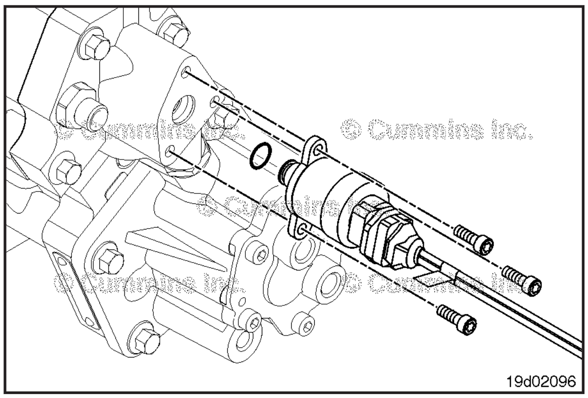
WARNING
When using a steam cleaner, wear safety glasses or a face shield, as well as protective clothing. Hot steam can cause serious personal injury.

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

Steam-clean the fuel pump and the area around the fuel pump.

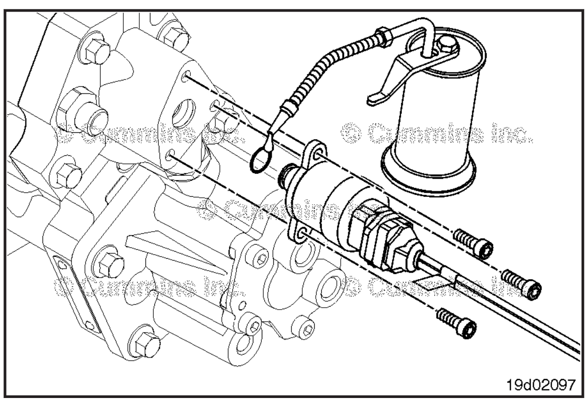
Dry with compressed air.

Remove



Remove the capscrews and fuel pump actuator.

Install



Install a new o-ring on the fuel pump actuator.

Lubricate the new o-ring with clean oil before installation.

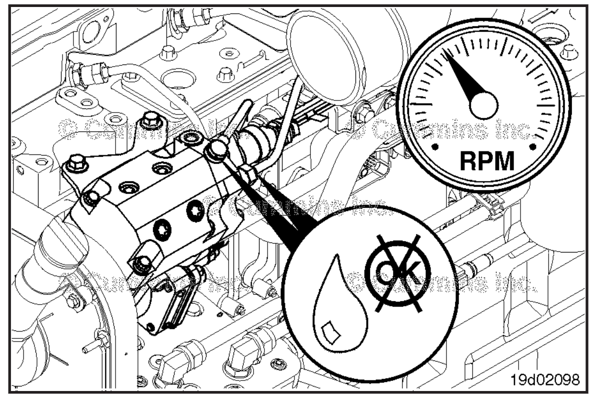
Be sure that the fuel pump actuator flange is flush with the mounting surface on the fuel pump.

Turn the fuel pump actuator in a **clockwise** direction while pressing it into the bore.

Install the capscrews.

Torque Value:	Step1	3 N•m	[27 in-lb]
	Step2	6 N•m	[50 in-lb]

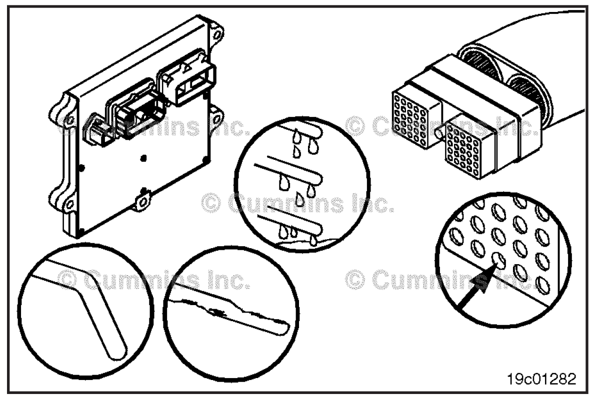
Operate the engine and check for leaks or fault codes.



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 electronic 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.



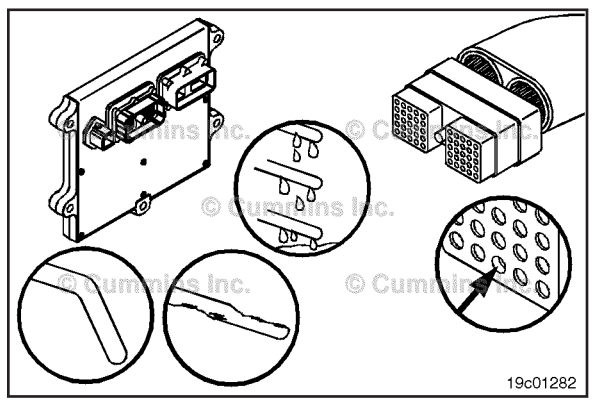
Resistance Check

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.

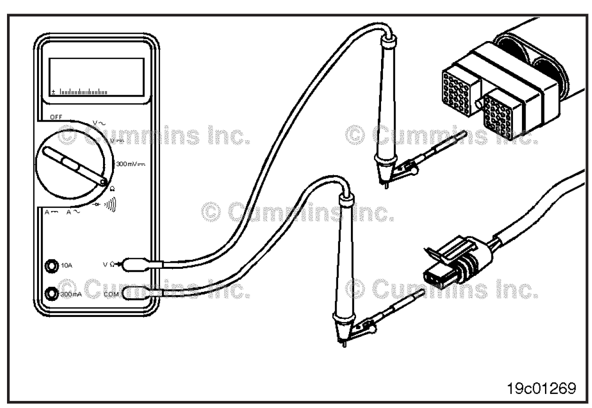


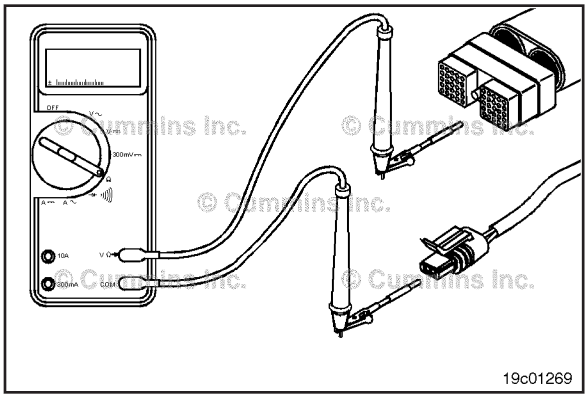
Return Wire Resistance - Checking

⚠CAUTION⚠

To reduce the possibility of pin and connector damage, use test lead, Part Number 3822758, when taking a measurement.

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.

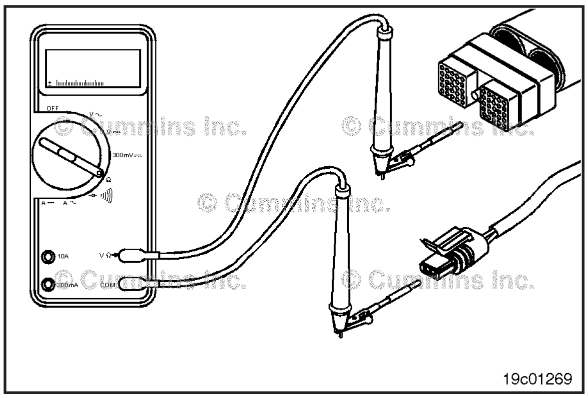




Measure the resistance.

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.



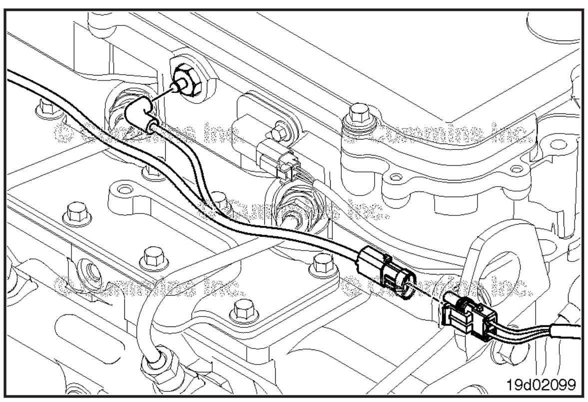
Signal Wire Resistance - Checking

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).

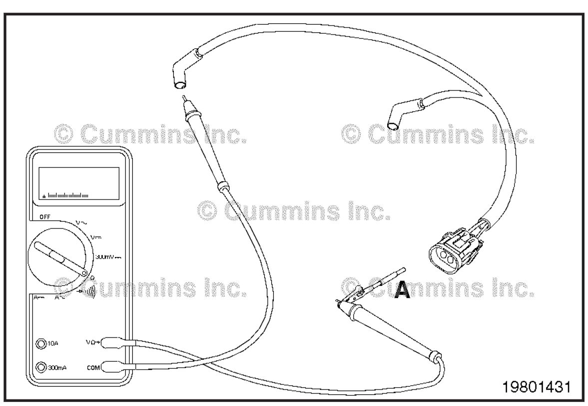
If more than 10 ohms are measured, there is an open circuit in the signal supply wire. Repair the wire, or replace the engine harness.



Engine Brake Harness (019-136)

Resistance Check

Disconnect the brake harness from the engine harness and from the rocker lever housing pass-through connectors.



Insert a test lead into pin A in the brake harness.

Insert the other test lead into the corresponding engine pass-through terminal connector in the brake harness.

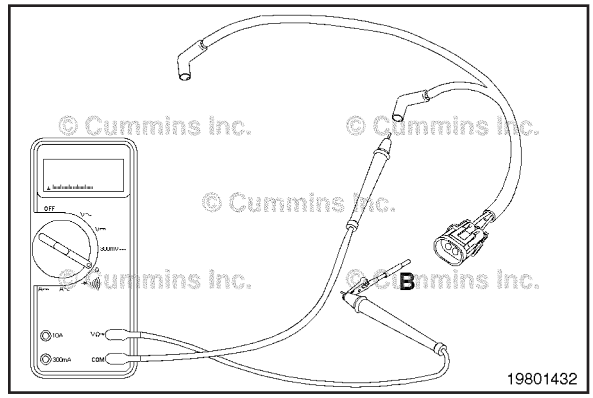
Measure the resistance. The multimeter **must** read a closed circuit (10 ohms or less).

Remove the test lead from pin A and insert it into pin B.

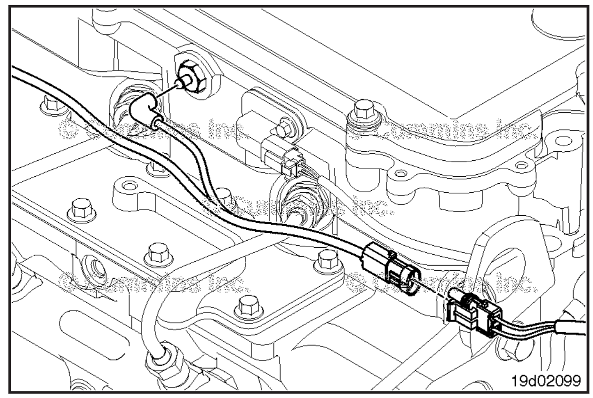
Insert the other test lead into the corresponding engine pass-through terminal connector.

Measure the resistance. The multimeter **must** read a closed circuit (10 ohms or less).

If the resistance values are **not** correct, inspect the wires for an open circuit.



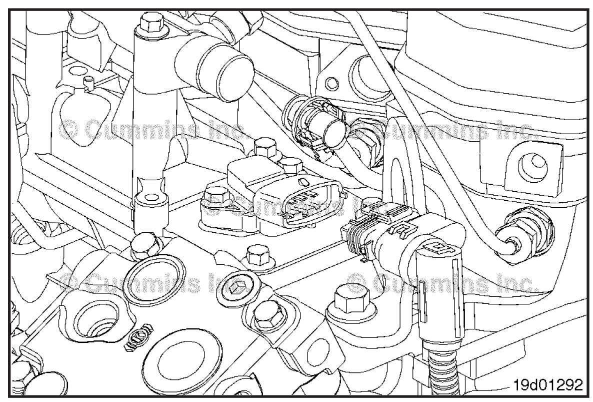
Connect the brake harness to the engine harness and the rocker lever housing pass-through connectors.



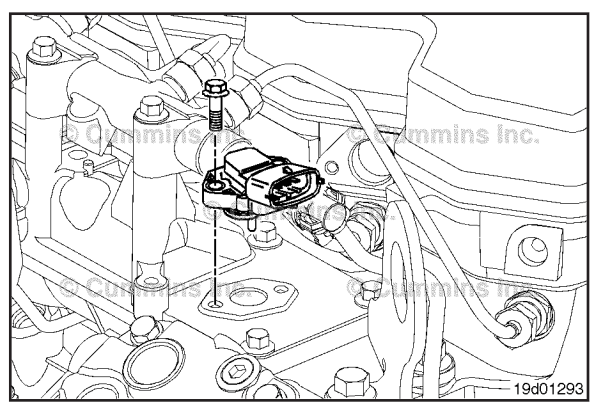
Intake Manifold Pressure/Temperature Sensor (019-159)

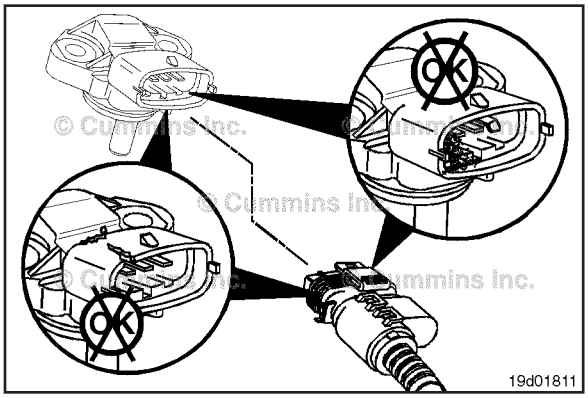
Remove

Lift up on the locking tab and pull the electrical connectors apart.



Remove the sensor from the engine.

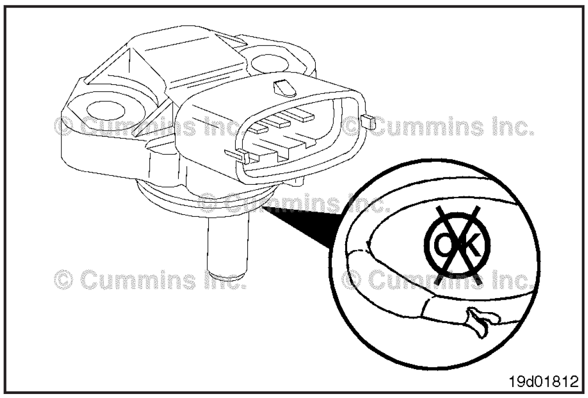




Inspect for Reuse

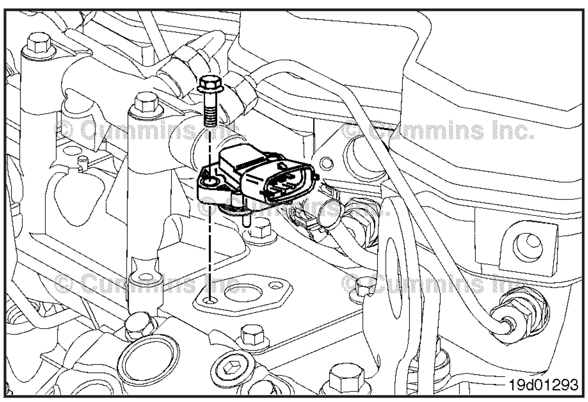
Inspect the engine harness connector and the intake manifold pressure/temperature sensor for the following:

1. Cracked or broken connector shell
2. Missing or damaged connector seals
3. Dirt, debris, or moisture in or on the connector pins
4. Corroded, bent, broken, pushed back, or expanded pins.



Inspect the intake manifold pressure/temperature sensor for the following:

1. Swollen o-ring
2. Nicks or cuts in or on the o-ring.

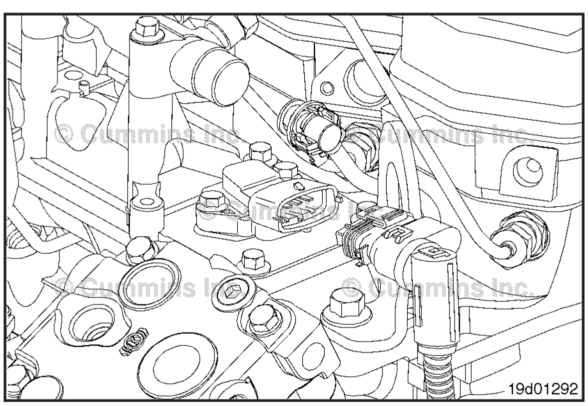


Install

Make sure the new sensor has an o-ring.

Install the new sensor into the engine. Tighten the sensor.

Torque Value: 6 N•m [53 in-lb]



Push the connectors together until they lock. An audible click will be heard as the connector locks in place.

Data Link Circuit, SAE J1939 (019-165)

General Information

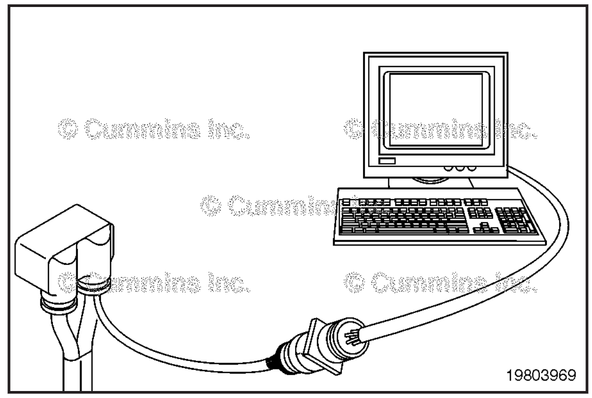
The OEM J1939 datalink circuit is located in the OEM wiring harness.

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.

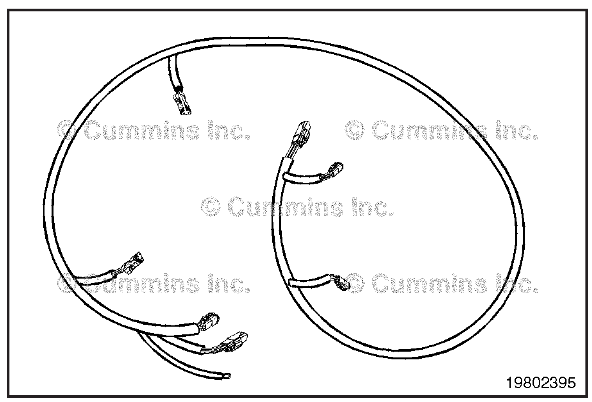
With the keyswitch in the ON position, public datalink messages will be broadcast on the OEM J1939 datalink. The broadcast will stop when the keyswitch is turned to the OFF position.



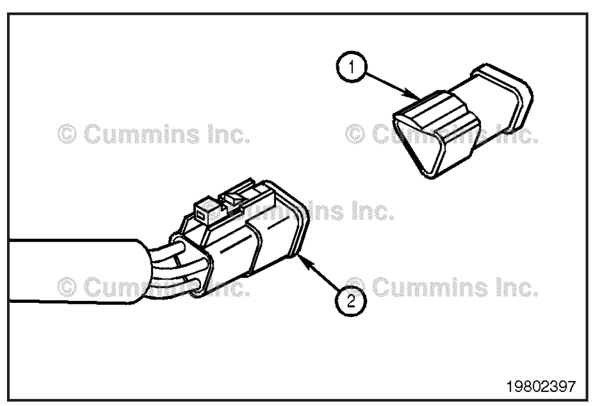
The Society of Automotive Engineers (SAE) J1939 has strict guidelines that **must** be followed for successful communication. Understanding some fundamentals about SAE J1939 will help make sure these guidelines are followed.

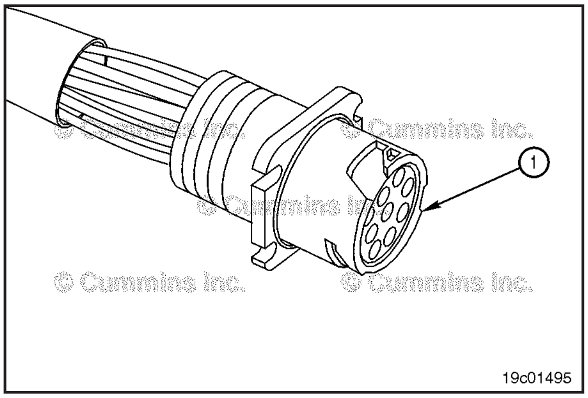
The main component of an SAE J1939 system is a backbone harness. The harness can be up to 40 meters [131 feet] in length. The backbone harness is terminated at each end with a 120 ohm resistor.

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.

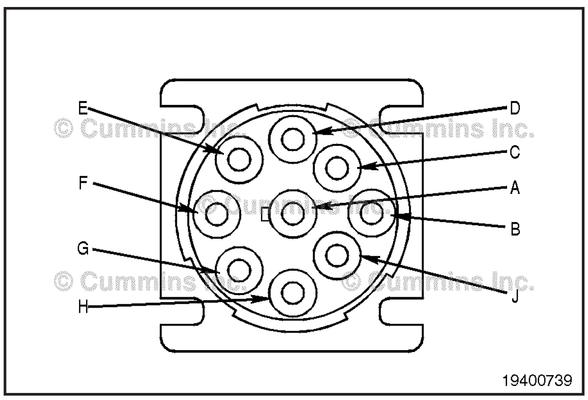
NOTE: Some OEM's place a 9-pin connector in the cab, but do **not** connect all of the pins to support J1939 protocol.

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.

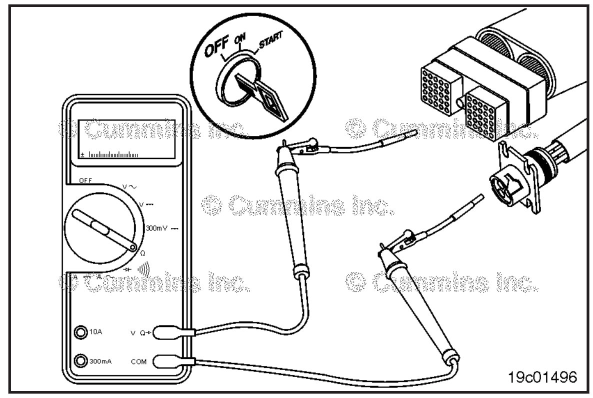
If the OEM does **not** supply the J1939 backbone harness to the 9-pin connector, the **only** way to establish J1939 communication is through either the bench communication setup or for the Engine Control Module through the engine communication setup. Refer to Procedure 022-999.

NOTE: The typical SAE J1939 connector will be a 9-pin connector.



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.

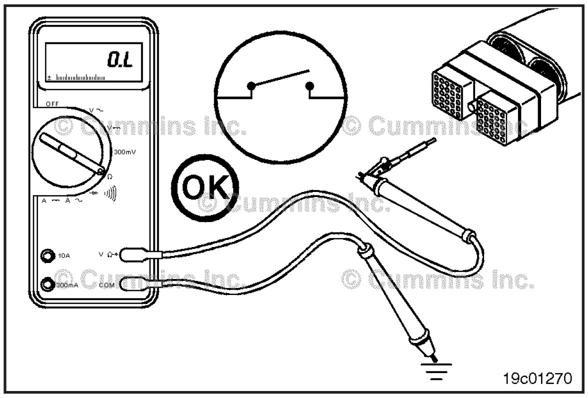
If the shield pin is provided, measure the resistance from the SAE J1939 datalink (shield) pin of the OEM harness connector to the SAE J1939 datalink (shield) pin of the 9-pin Deutsch™ connector.

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.

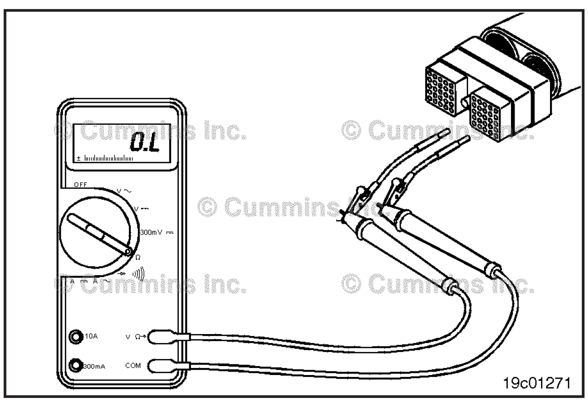
Disconnect the OEM harness connector from the ECU. Insert a test lead into the SAE J1939 datalink positive (+) pin of the OEM harness connector and connect it to a multimeter probe. Touch the other multimeter probe to the engine block or chassis ground.

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.

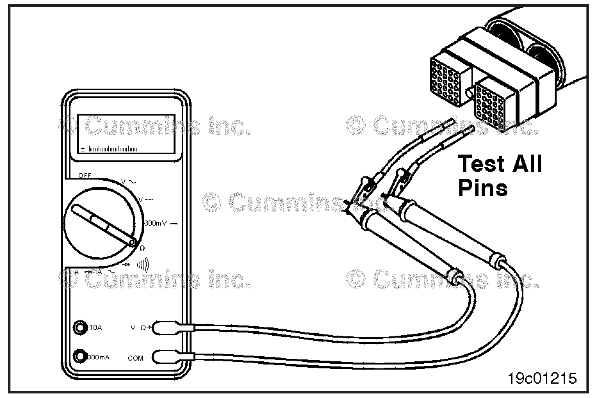
Insert a test lead into the SAE J1939 datalink positive (+) pin of the OEM harness connector and connect it to the multimeter probe. Insert the other test lead into another pin in the connector of the OEM harness and connect it to the other multimeter probe.

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.

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.



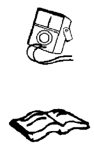
Remove the test lead from the J1939 datalink positive (+) pin and insert it into the J1939 datalink (shield) pin of the OEM harness connector, if the shield pin is available

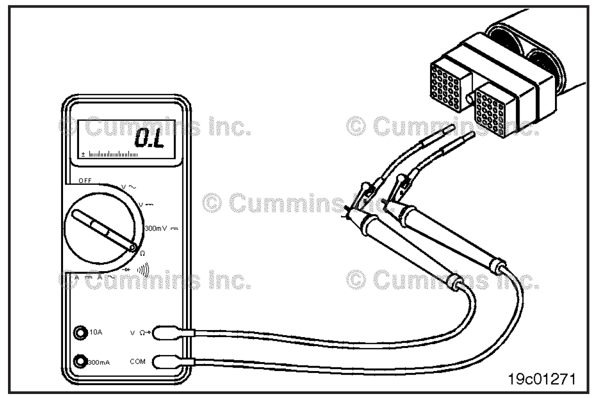
NOTE: If the J1939 datalink circuit is an unshielded twisted pair (UTP), the (shield) pin will **not** be provided. If the shield pin is **not** provided, the datalink negative (-) pin **must** still be checked for a short circuit to the other pins.

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).

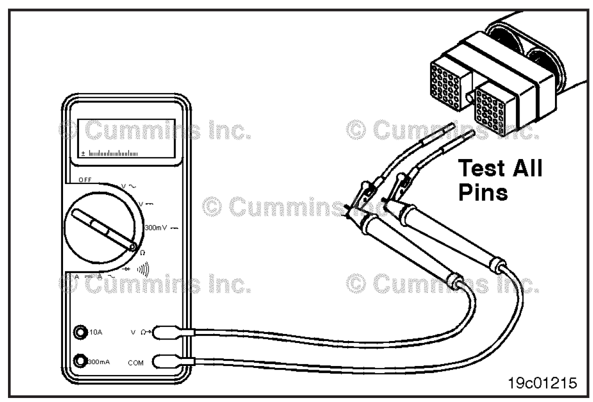
If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.





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).

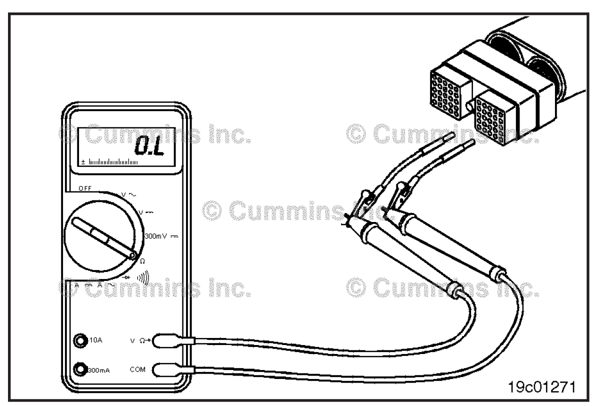
If the circuit is **not** open, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

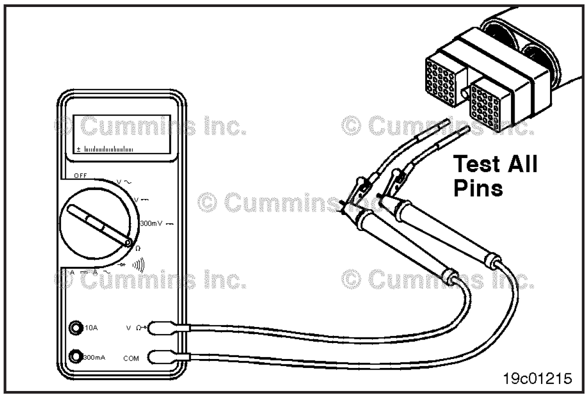


Remove the test lead from the SAE J1939 datalink (shield) pin and insert it into the SAE J1939 datalink negative (-) pin of the OEM harness connector. Insert the other test lead into another pin in the connector. Measure the resistance.

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.

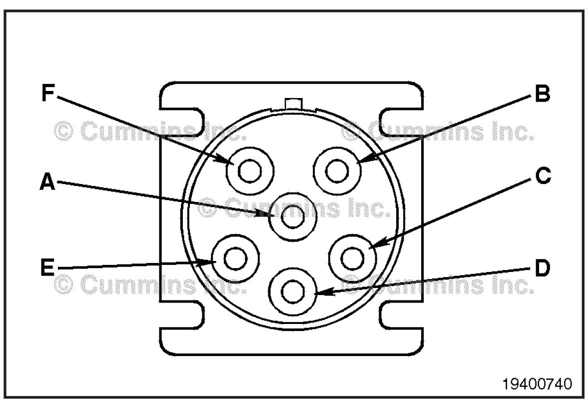
Data Link Circuit, SAE J1587 (019-166)

General Information

The OEM J1587 datalink circuit is located in the OEM wiring harness.

The purpose of this datalink is to allow the ECM to communicate to the vehicle control operated systems such as the transmission controllers, traction control system, etc. The J1587 datalink includes the Society of Automotive Engineers (SAE J1587) datalink positive (+) and the SAE J1587 datalink negative (-) wires in the OEM wiring harness.

NOTE: Typical SAE J1587 connectors will either be 2 or 6-pin connectors.



6-Pin Connector	
Position A	Datalink positive (+)
Position B	Datalink negative (-)
Position C	Battery (12/24 VDC)
Position D	Open
Position E	Engine block ground
Position F	**Not** used

Resistance Check

CAUTION

The leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

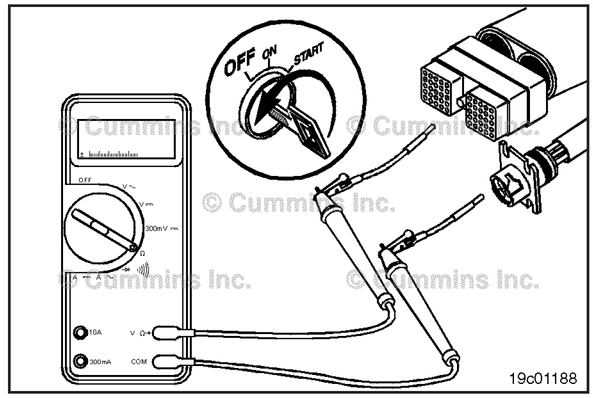
Turn the keyswitch to the OFF position. Disconnect the OEM harness connector from the ECM.

Insert a test lead into the SAE J1587 datalink positive (+) pin of the OEM harness connector and connect to a multimeter probe. Insert the other test lead into the SAE J1587 datalink positive (+) pin of the 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 OEM harness. Refer to the OEM troubleshooting and repair manual.

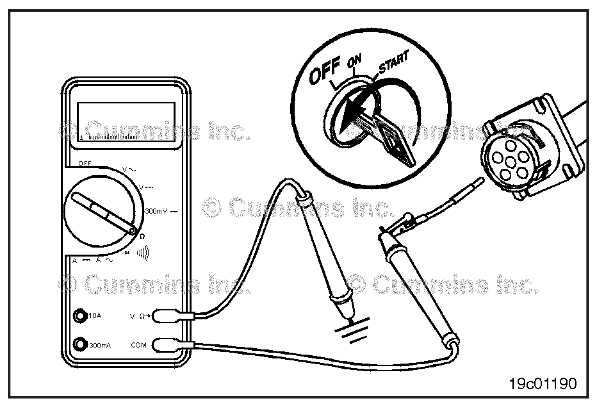
Remove the test lead from the SAE J1587 datalink positive (+) pin and insert it into the SAE J1587 datalink negative (-) pin. Remove the other test lead from the SAE J1587 datalink positive (+) pin and insert it into the SAE J1587 datalink negative (-) pin of the 6-pin connector. Measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).

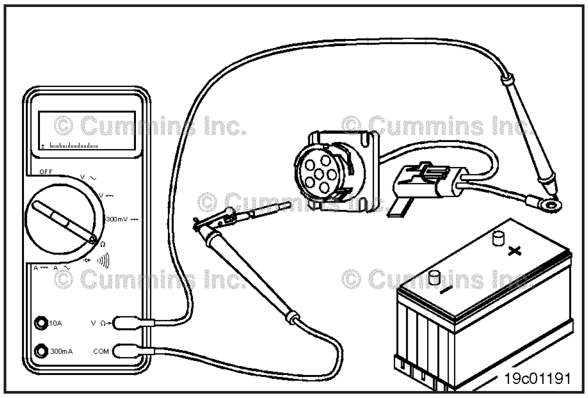
If the circuit is **not** closed, repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

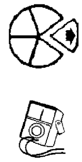


Remove the test lead from the SAE J1587 datalink negative (-) pin and insert it into the battery negative (-) pin of the 6-pin Deutsch connector. Remove the test lead from the SAE J1587 datalink negative (-) pin and disconnect it from the multimeter probe. Touch the multimeter probe to the engine block ground. 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.







⚠WARNING⚠

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the 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 leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

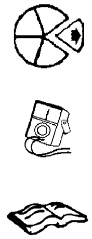
Disconnect the batteries.

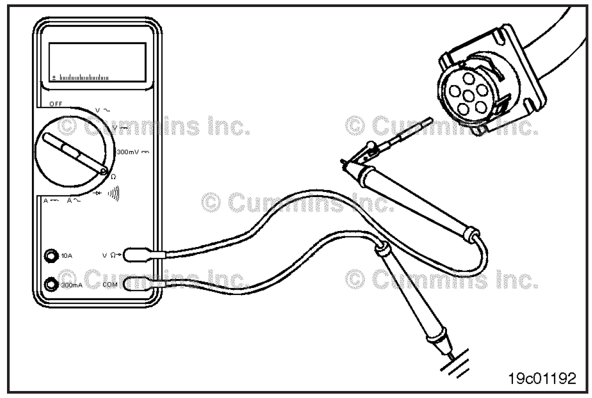
Measure the resistance from the positive (+) battery terminal to battery positive (+) of the 6-pin Deutsch connector. The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, repair or replace the OEM battery supply circuit. 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.

Check for Short Circuit to Ground





WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the 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 leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

Disconnect the batteries.

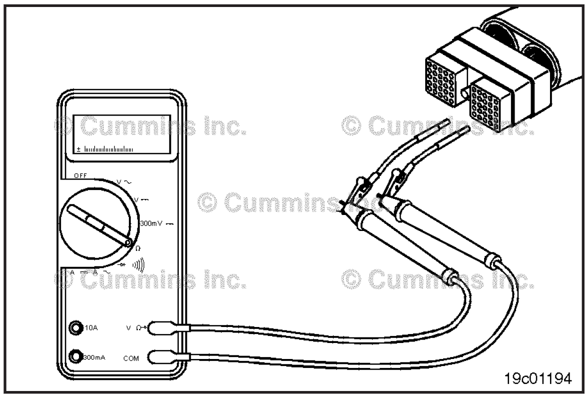
Disconnect the OEM harness connector from the ECM.

Insert a test lead into the SAE J1587 datalink positive (+) pin of the 6-pin 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 OEM harness. Refer to the OEM troubleshooting and repair manual.

Remove the test lead from the SAE J1587 datalink positive (+) pin and insert it into the SAE J1587 datalink negative (-) pin of the 6-pin connector. Touch the other multimeter probe to the engine block ground. Measure the resistance from the SAE J1587 datalink negative (-) pin of the 6-pin 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 OEM harness. Refer to the OEM troubleshooting and repair manual.



Check for Short Circuit from Pin to Pin

CAUTION

The leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

Disconnect the OEM harness connector from the ECM.

Insert a test lead into the SAE J1587 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 OEM harness and connect it to the other 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 OEM harness. Refer to the OEM troubleshooting and repair manual.

Measure the resistance from the SAE J1587 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).

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 J1587 datalink positive (+) pin of the OEM harness connector and insert it into the SAE J1587 datalink negative (-) pin. Measure the resistance from the SAE J1587 datalink 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 OEM harness. Refer to the OEM troubleshooting and repair manual.

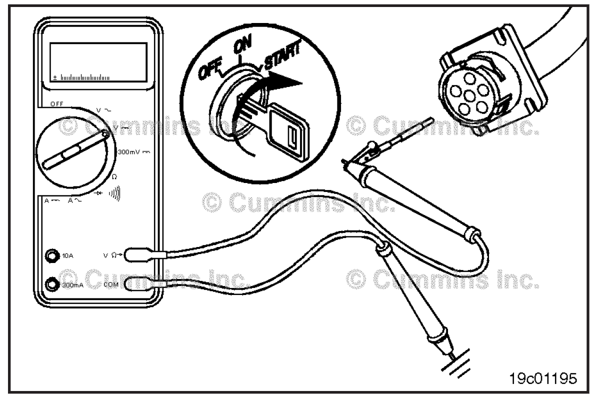
Connect all components after repairs are completed.

Voltage Check

Locate the datalink connector on the OEM harness. The location will depend on the OEM.

⚠CAUTION⚠

The leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.



Turn the keyswitch to the ON position. Adjust the multimeter to measure VDC.

Insert a test lead into the SAE J1587 datalink positive (+) pin of the 6-pin connector and connect it to a multimeter probe. Touch the other multimeter probe to the engine block ground. Measure the voltage.

The multimeter **must** read 3.5 to 5 VDC for the voltage check from the SAE J1587 datalink positive (+) pin of the datalink connector to ground.

Remove the test lead from the SAE J1587 datalink positive (+) pin and insert it into the SAE J1587 datalink negative (-) pin of the 6-pin Deutsch connector. Touch the other multimeter probe to the engine block ground. Measure the voltage.

The multimeter **must** read 0 to 2.5 VDC for the voltage check from the SAE J1587 datalink negative (-) pin of the datalink connector to ground.

Remove the test lead from the SAE J1587 datalink negative (-) pin and insert it into battery positive (+) pin of the 6-pin connector. Touch the other multimeter probe to the engine block ground. Measure the voltage.

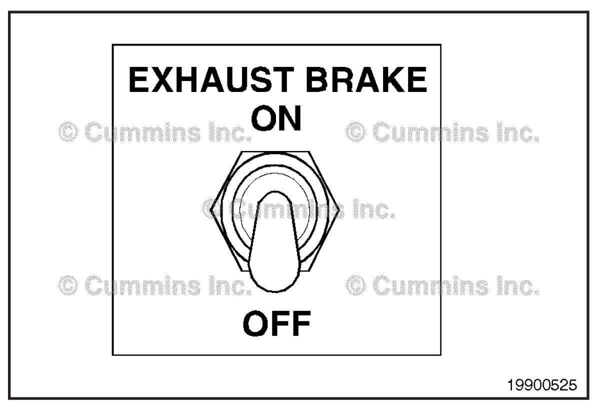
The multimeter **must** read battery voltage for the voltage check from pin C of the datalink connector to ground.

Remove the test lead from the battery positive (+) pin and insert it into the battery negative (-) pin of the 6-pin connector. Touch the other multimeter probe to the engine block ground. Measure the voltage.

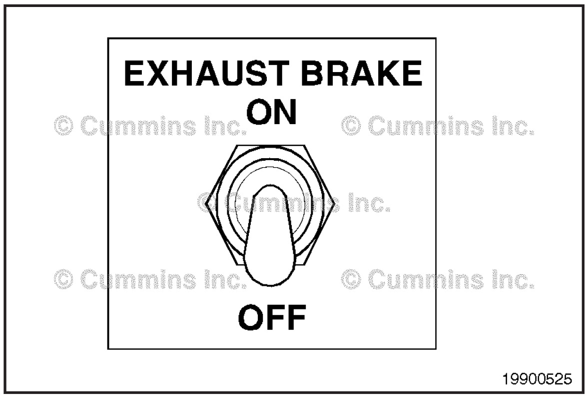
The multimeter **must** read 0 voltage for the voltage check from the battery negative (-) pin of the datalink connector to ground.

Exhaust Brake ON/OFF Switch (019-193)

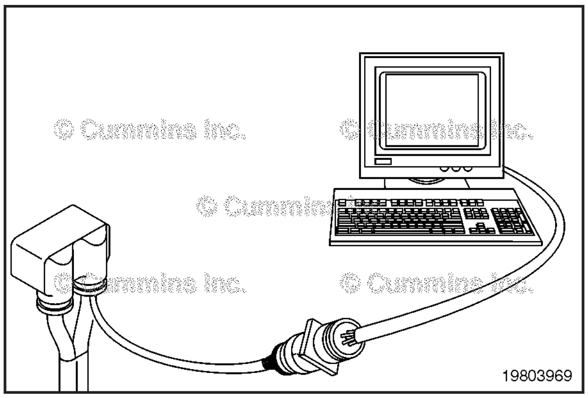
General Information



The exhaust brake on/off switch circuit signals the system that the operator is requesting the exhaust brake system to be activated.



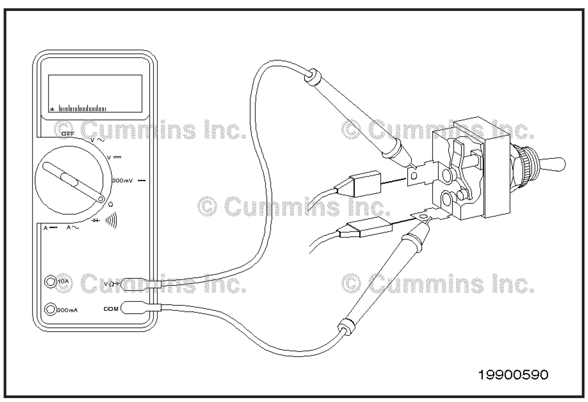
After the ECM receives the signal from the exhaust brake on/off switch, the ECM will supply 12 VDC to the exhaust brake signal pin in the engine harness, provided the engine speed is **not** below 1000 rpm and the driver is **not** in cruise control or depressing the accelerator or clutch pedals.



Resistance Check

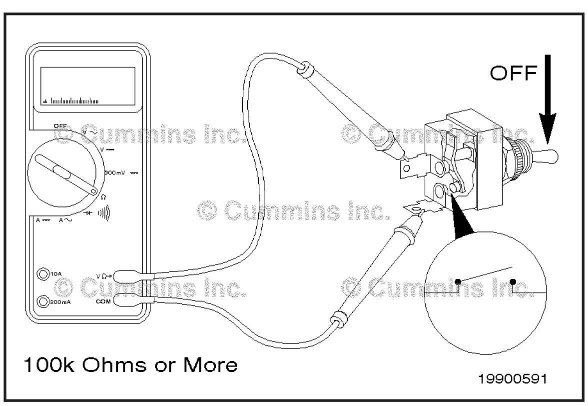
If INSITE™ electronic service tool is available, monitor the exhaust brake select switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

Label the wires with the location on the switch or the wire number. Remove the electrical connectors from the switch.



Set the multimeter to measure resistance.

Touch one multimeter probe to the center terminal of the switch. Touch the other multimeter probe to the bottom terminal of the switch.



Set the switch to the OFF position.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Replace the switch.

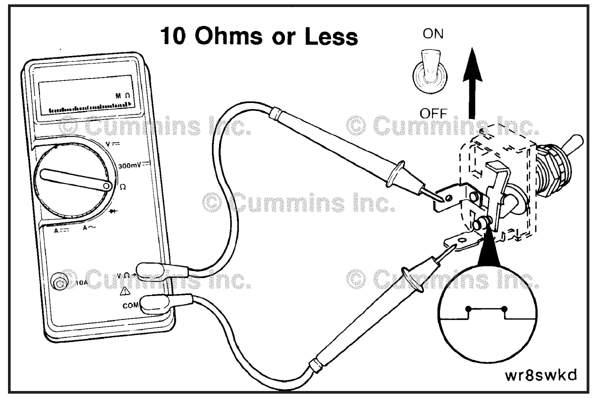
Refer to the OEM repair manual for replacement instructions.

Set the switch to the ON position.

The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

Refer to the OEM troubleshooting and repair manual for replacement instructions.



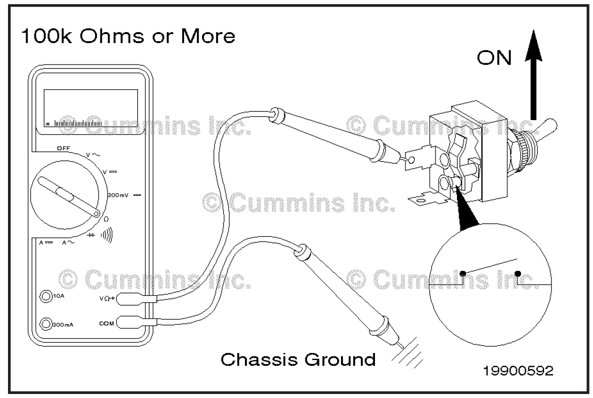
Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position, and measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Replace the switch. Refer to the OEM troubleshooting and repair manual for replacement instructions.

If the switch passes all of the previous checks, the circuit **must** be checked for open circuits, short circuits to ground, short circuits from pin to pin, and short circuits to an external voltage source.



Exhaust Brake ON/OFF Switch Circuit (019-194)

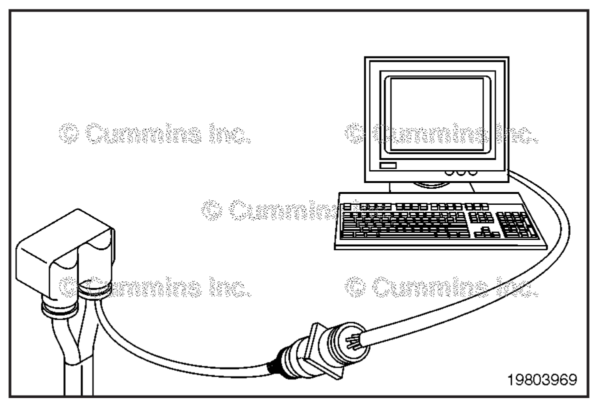
Resistance Check

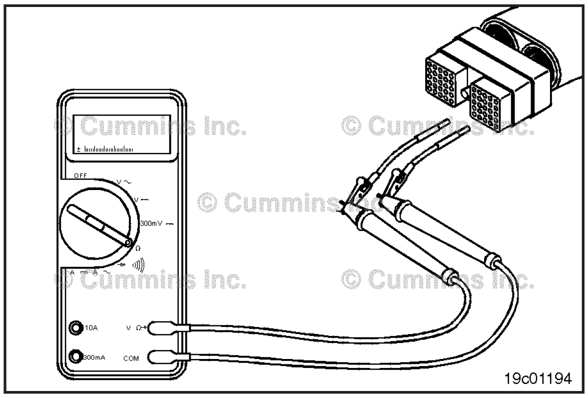
⚠CAUTION⚠

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If INSITE™ electronic service tool is available, monitor the exhaust brake switch circuit for proper operation.

If **not**, follow the troubleshooting procedures in this section.

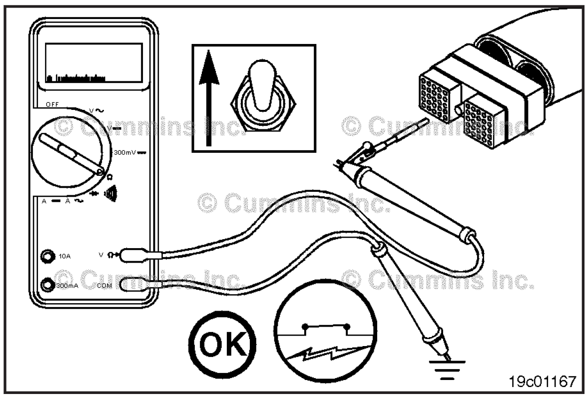




Disconnect the OEM harness from the ECM connector.

Insert the appropriate test lead into exhaust brake ON/OFF switch input pin of the OEM harness connector.

Insert the other appropriate test lead into switch return pin of the connector.

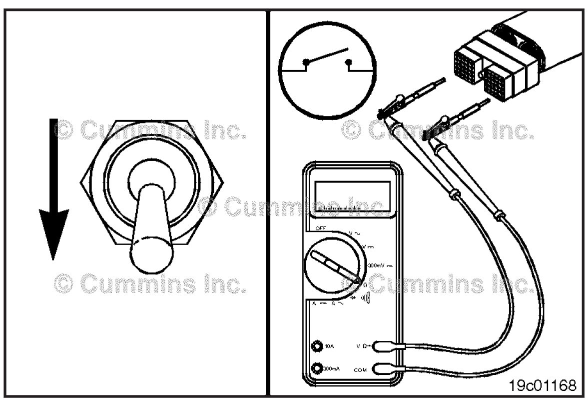


Set the exhaust brake switch to the ON position.

The multimeter **must** show a closed circuit (10 ohms or less).

Set the exhaust brake switch to the OFF position.

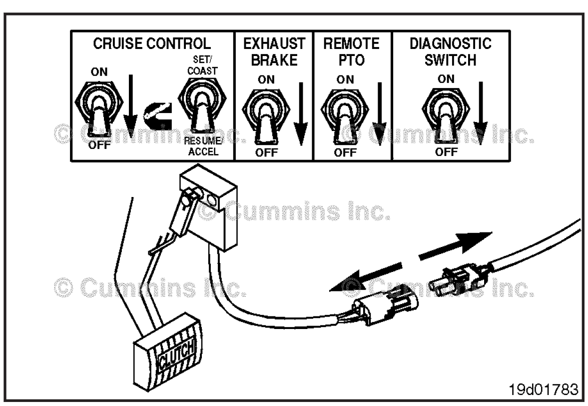
The multimeter **must** show an open circuit (100k ohms or more).



If the resistance values are **not** correct, make sure exhaust brake ON/OFF switch input pin and the battery positive (+) bus to switch return pin are properly installed on the switch.

If both wires are correctly installed, inspect exhaust brake ON/OFF switch input pin and the battery positive (+) bus to switch return pin for open circuits to ground and short circuits to other pins, provided the switch has been previously checked.

If the resistance values are correct in the previous checks, exhaust brake ON/OFF switch input pin and switch return pin **must** still be checked for short circuits to ground and short circuits from pin-to-pin.

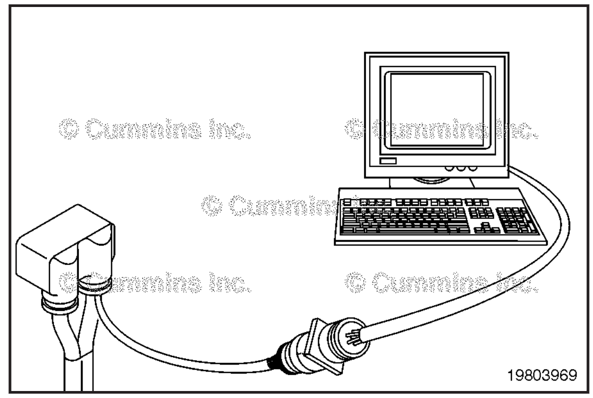


Check for Short Circuit to Ground

To isolate the exhaust brake circuit when checking for an electrical short, turn all cab switches to the OFF or NEUTRAL position.

If INSITE™ electronic service tool is available, monitor the engine brake ON/OFF switch circuit for proper operation.

If **not**, follow the troubleshooting procedures in this section.



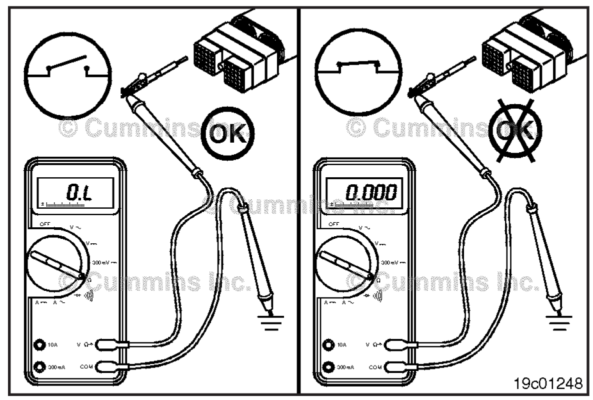
Disconnect the OEM harness from the ECM connector.

Insert the appropriate test lead into exhaust brake ON/OFF switch input pin of the OEM harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the resistance value is **not** correct, there is a short circuit to ground in the harness.

Repair or replace the OEM harness. Refer to Procedure 019-071.

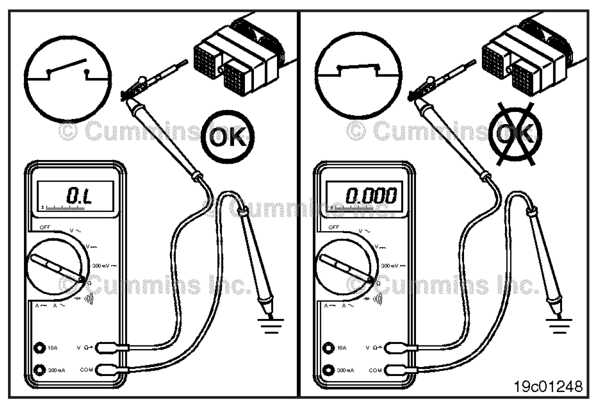


Touch one multimeter probe to the engine block. Insert the other multimeter probe with attached appropriate test lead into switch return pin of the OEM harness connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).

If the resistance value is **not** correct, there is a short circuit to ground in the harness. Repair or replace the OEM harness. Refer to Procedure 019-071.

If the resistance value is correct in the previous checks, the exhaust brake ON/OFF switch input pin **must** still be checked for short circuits from pin-to-pin.



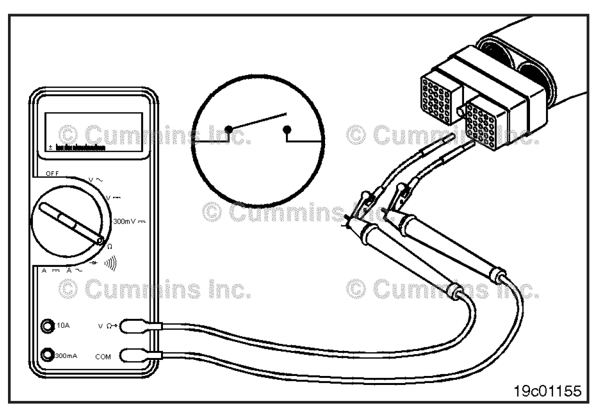
Check for Short Circuit from Pin to Pin

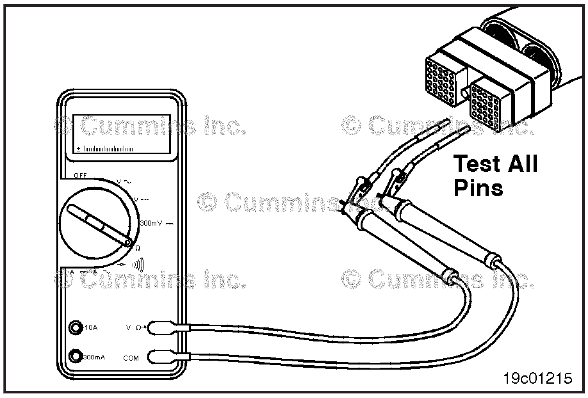
Isolate the switch circuit as in the previous section.

Insert the appropriate test lead into exhaust brake ON/OFF switch input pin of the OEM harness connector.

Insert the other appropriate test lead into pin 1 of the connector. Connect the alligator clips to the multimeter probes. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more).



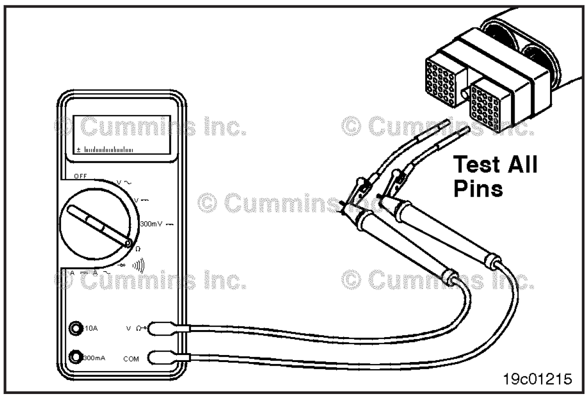


Remove the lead and check all other pins.

The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit between the wire connected to exhaust brake ON/OFF switch input pin and any pin that measured less than 100k ohms.

Repair or replace the OEM harness. Refer to (Procedure Refer to Procedure 019-071).



Insert the test lead into switch return pin of the OEM harness connector. Check all pins of the harness connector. Measure the resistance.

The multimeter **must** show an open circuit (100k ohms or more) at all pins.

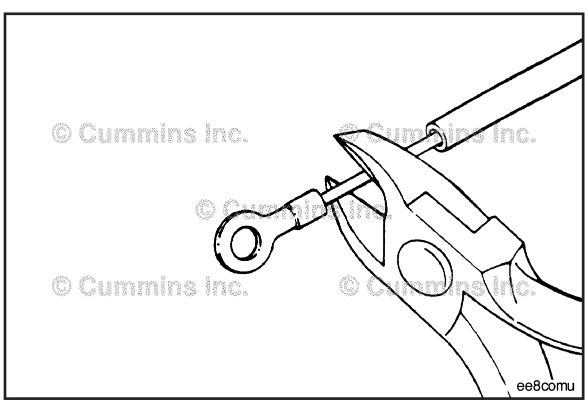
If the circuit is **not** open, there is a short circuit to ground in the positive switch supply bus, provided the switch has been previously checked.

Repair or replace the wiring connected to switch return pin in the OEM harness. Refer to Procedure 019-071.

Ring Terminal (019-197)

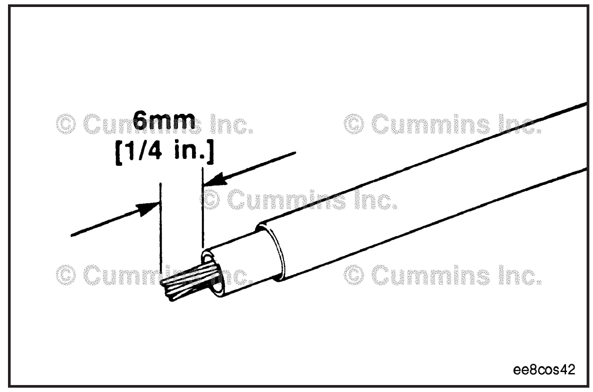
Connector Replacement

Terminals are used for various connections including grounds and fuel shutoff valve supply.



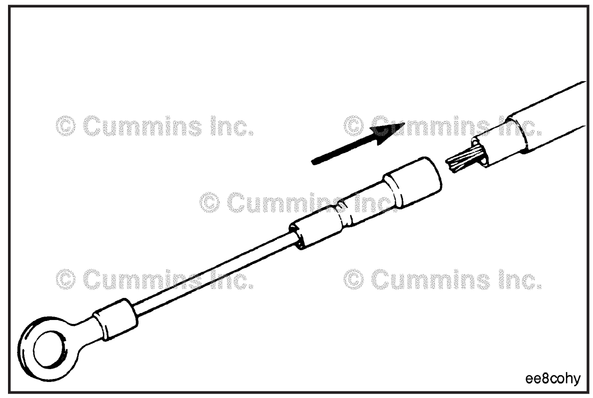
Use wire crimp tool, Part Number 3822930, to cut and remove the ring terminal connector as shown.

Use wire crimp tool, Part Number 3822930, to remove 6 mm [1/4 in] of insulation from the harness wire.



Install the proper-size ring terminal on the bare wire. The ring terminals that are included in the wiring repair kit, Part Number 3164572, are as follows:

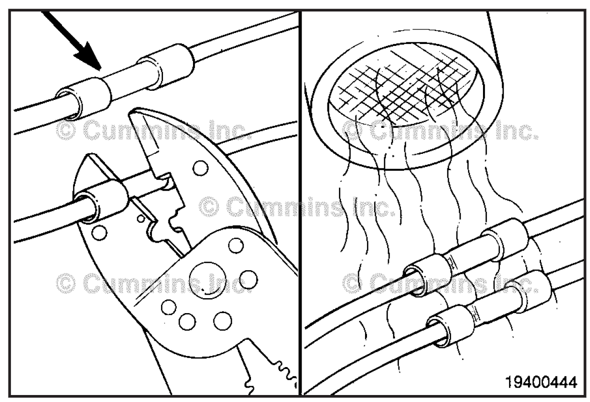
Ring Terminal Size	Part No.
No. 10	3823760
1/2 inch	3823761



⚠CAUTION⚠
Only use wire crimping pliers, Part Number 3822930, when repairing electrical terminals.

Crimp the repair wire on the bare wire.

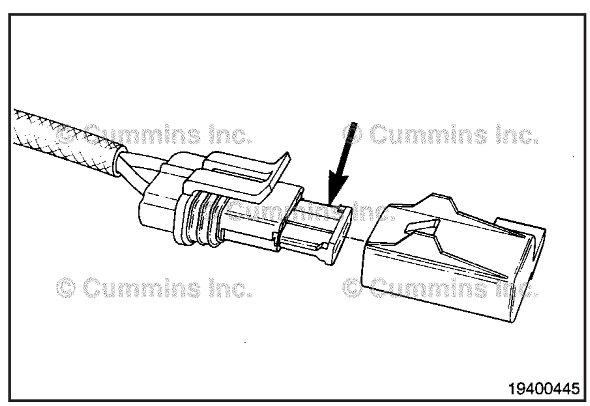
Use a heat gun, Part Number 3822860, or open flame to heat the shrink tubing. The tubing will shrink and make the connection waterproof.

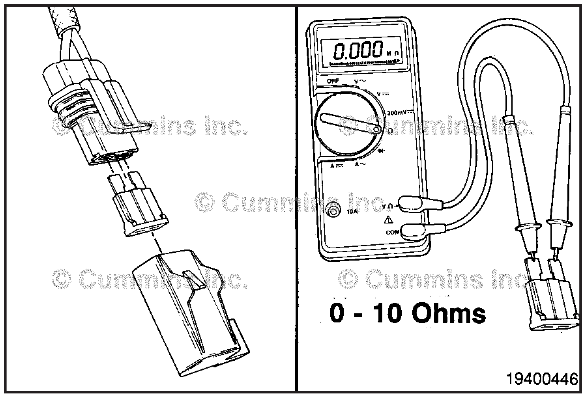


Fuse, Harness In-Line (019-198)

Inspect

Remove the fuse protective covers from the fuse(s) that are being checked. Check to make sure the fuse is installed in the fuse holder correctly.



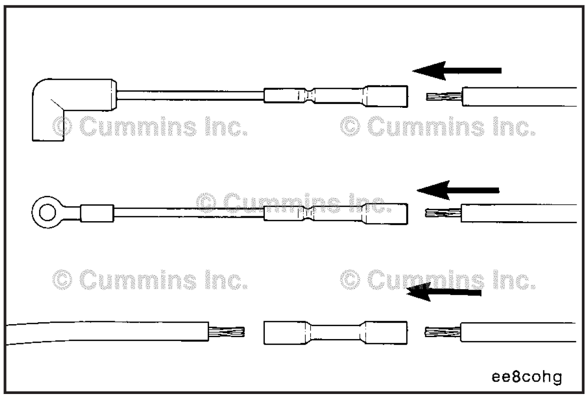


If the fuse is installed correctly, check for a blown fuse.

Remove the fuse(s) to be checked.

Touch each one of the multimeter leads to each fuse terminal. Measure the resistance.

The multimeter **must** show less than 10 ohms, which is a closed circuit. If the circuit is closed then put the fuse back into the holder and connect the fuse cover.

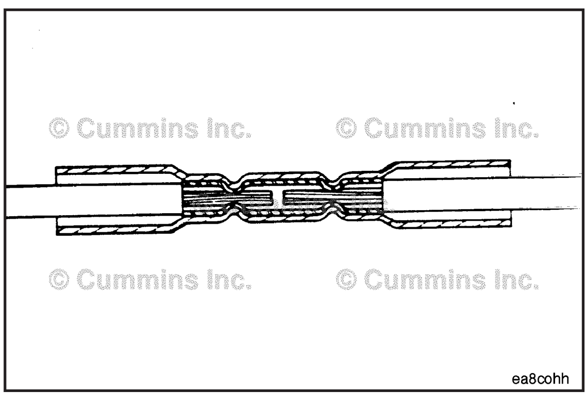


Connector, Butt Splice (019-199)

General Information

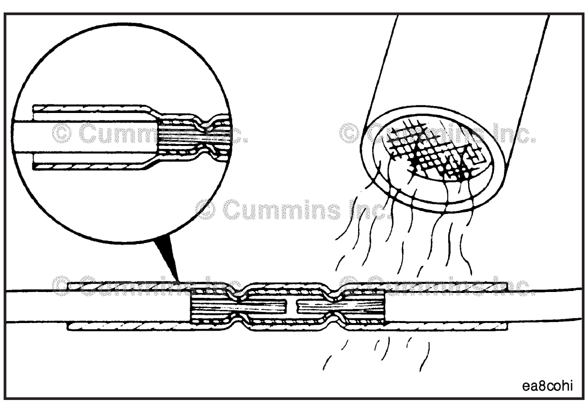
Butt splice connectors are used when repairing harnesses or damaged wires.

Only use the butt splices that are supplied with the wiring repair kit, Part Number 3164572, when repairs are necessary.



Butt splices are designed to provide the best possible cold joint connection when properly crimped.

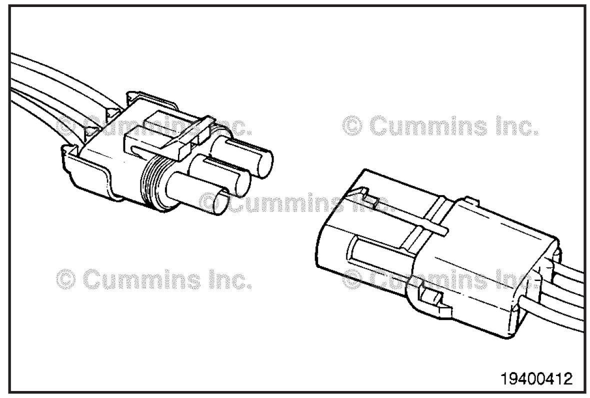
Use wire crimp tool, Part Number 3822930, supplied with the electrical wiring repair kit.



Butt splices also provide protection against corrosion. After crimping the connection, heat the shrink tube with the heat gun, Part Number 3822860, or an open flame, until the shrink tube has sealed the joint.

Weather Pak Connector Series (019-201)

Pin Replacement



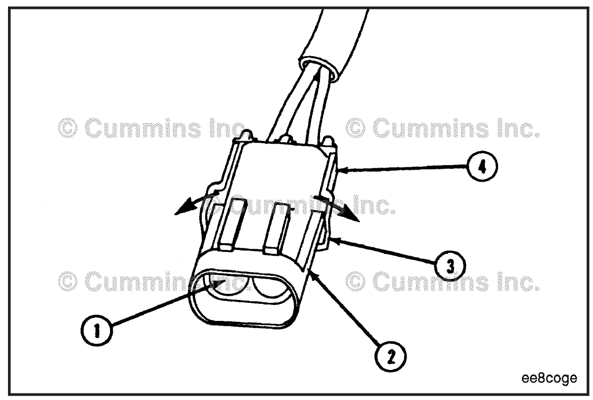
This connector is used to connect many different components to the engine, or other devices. The connector can have many different pin configurations. All types of connectors are repaired in the same manner. The two-way connector is displayed in this procedure.

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.

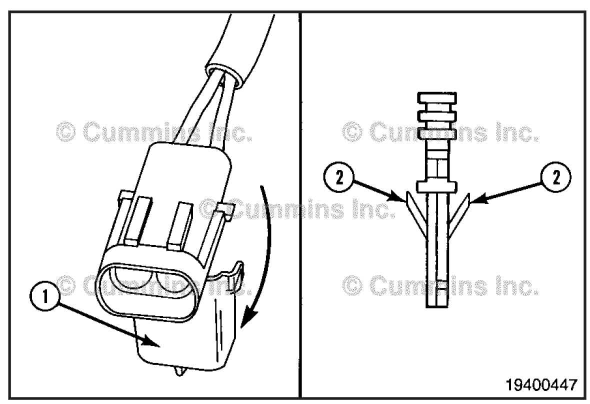
Refer to the wiring diagram in Section E for pin locations.

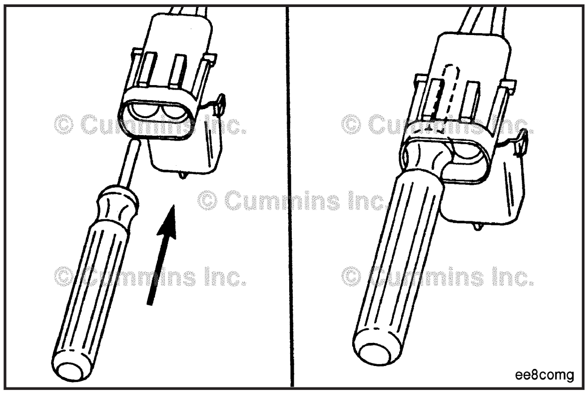
To replace the Weather-Pack terminal (1), pull the locking tabs (3) apart on the wire lock (4).



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.

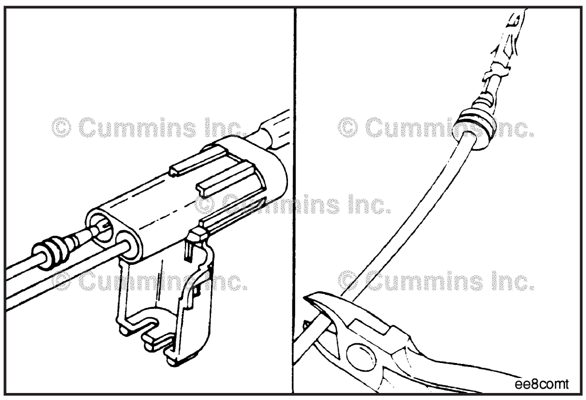




△CAUTION△

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.



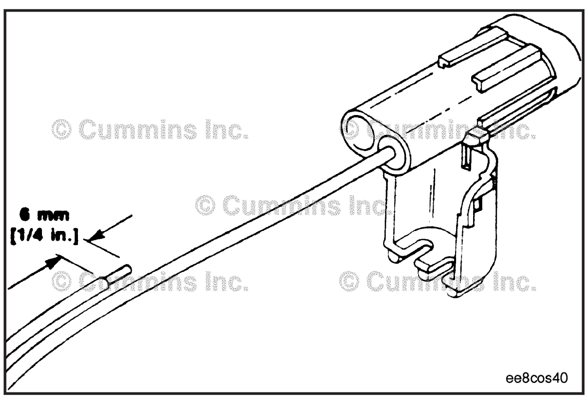
△CAUTION△

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.

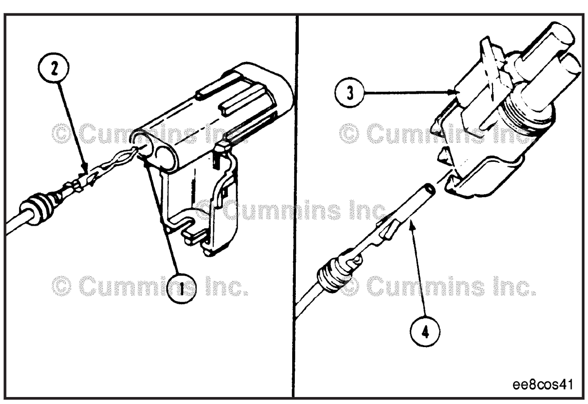
Pull the wire and the terminal out of the connector body.

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 [¼ 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).

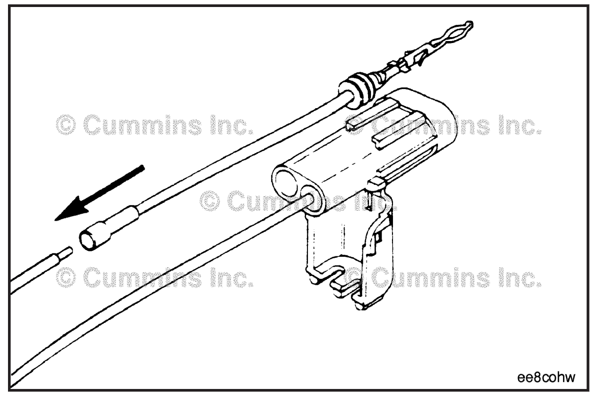
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

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.

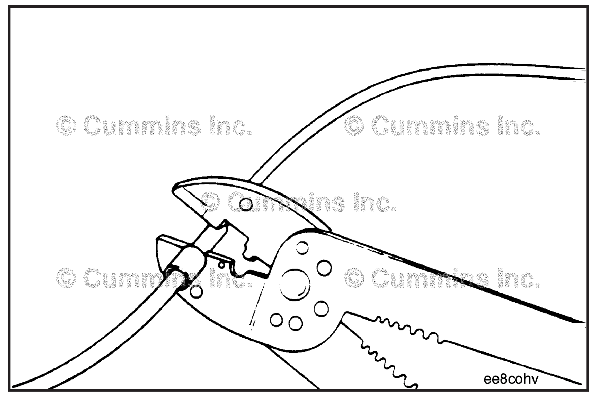
Refer to the wiring diagram in Section E for pin locations.

Install the correct repair wire on the bare wire.

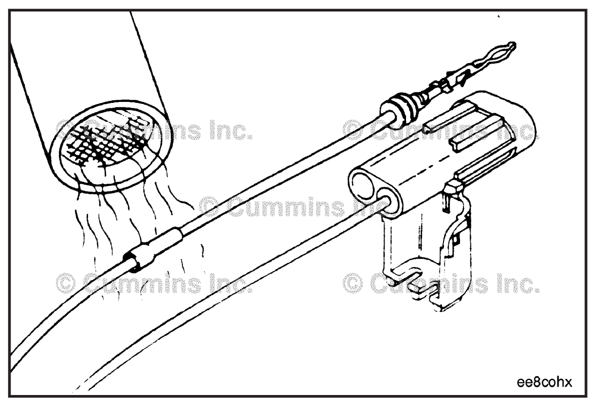
Make sure that the bare wire extends into the insulated butt splice connector.



Use wire crimping tool, Part Number 3822930, to crimp the repair wire on the bare wire.



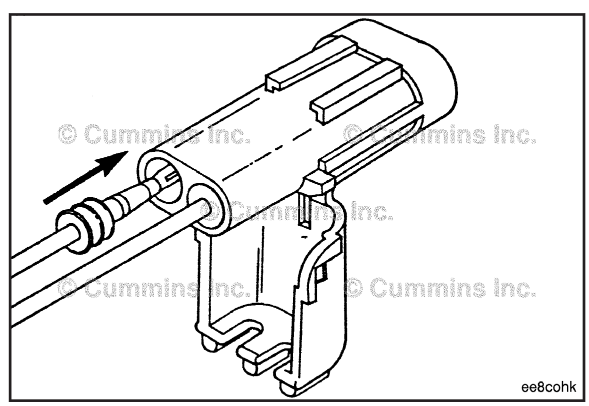
Use heat gun, Part Number 3822860, to heat the shrink tubing. The tubing will shrink and make the connection waterproof.

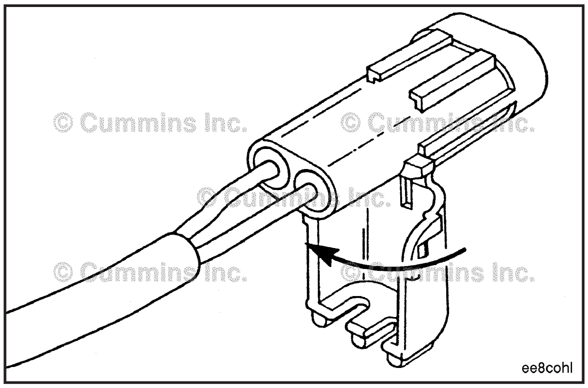


⚠CAUTION⚠

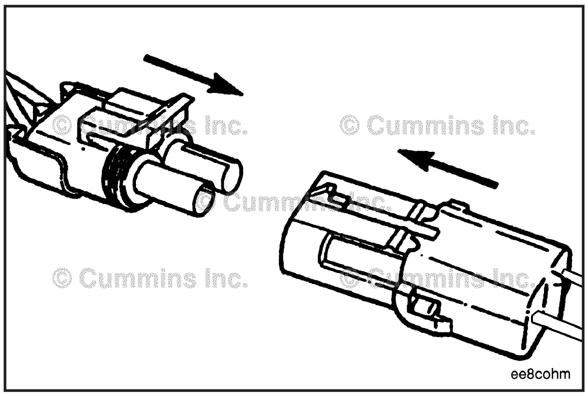
If more than one wire is repaired or if the connector body is replaced, make sure to insert the wires into the same locations as they were in. Electrical problems can occur if wires are switched.

Insert the terminal into the connector body. The terminal locking lances **must** click and hold the terminal in the body.

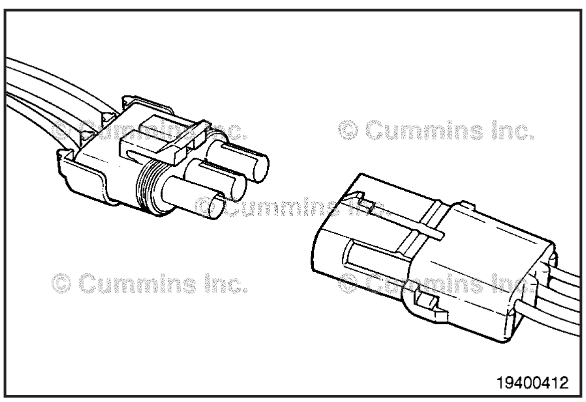




Close and latch the wire on the connector body.



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.

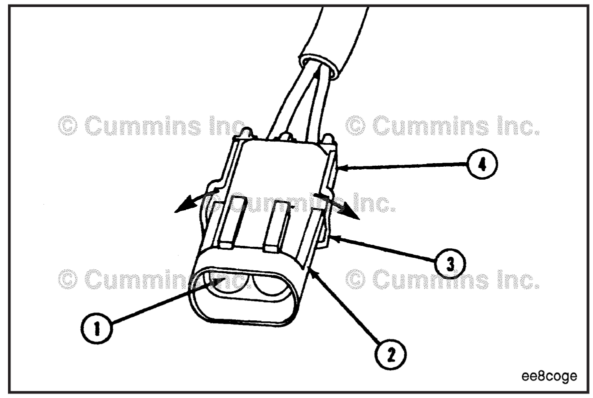
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

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.

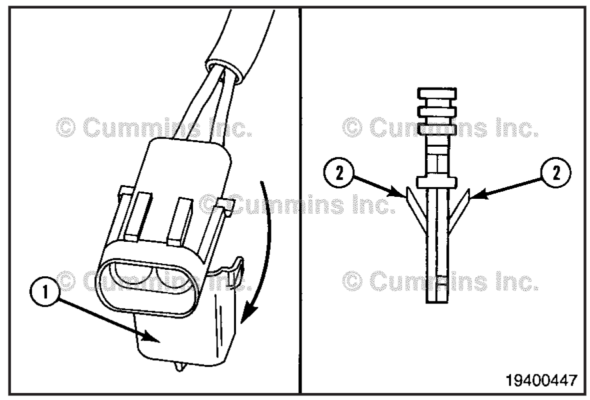
Replace one contact wire at a time. If more than one wire needs to be replaced, attach a lettered tag to each wire removed.

To replace the Weather-Pack connector body (2), pull the locking tabs (3) apart on the wire lock (4).



The wire is head in the connector body by the wire lock (1) and two locking lances (2) on the terminal.

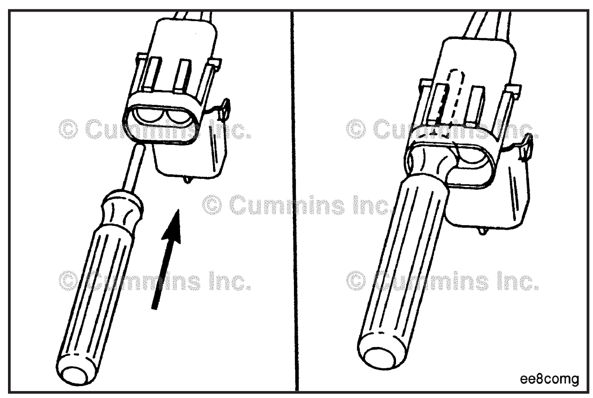
Open the wire lock.



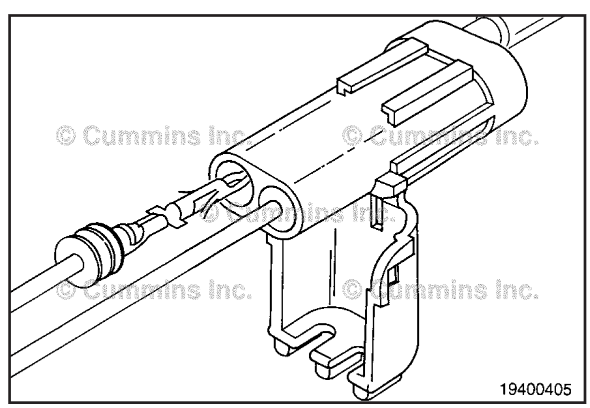
⚠CAUTION⚠

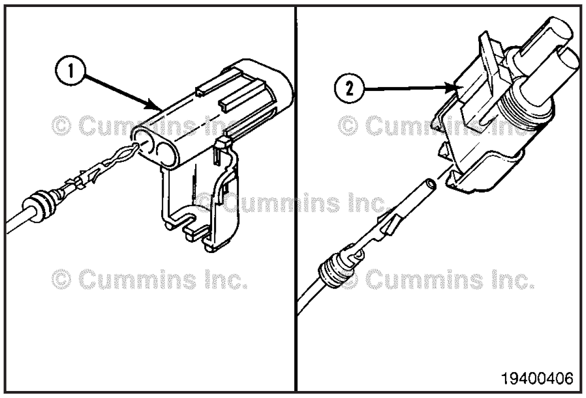
This tool can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

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.

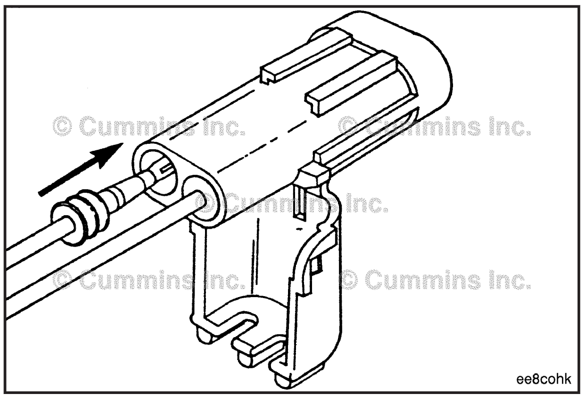




Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

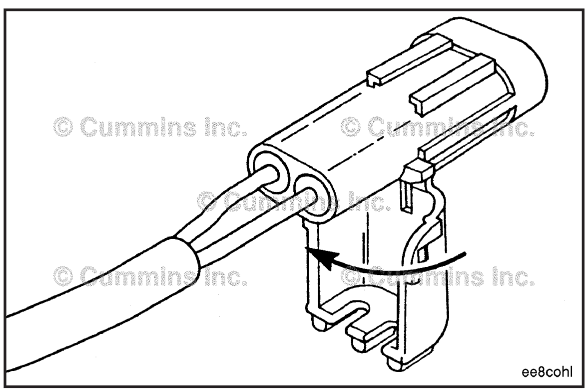
Replace one contact wire at a time. If more than one wire needs replaced, attached a lettered tag to each wire removed.



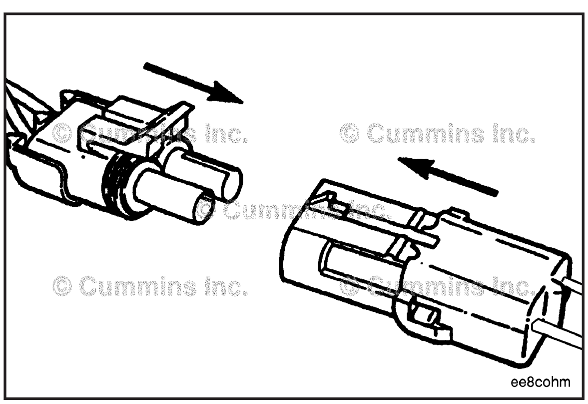
⚠CAUTION⚠

If more that 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.

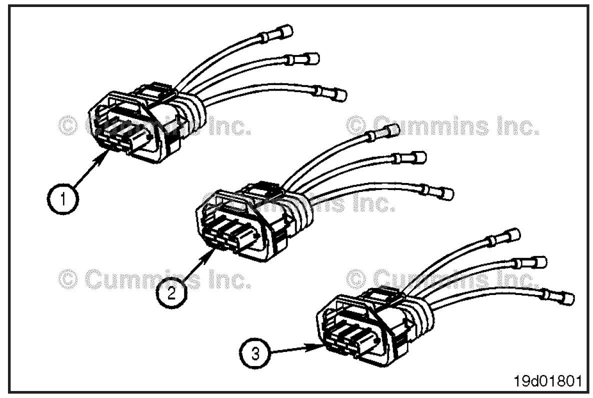


Insert the two connector halves together.

Metripack Connector Series (019-202)

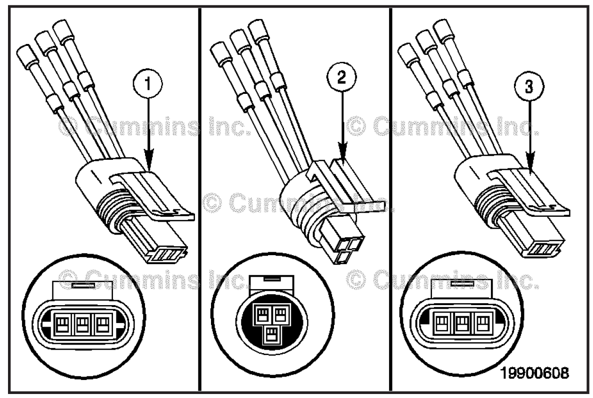
Pin Replacement

The connector can have multiple pin configurations. All types of connectors are repaired in the same manner.



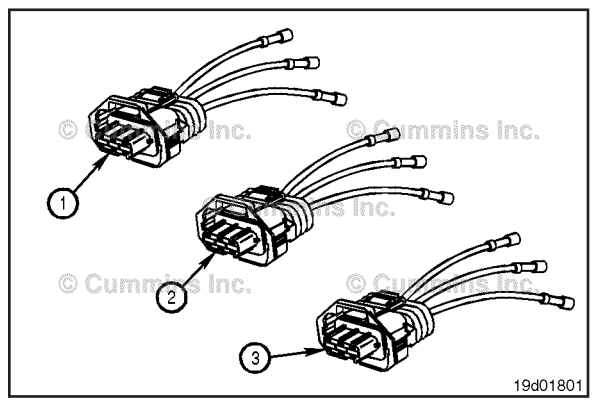
The connector pins can **not** be repaired or replaced. The connector **must** be replaced as a unit.

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.



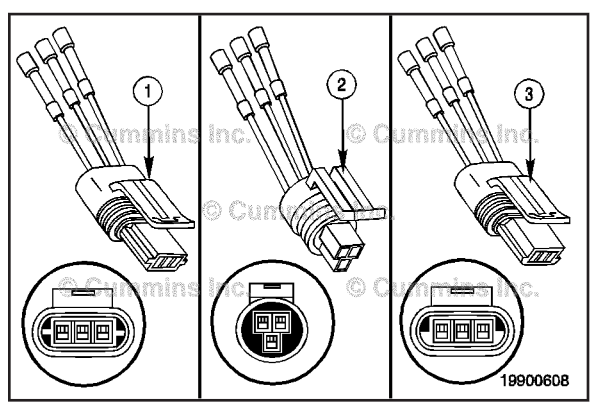
The connectors have different keying and can **not** be interchanged with each other.

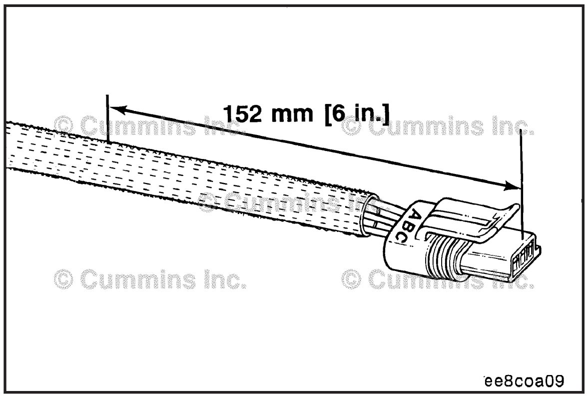
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

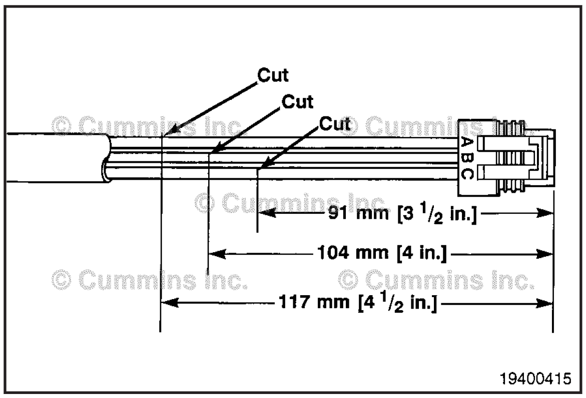
Refer to the wiring diagram in Section E for pin locations.

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.

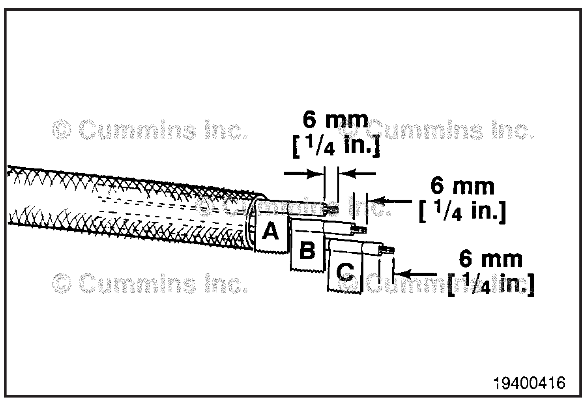


Before cutting the wires, measure and tag the wires.

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.



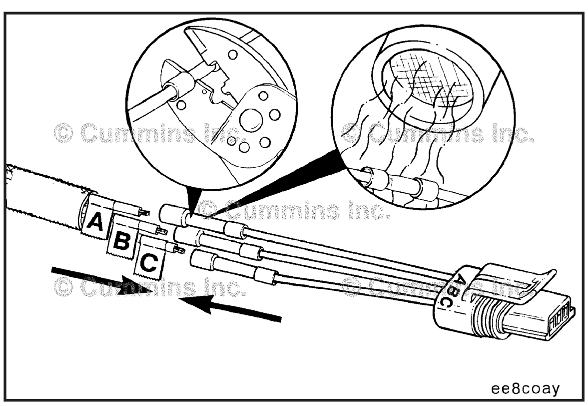
Use crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from all electrical wires.

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to Section E for pin locations.

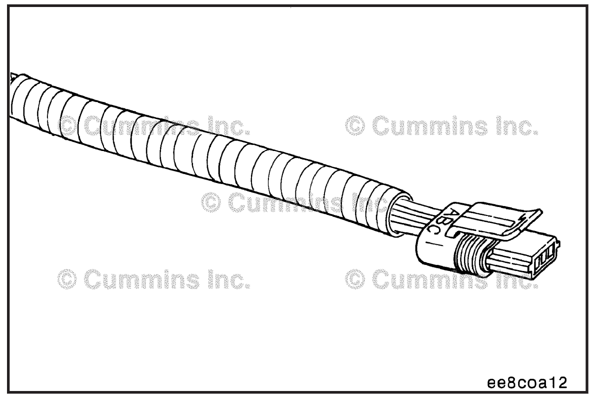
Replace one contact at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.



Install the terminal repair wires on the bare wires and use wire crimping tool, Part Number 3822930, to crimp the terminals.

Use heat gun, Part Number 3822860, to heat the shrink tubing. The tubing will shrink and make the connection waterproof.

Wrap the wires with tape, for added protection to complete the repair.



AMP Connector Series (019-203)

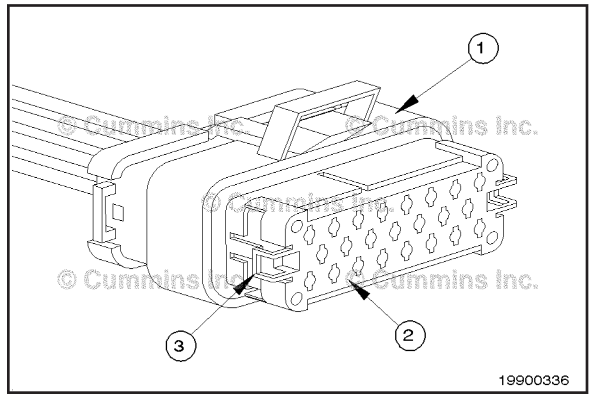
Pin Replacement

⚠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.



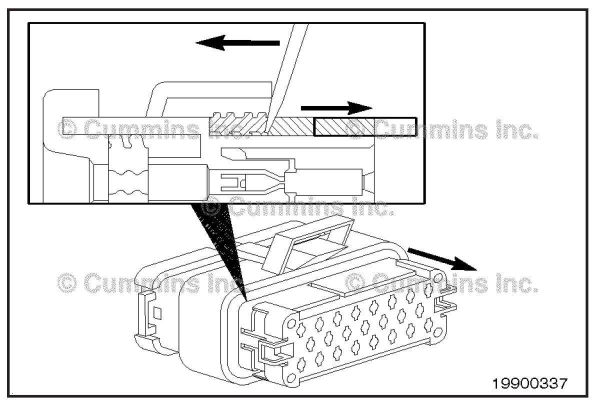
If the wedge lock is closed, perform the following:

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.

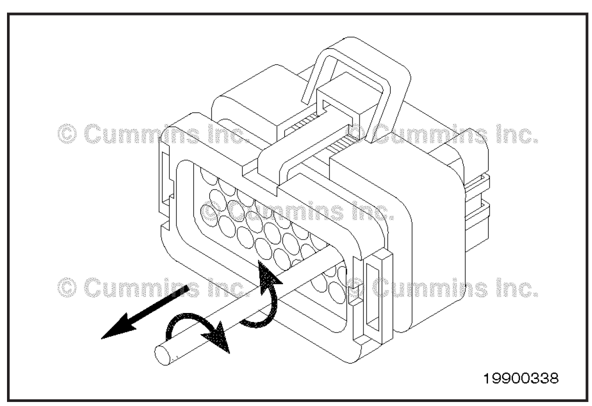


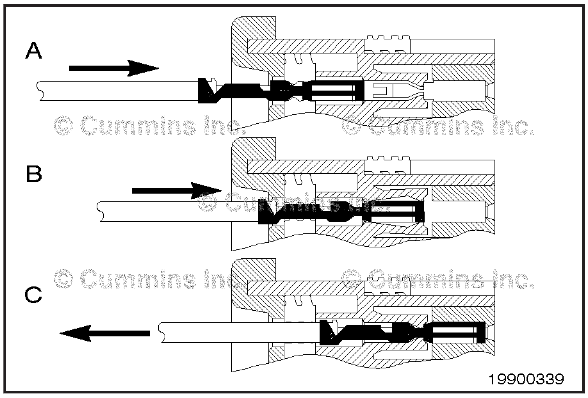
Remove the damaged contacts, rotate the contact wire back and forth over a half turn (¼ turn in each direction). Gently pull the wire until the contact is removed.

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.





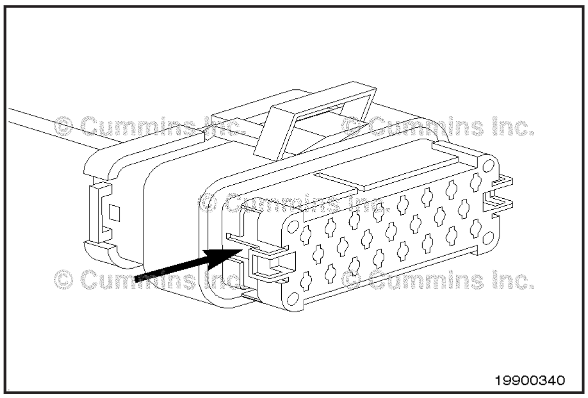
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

Install a new wire and contact.

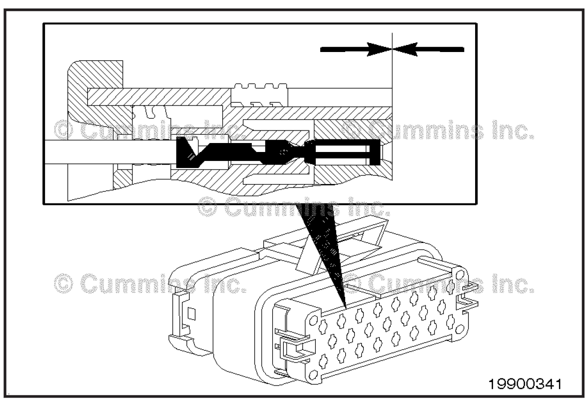
Insert wire straight into the appropriate circuit cavity.

Insert the wire until the pin bottoms out.

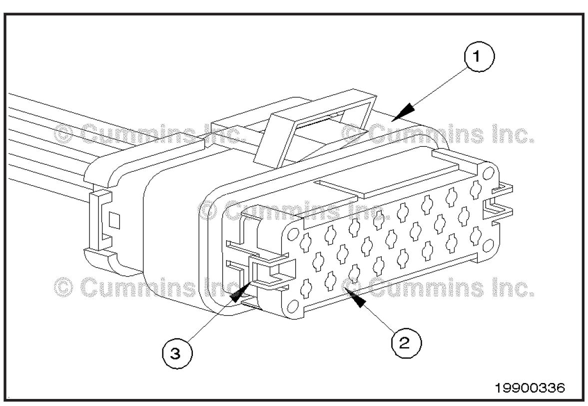
Pull back gently to be sure the retention fingers are holding the contact.



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.



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.

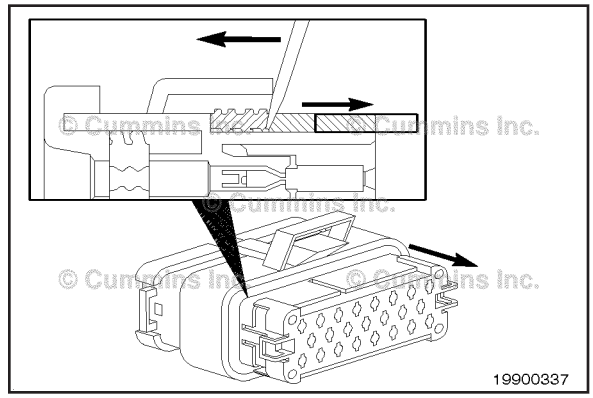
NOTE: The wedge lock **must not** be removed from the housing for insertion or removal of the contacts.

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.



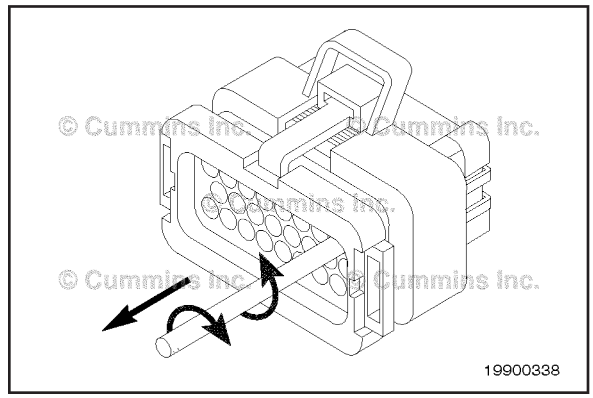
Replace one contact wire at a time. Attach a lettered tag to each wire removed.

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 (¼ 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.

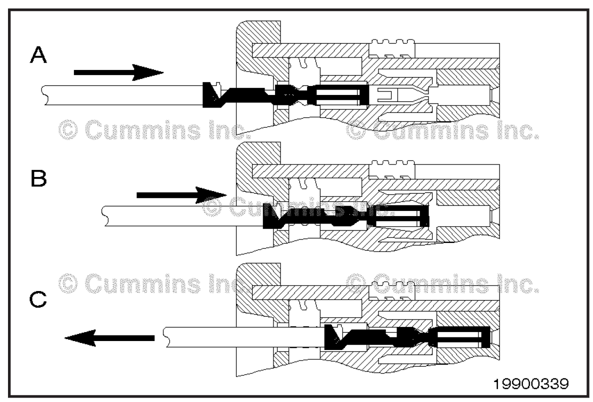


Install a new wire and contact by:

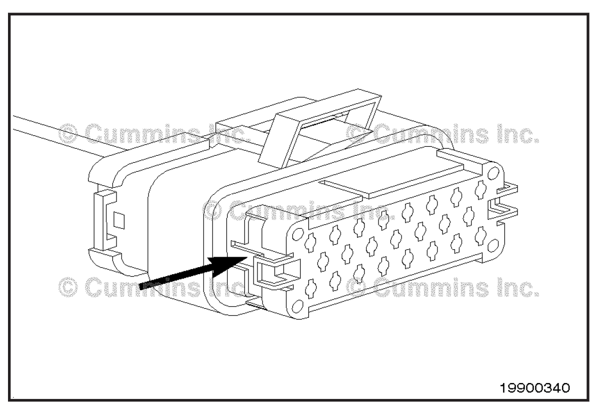
Insert wire straight into the appropriate circuit cavity.

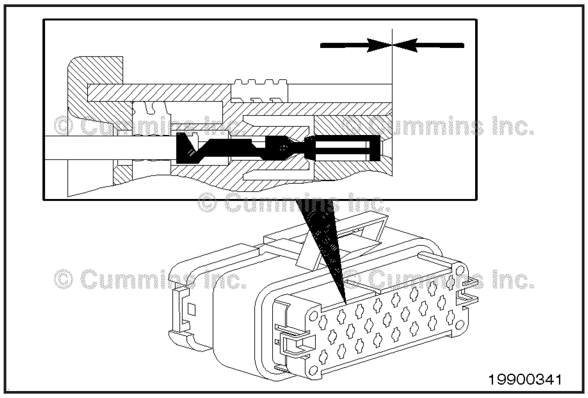
Insert the wire until the pin bottoms out.

Pull back gently to be sure the retention fingers are holding the contact.

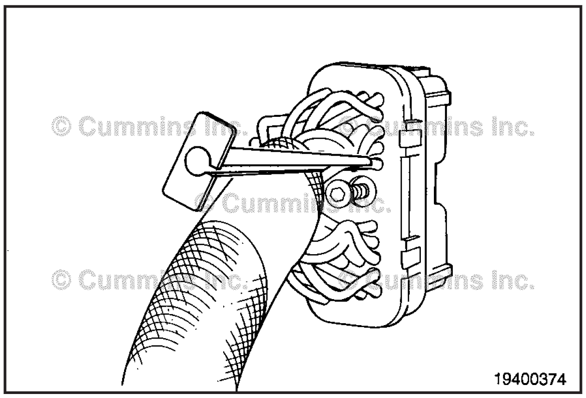


After all of the required contacts have been replaced, the wedge lock **must** be closed to its LOCKED position. Release the locking latches by squeezing them inward.





Slide the wedge lock into the housing until it is flush with the housing.



Deutsch DRC Connector Series (019-204)

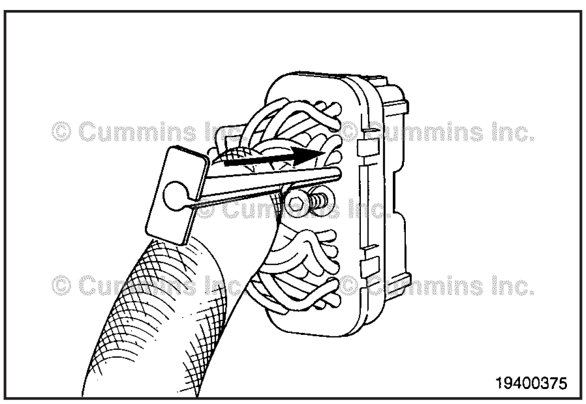
Pin Replacement

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.

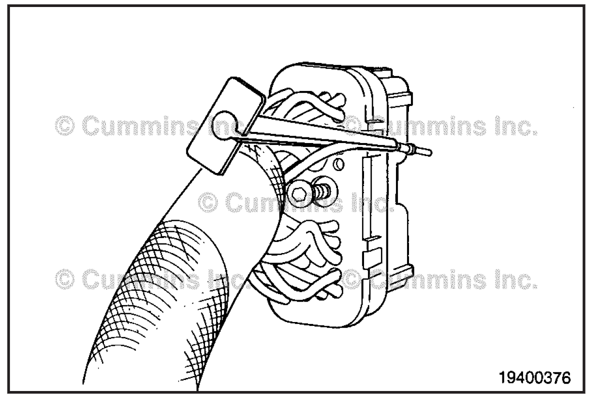
Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.

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.

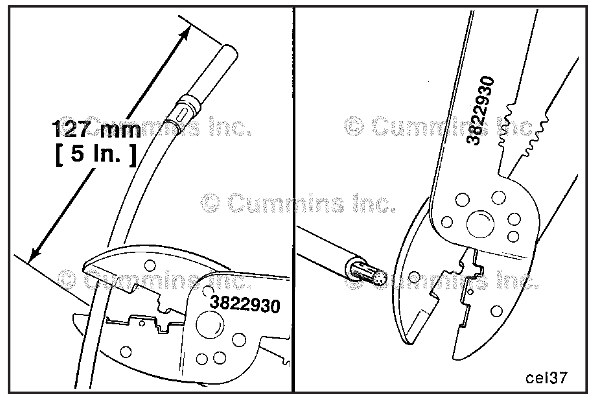
Hold the tool on the terminal flange and pull the wire and connecting pin out of the connector. Note and record the hole from which the pin is removed.



NOTE: The repair wire is 127 mm [5 in] long.

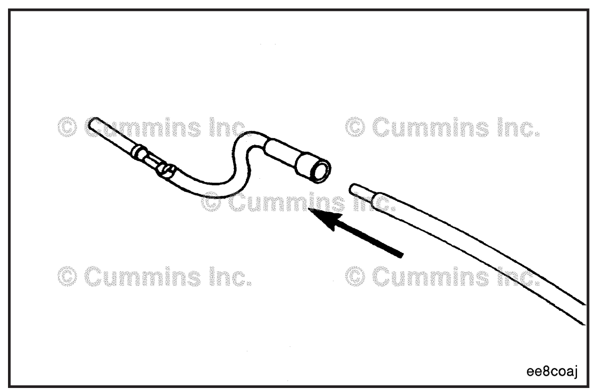
Use wire crimping tool, Part Number 3822930, to cut 127 mm [5 in] off the wire and pin.

Use the crimping tool to remove 6 mm [¼ in] of insulation from the wire.

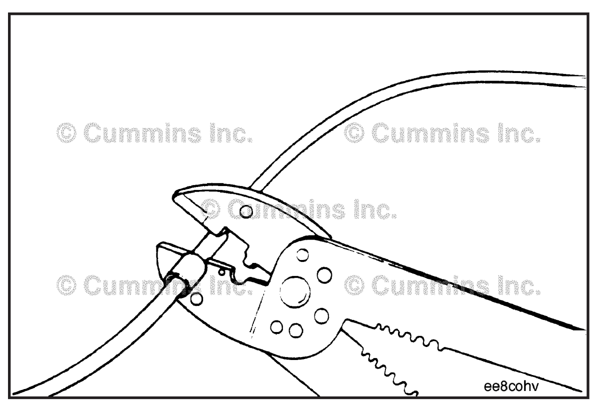


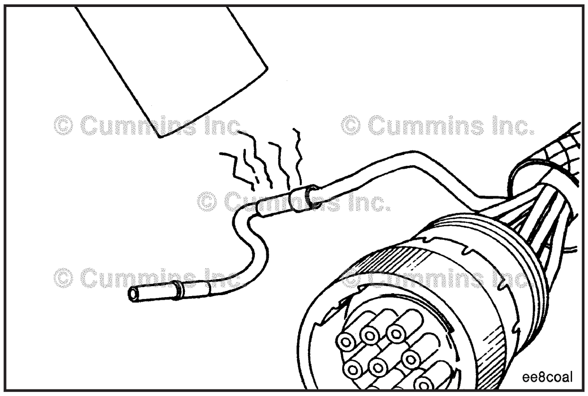
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

Install the correct repair wire on the bare wire, make sure that the bare wire extends into the splice connector.

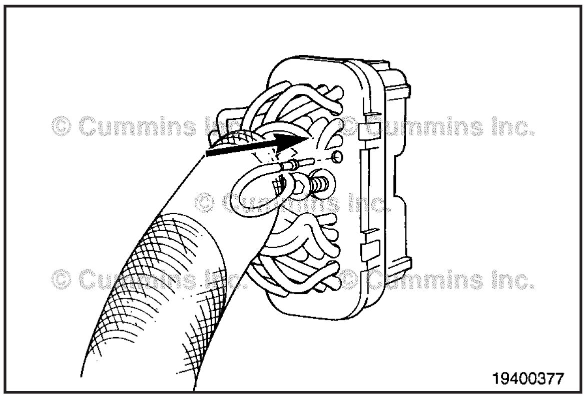


Use the wire crimping tool to crimp the repair wire onto the bare wire.





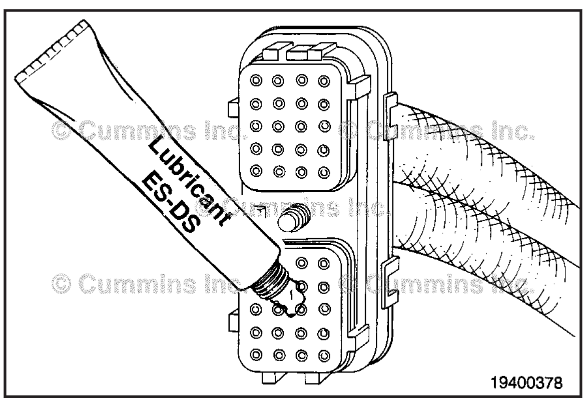
Use heat gun, Part Number 3822860, or an open flame to heat the shrink tubing around the wire. The tubing will shrink and make the connector waterproof.



Insert the pin into the correct hole of the connector.

The pin **must** click into place and hold the wire in the connector.

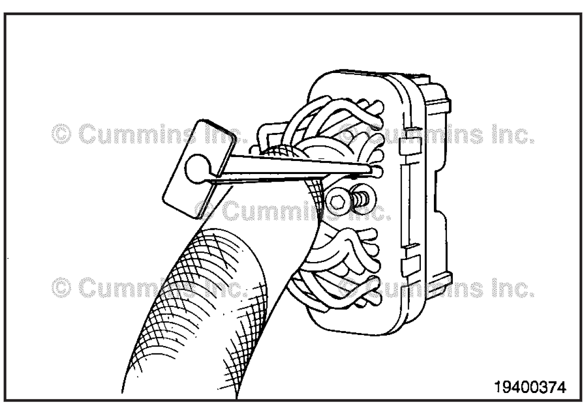
Pull the wire gently to make sure it is seated in the connector.



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

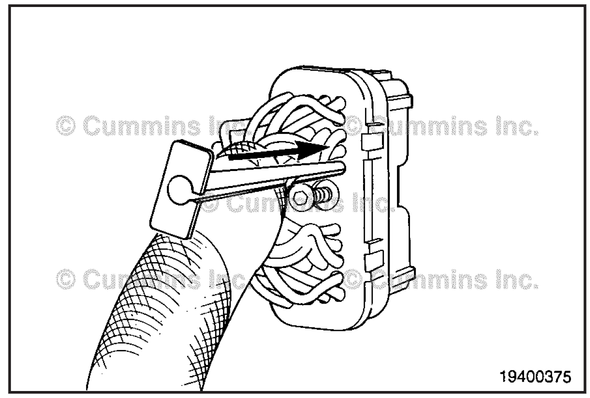
Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.

Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

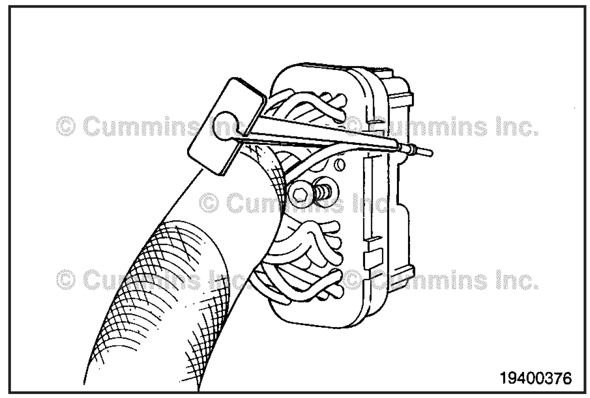
Replace one wire at a time. Attach a lettered tag to each wire removed.

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.


19400375

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.


19400376

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

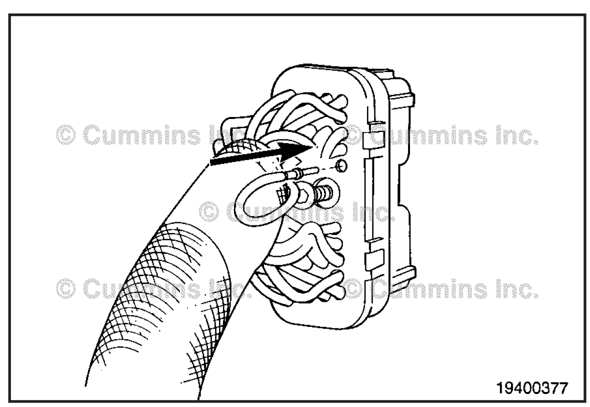
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

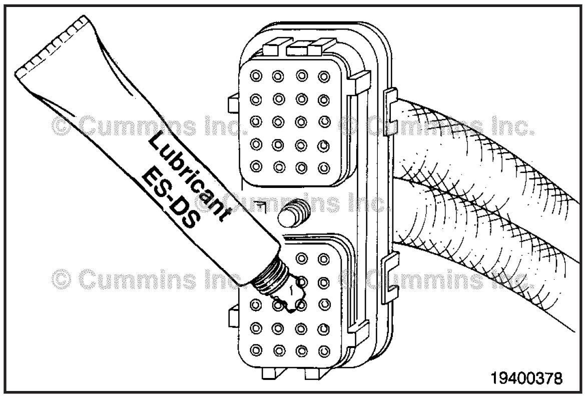
Refer to the wiring diagram for pin locations.

Insert the pins into the correct holes of the replacement connector.

Each pin **must** click into place and hold the wires in the connector.

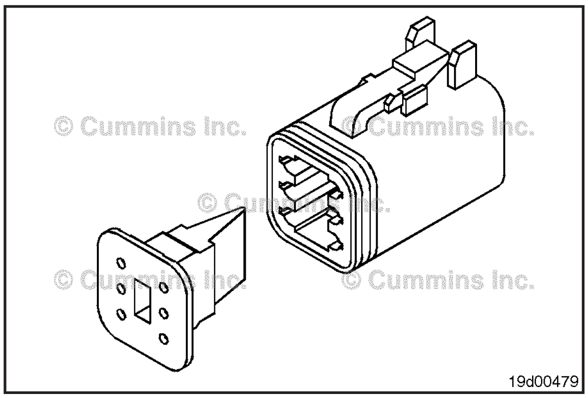
Pull each wire gently to make sure it is seated in the connector.


19400377



⚠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.



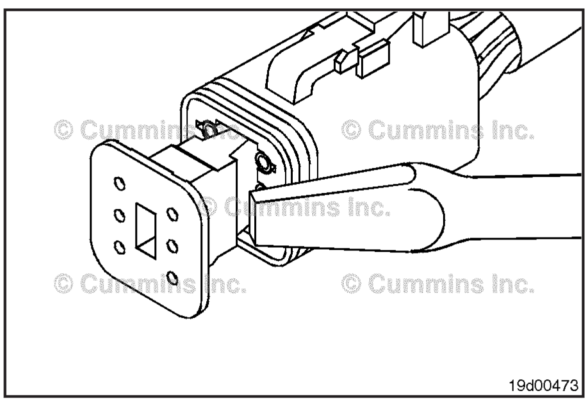
Deutsch DT Connector Series (019-205)

Pin Replacement

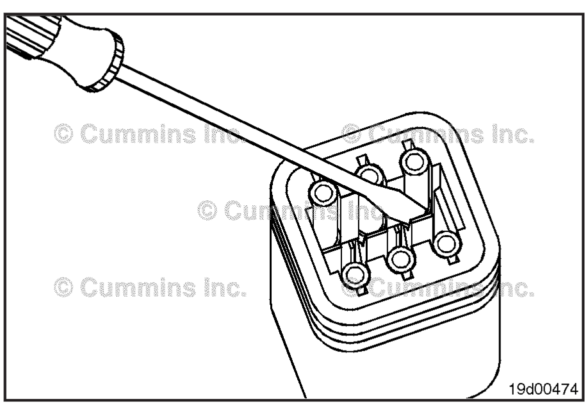
The connector can have multiple pin configurations. All type of connectors are repaired in the same manner.

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.



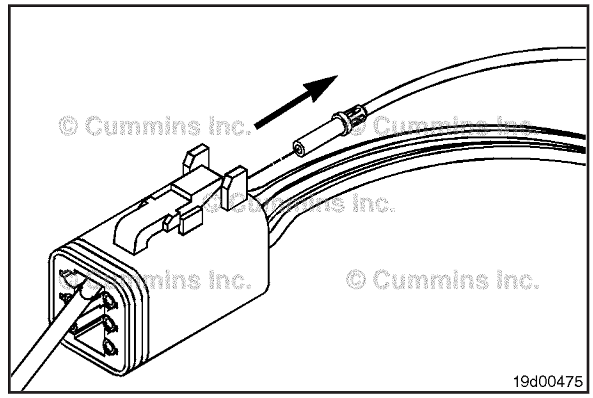
⚠CAUTION⚠
Locking finger can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

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.



Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

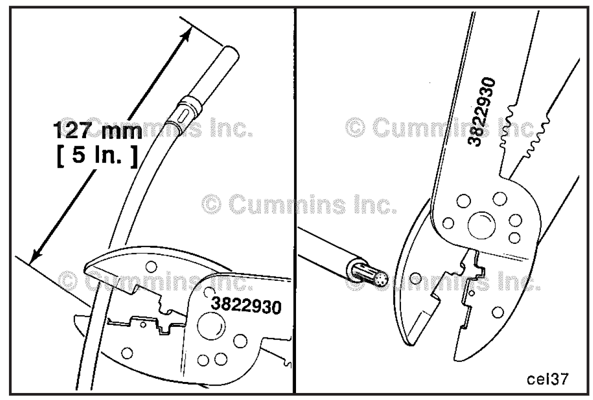
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

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.

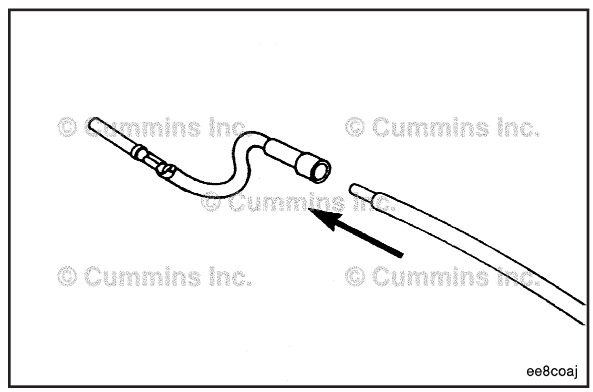
Use wire crimping tool, Part Number 3822930, to cut 127 mm [5 in] off the wire and pin.

Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from the wire.

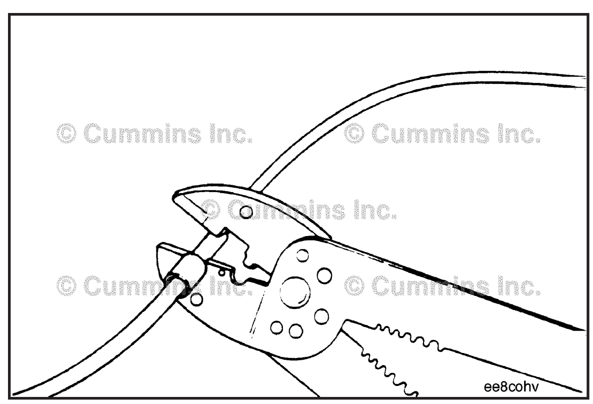


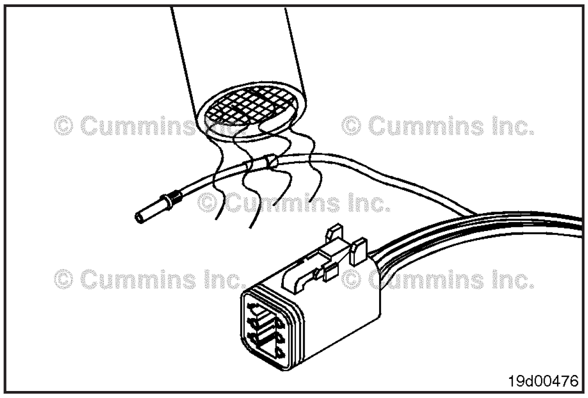
Install the correct repair wire on the bare wire.

Make sure the bare wire extends into the splice connector.



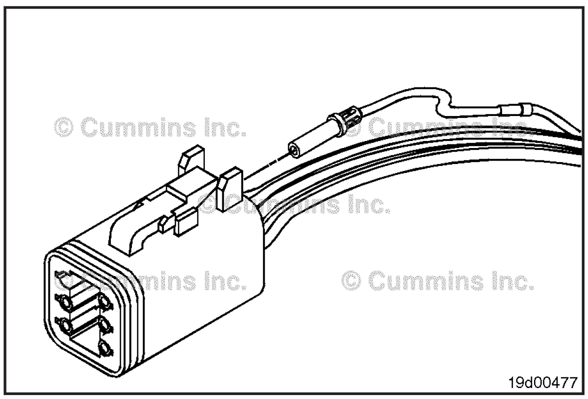
Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.





Use heat gun, Part Number 3822860, to heat shrink the tubing around the wire.

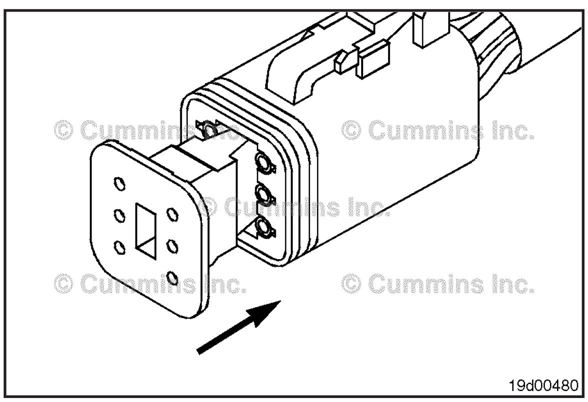
The tubing will shrink and make the connection waterproof.



CAUTION

If more than one wire is repaired or if the connector body is replaced, make sure to insert wires into the same locations as they are in the original connector. If wires are not in the original location electrical damage can occur.

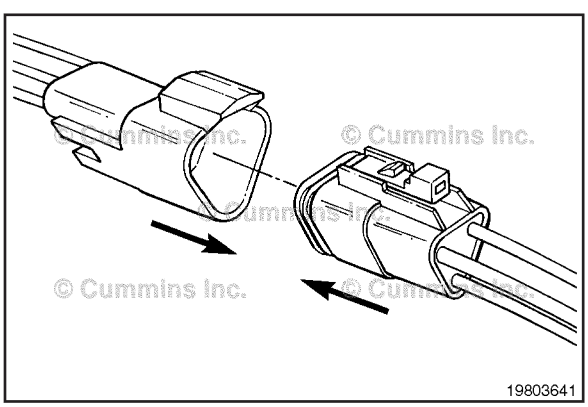
Replace the connector and install the wire and terminal into the connector body. Push the wire and terminal into the seal at the back of the connector. Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.



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.

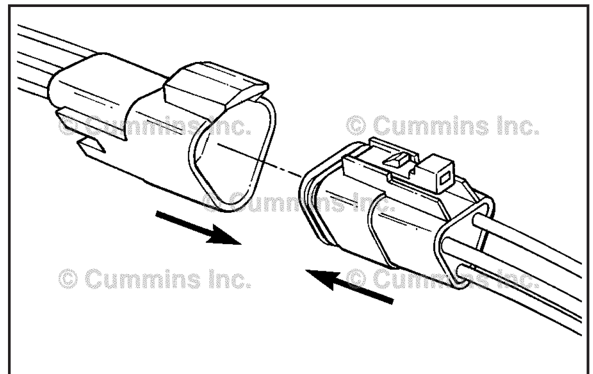
Connector Replacement

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.

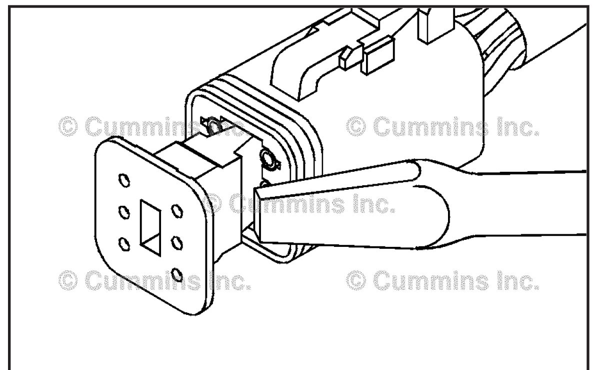
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.



19803641

To replace the pin in the plug connector, grasp the orange wedge and pull the wedge straight out.

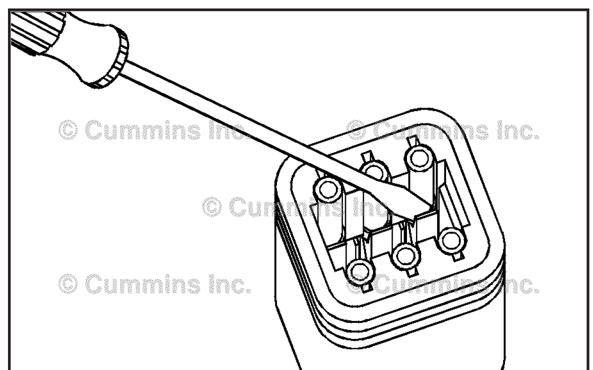


19d00473

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.

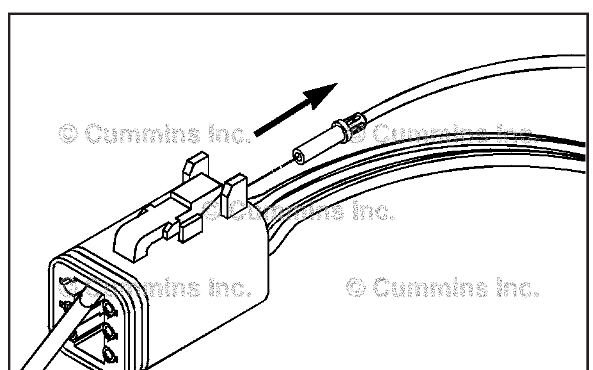


19d00474

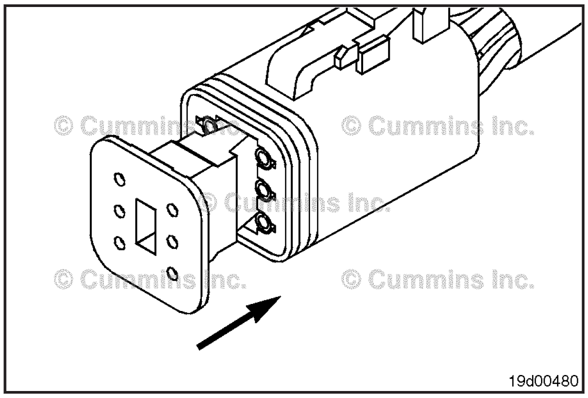
CAUTION

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.

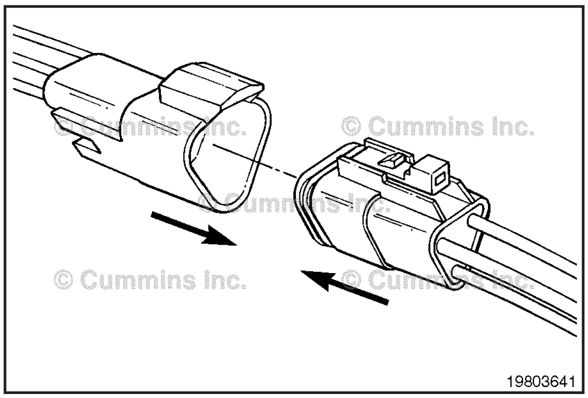


19d00475

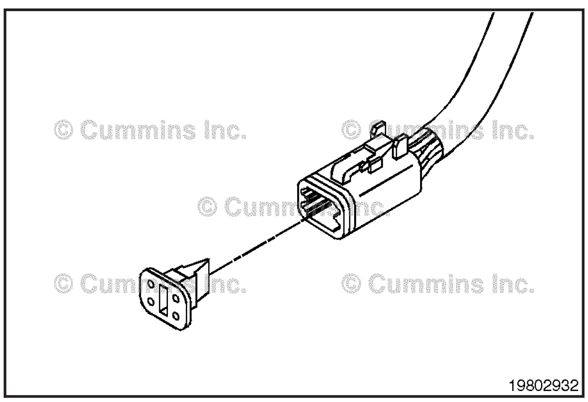

19d00480

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.


19803641

Push the connector plug into the connector receptacle until the external locking clip snaps into place.


19802932

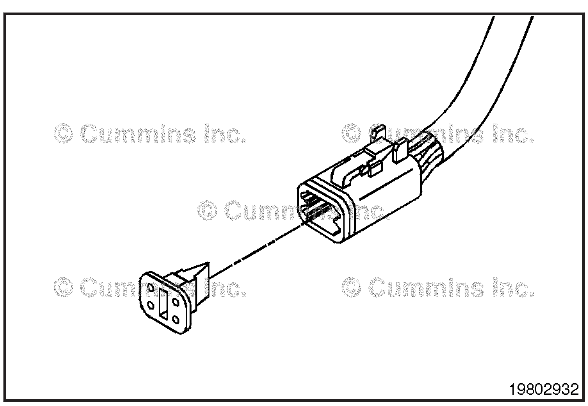
Deutsch DTM and DTP Connector Series (019-206)

Pin Replacement

The connector can have multiple pin configurations.

The connector pins can **not** be repaired or replaced. The connector **must** be replaced as a unit.

Refer to the connector replacement procedure for replacement procedures.


19802932

Connector Replacement

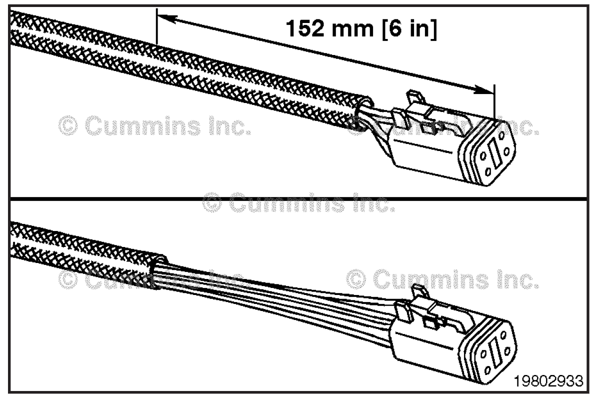
Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tool table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.

The replacement connector shown in the following procedure is a 4-pin Deutsch series. All sizes of DTM connectors are replaced in the same manner.

Measure 152 mm [6 in] back from the face of the connector and remove the wiring harness protective cover.

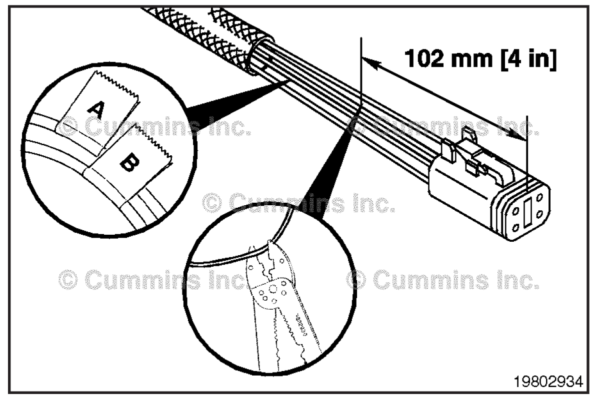


Before cutting the wires, measure and tag all wires.

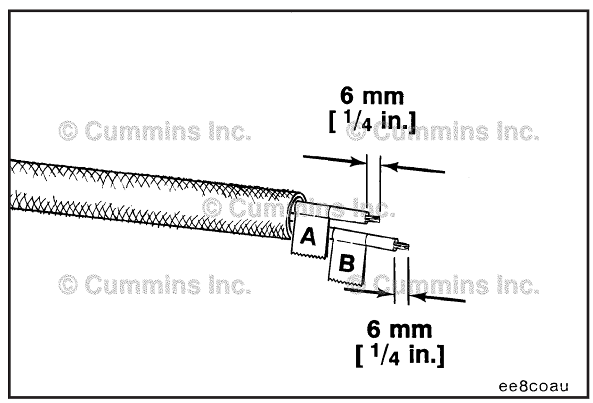
Use wire crimping tool, Part Number 3822930.

Cut wire A 102 mm [4 in] from the face of the connector.

Cut wire B 102 mm [4 in] from the face of the connector.

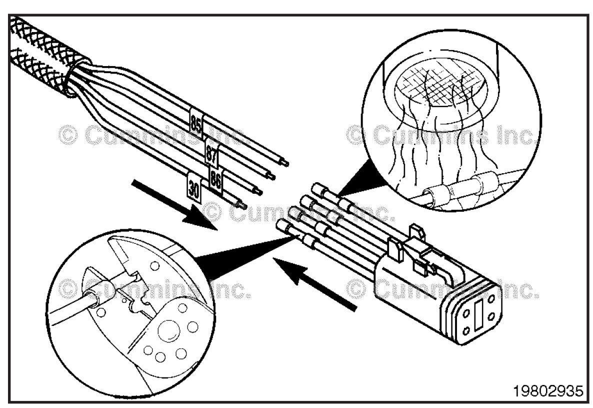


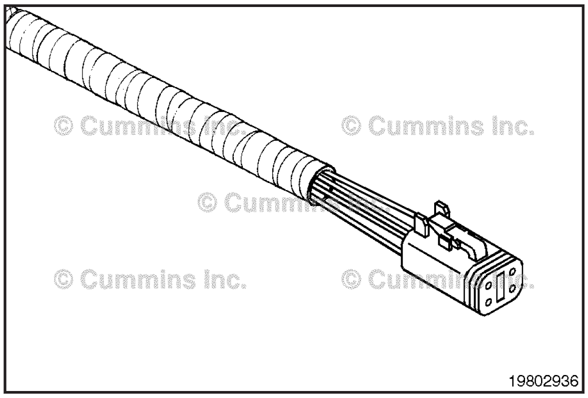
Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from both electrical wires.



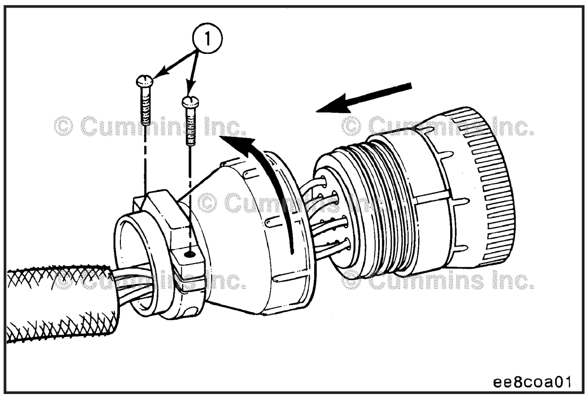
Install the connector repair wires and use wire crimping tool, Part Number 3822930, to crimp the terminals.

Use heat gun, Part Number 3822860, to heat the shrink tubing. The tubing will shrink and make the connection waterproof.





Wrap the wires with tape, for added protection, to complete the repair.



Deutsch HD10 Connector Series (019-207)

Pin Replacement

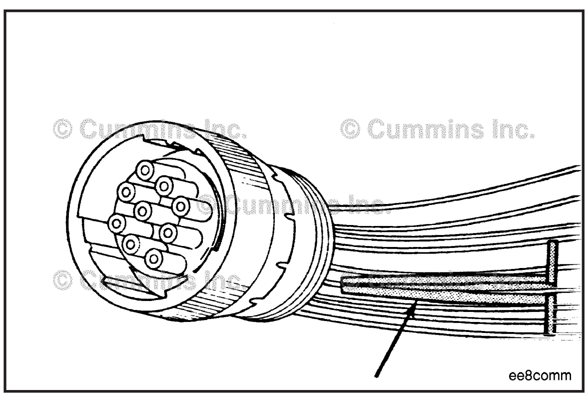
These connectors are available with multiple pin configurations.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire. Replace one contact at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

Unlock the connector. Rotate the locking tab **counterclockwise** by hand. Do **not** use pliers; they can damage the connector.

Remove the two clamp capscrews (1) from the rear of the connector. Turn the rear support of the connector **counterclockwise** until the two pieces are separated.



These connectors are available with multiple pin configurations.

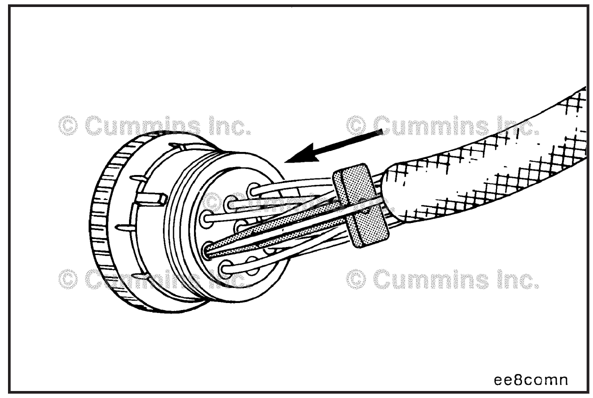
Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.

Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

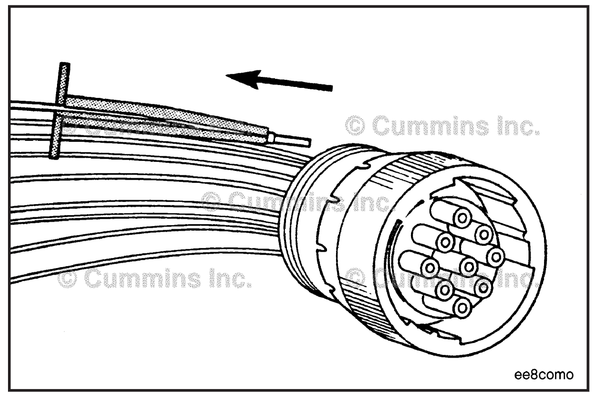
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

Push the tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange.



Hold the tool on the terminal flange and pull the wire and the connecting pin out of the connector. Note and record the hole from which the pin is removed.



NOTE: The repair wire is 127 mm [5 in] long.

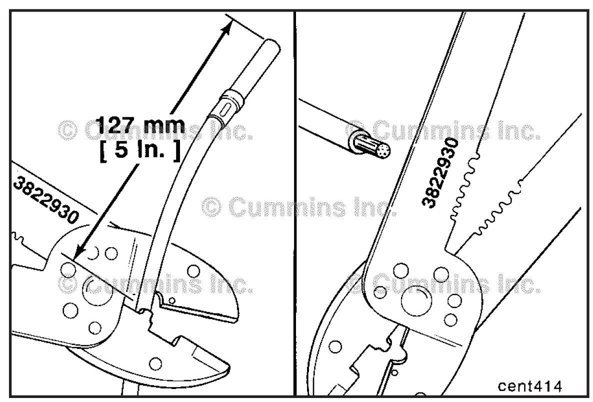
Remove about 6 mm [¼ in] of insulation from the wire.

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

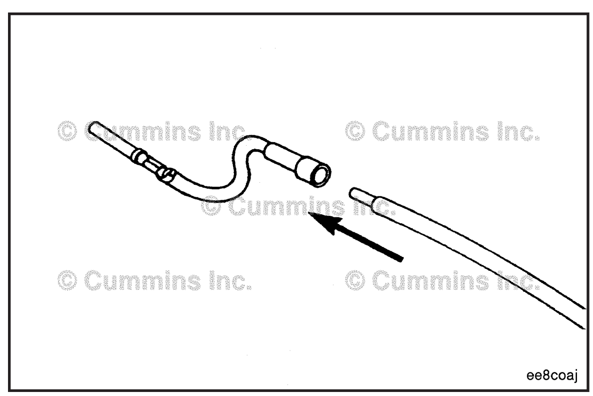
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

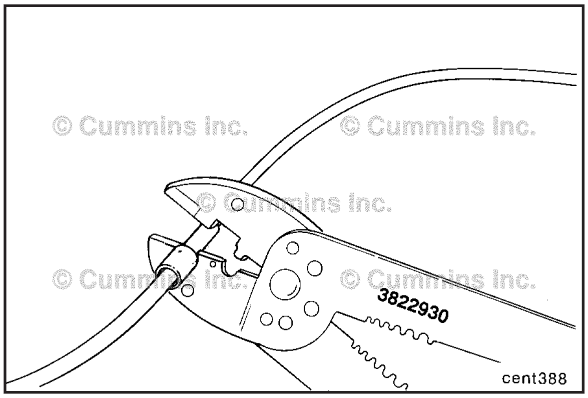
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

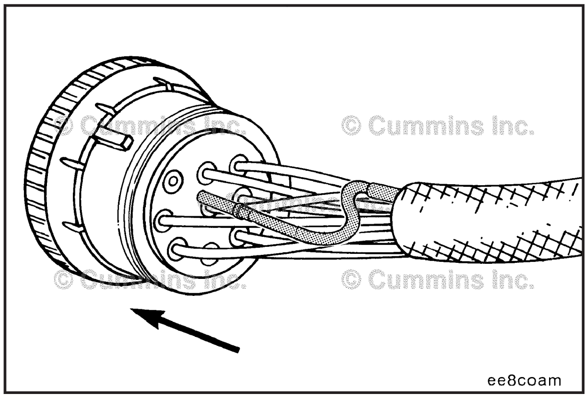


Install a repair wire on the bare wire. Make sure the bare wire extends into the splice.





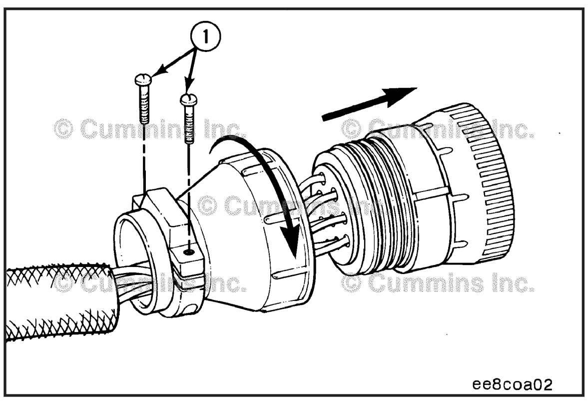
Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



Insert the pin into the correct hole of the connector.

The pin **must** lock into place and hold the wire in the connector.

Pull the wire gently to make sure it is seated in the connector.



Install the rear connector support.

Tighten the two wire clamp capscrews.

Torque Value: 1 N•m [9 in-lb]

Connector Replacement

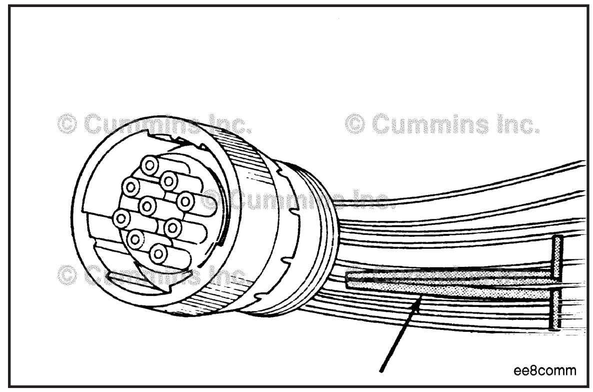
These connectors are available with multiple pin configurations.

Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.

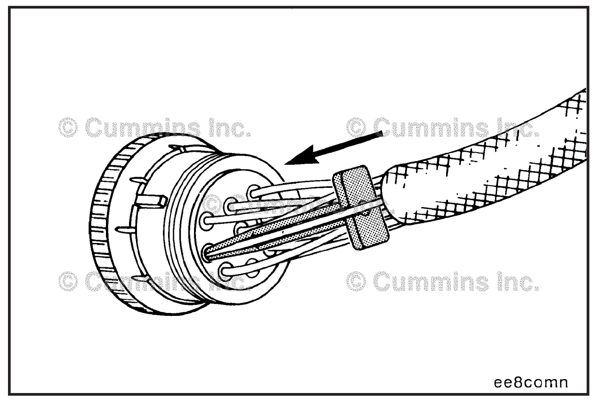
Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

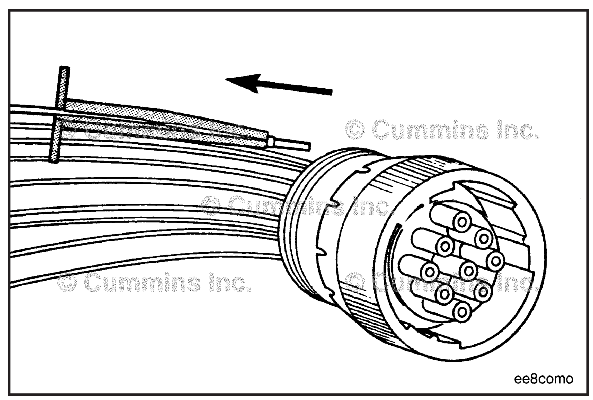
Refer to the wiring diagram in Section E for pin locations.

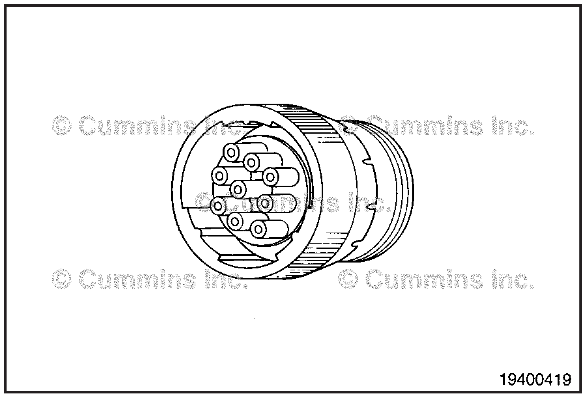


Push the tool into the connector approximately 25 mm [1 in] until it bottoms on the terminal flange.



Hold the tool on the terminal flange and pull the wire and the connecting pin out of the connector. Note and record the hole from which the pin is removed.

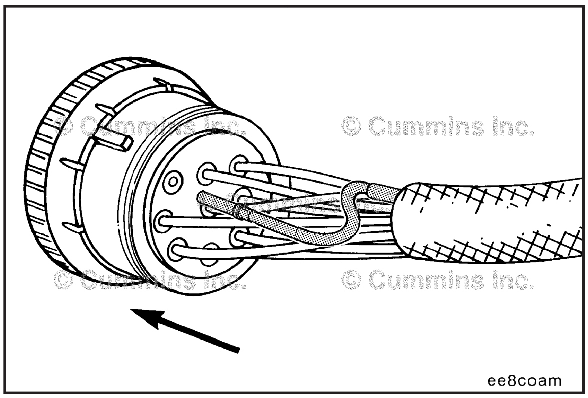




Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

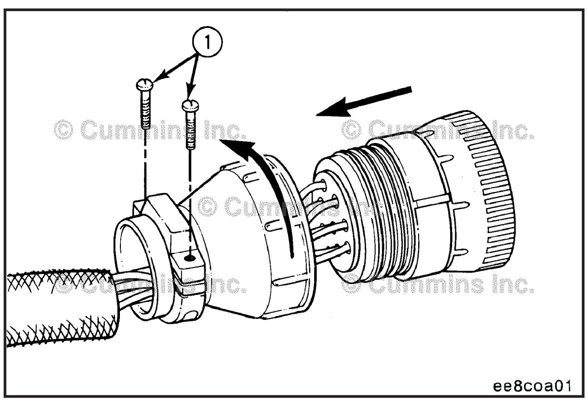
Refer to the wiring diagram in Section E for pin locations.



Insert the pins into the correct holes of the replacement connector.

The pin **must** click into place and hold the wire in the connector.

Pull the wire gently to make sure it is seated in the connector.



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.

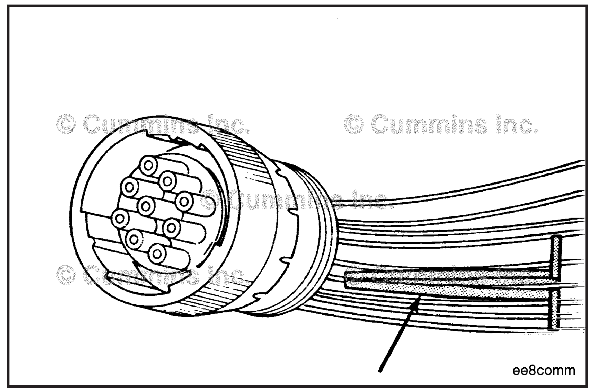
Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

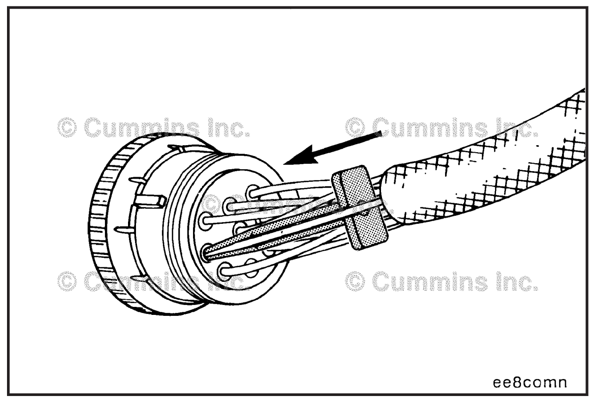
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

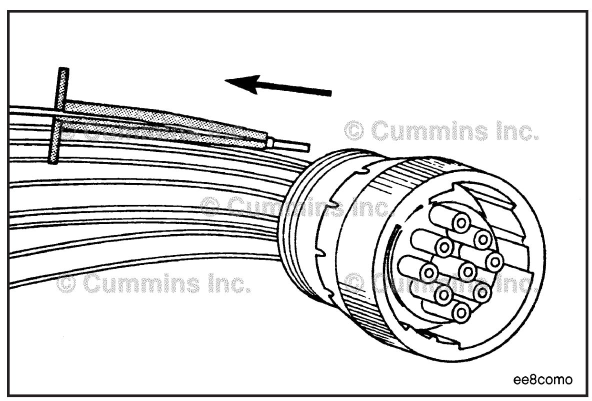
Refer to the wiring diagram in Section E for pin locations.

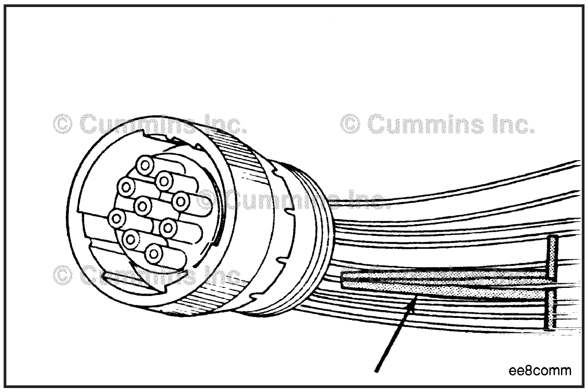


Push the tool into the connector about 25 mm [1 in] until it bottoms on the terminal flange.



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.

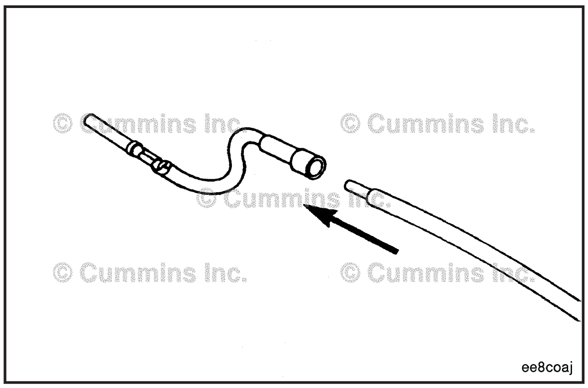
Refer to the appropriate wiring repair kit tools table in the front of Section 19 for the correct repair wire.

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.

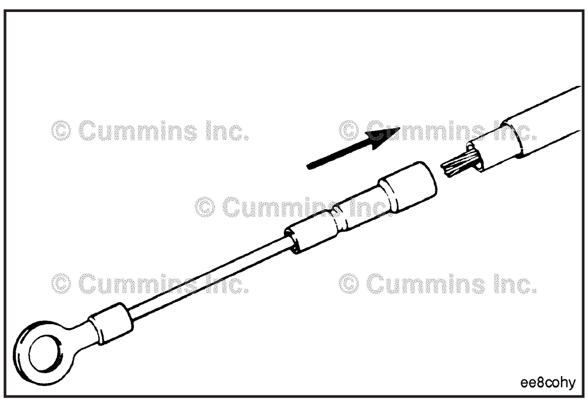
Use wire crimping tool, Part Number 3822930, to cut 127 mm [5 in] off the wire and pin.

Use the wire crimping tool to remove 6 mm [¼ in] of insulation from the wire.

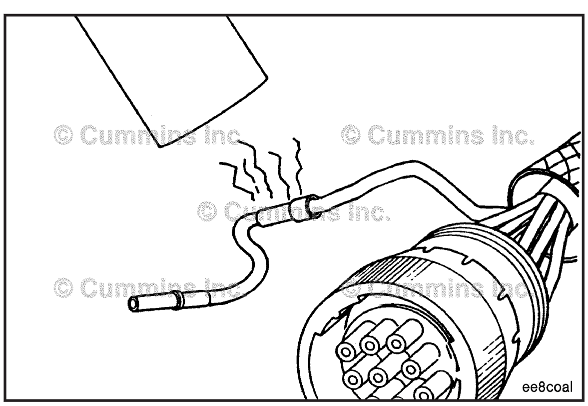


Install the correct repair wire on the bare wire.

Make sure the bare wire extends into the splice connector.



Use the wire crimping tool to crimp the repair wire onto the bare wire.

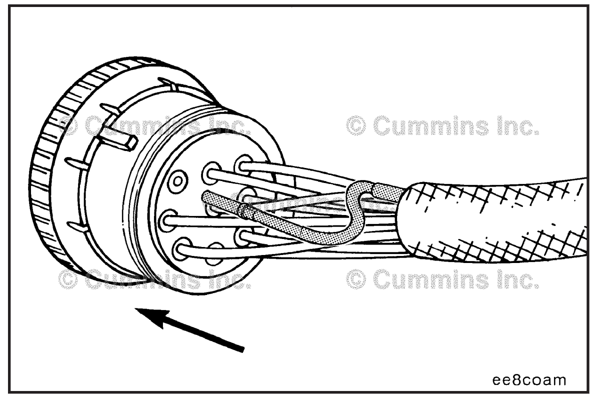


Use heat gun, Part Number 3822860, or an open flame to heat shrink the tubing around the wire. The tubing will shrink and make the connector waterproof.

Insert the pin into the correct hole of the connector.

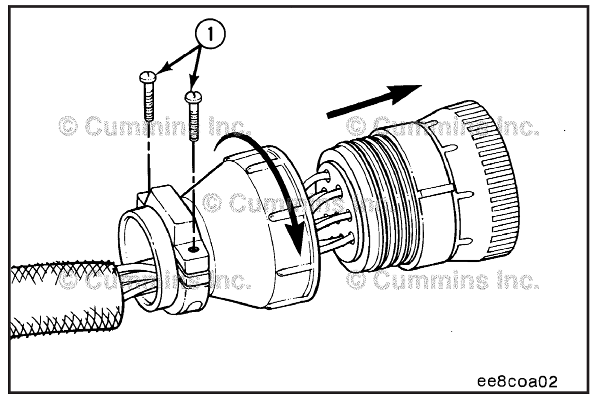
The pin **must** click into place and hold the wire in the connector.

Pull the wire gently to make sure it is seated in the connector.



Install the retainer. Tighten the two clamp capscrews.

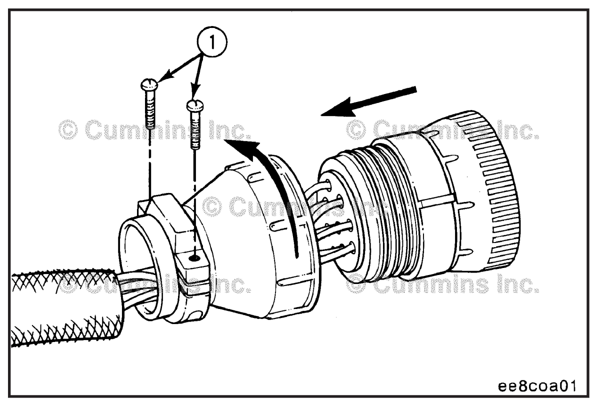
Torque Value: 1 N•m [9 in-lb]

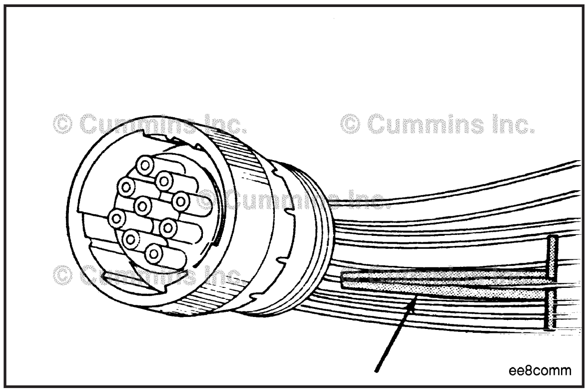


Connector Replacement

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.





Use the Deutsch extraction tool, listed in the table below, to remove a pin from the connector.

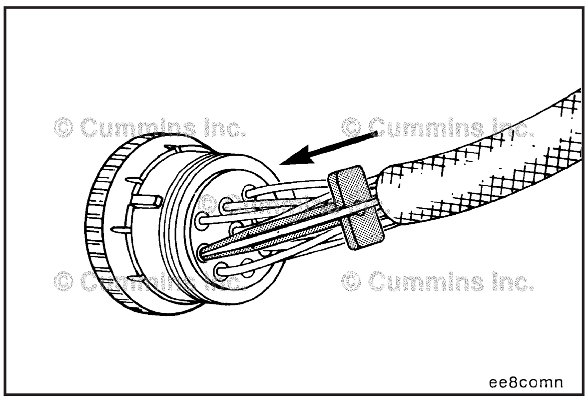
Tool Part Number	Wire Size
3824815	20 gauge
3822760	16 gauge
3824816	12 gauge

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

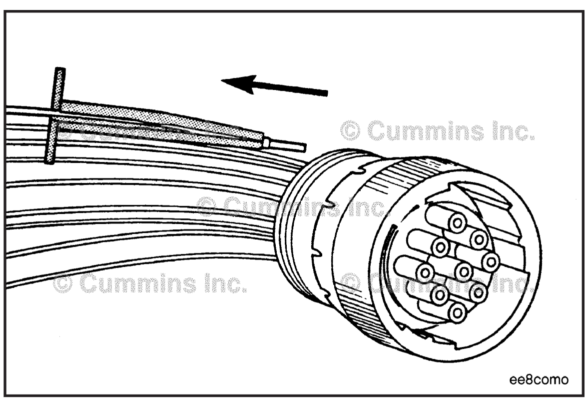
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

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.

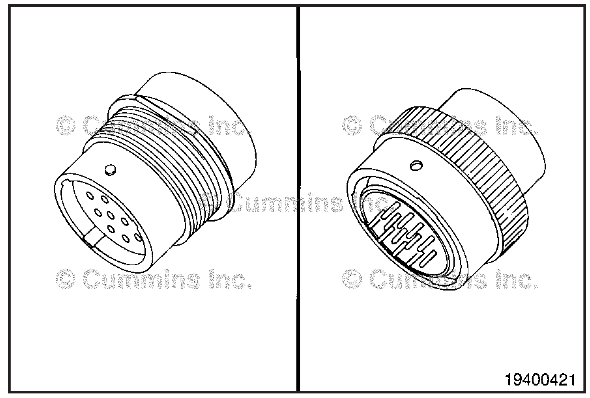


Hold the tool on the terminal flange and pull the wire and connecting pin out of the connector. Note and record the hole from which the pin is removed.

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.

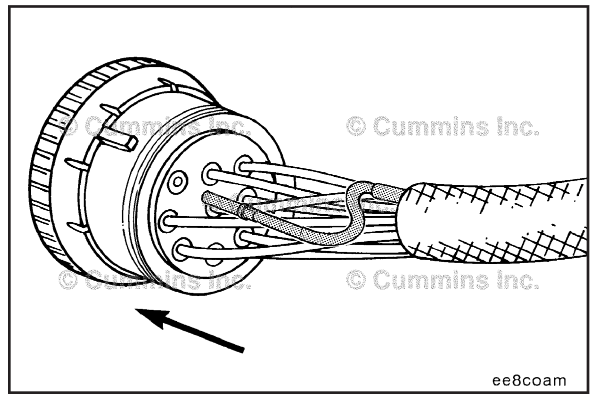
Refer to the wiring diagram in Section E for pin locations.



Insert the pins into the correct holes of the connector.

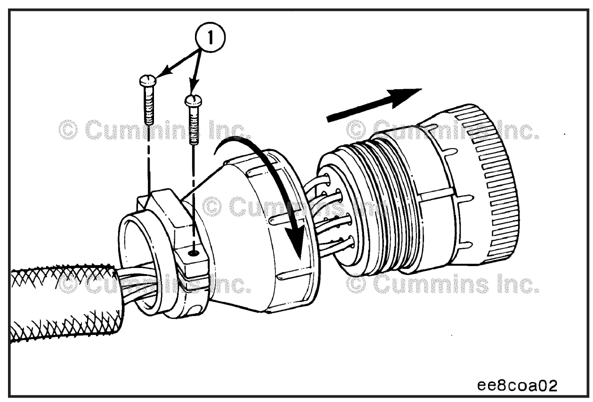
The pin **must** click into place and hold the wire in the connector.

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]

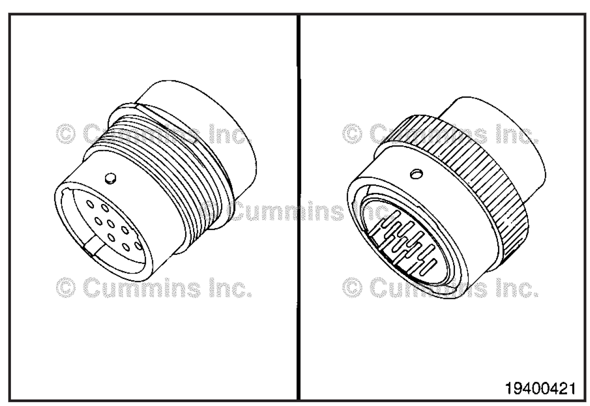


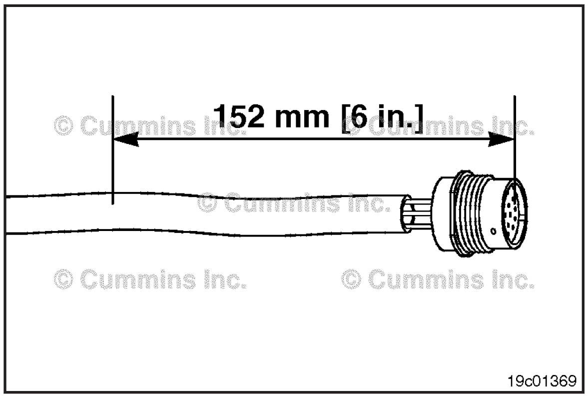
ITT Cannon Connector Series (019-209)

Pin Replacement

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.





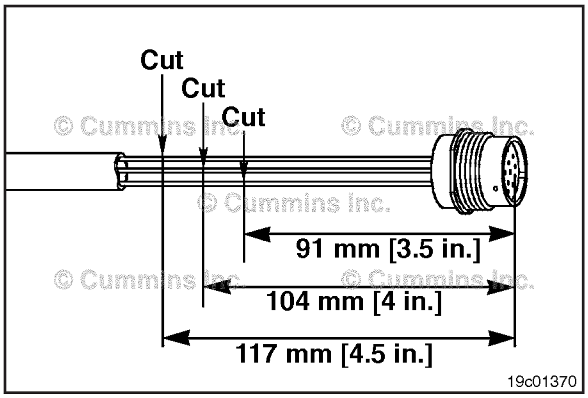
Connector Replacement

Measure 152 mm [6 in] back from the face of the connector and remove the wiring harness protective cover.

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

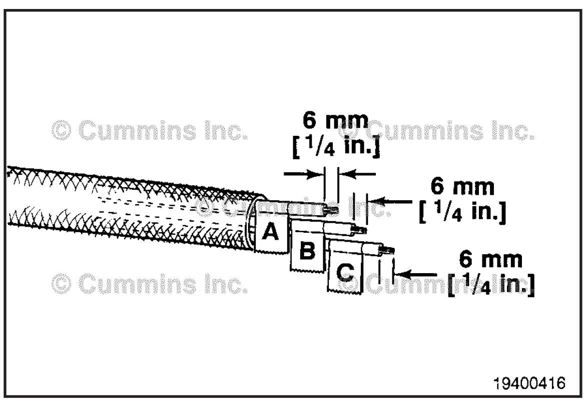
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

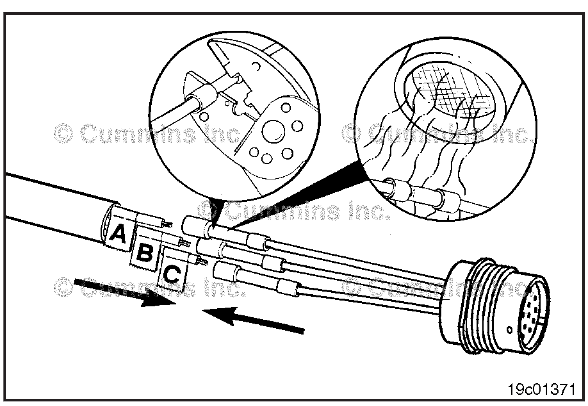


Use wire crimping tool, Part Number 3822930, to cut the wires. Cut the first wire 91 mm [3-½ in] from the face of the connector.

Cut the remaining seven wires in increments of 12 mm [½ in] back from the previous cut.



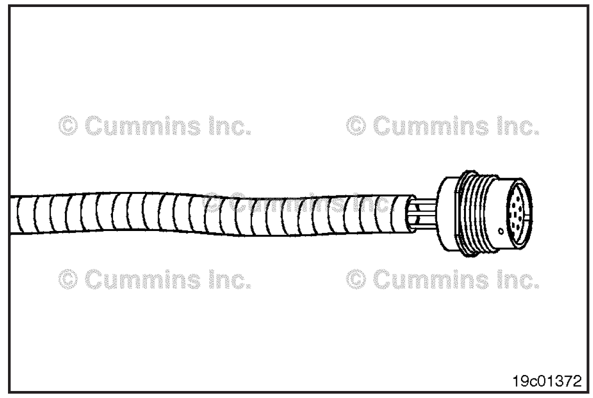
Use the wire crimping tool to remove 6 mm [¼ in] of insulation from all eight electrical wires.



Install the terminal repair wires on the bare wires and use the wire crimping tool to crimp the terminal.

Use heat gun, Part Number 3822860, or an open flame to heat the shrink tubing. The tubing will shrink and make the connection waterproof.

For added protection, wrap the wire with tape to complete the repair.

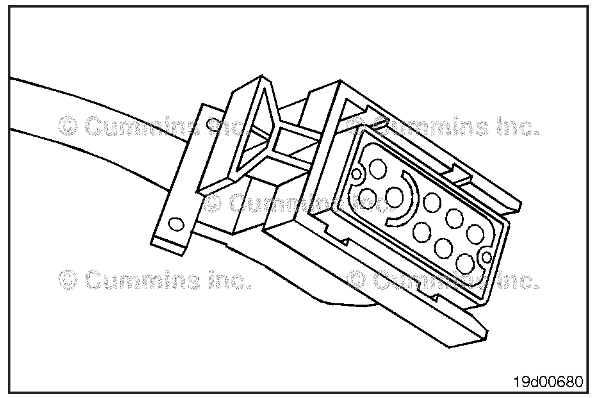


AMP VP44 Connector Series (019-210)

Pin Replacement

The connector pins can **not** be repaired or replaced. The connector **must** be replaced as a unit.

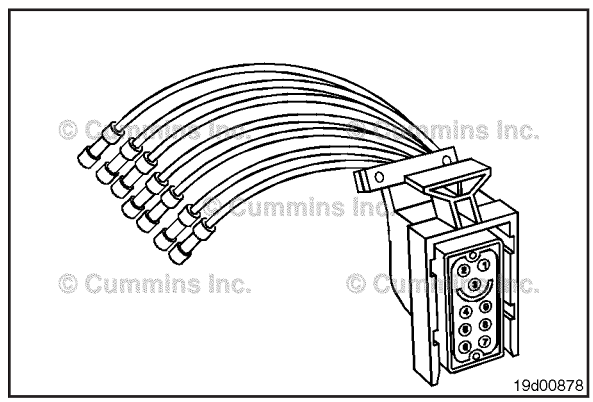
Refer to the Connector Replacement step in this procedure for replacement instructions.



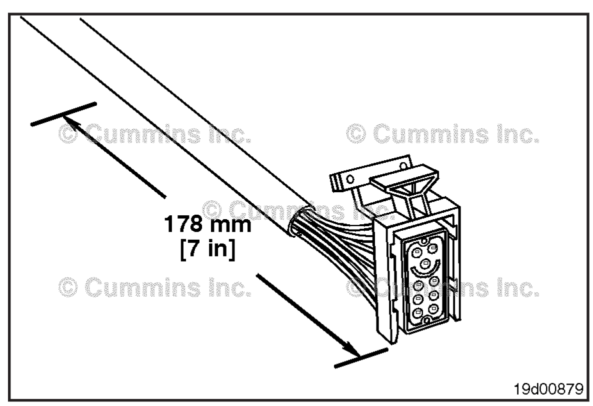
Connector Replacement

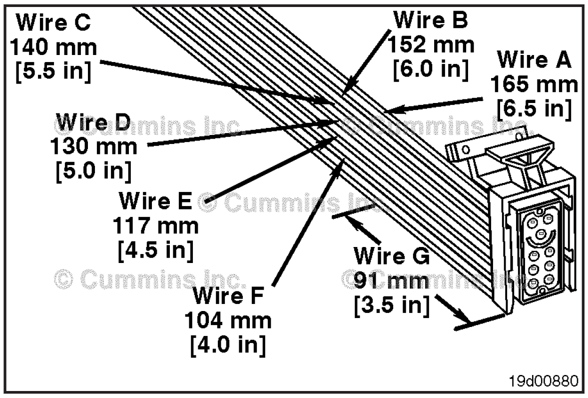
This connector is used to connect the VP44 fuel pump to the ECM.

The pins in this connector can **not** be repaired or replaced. The connector **must** be replaced as a unit.



Measure 178 mm [7 in] back from the face of the connector and remove the wiring harness protective cover.





Before cutting the wires, measure and tag all of the wires.

Use wire crimping tool, Part Number 3822930, to cut the wires.

Cut wire A 165 mm [7 in] from the face of the connector.

Cut wire B 152 mm [6-½ in] from the face of the connector.

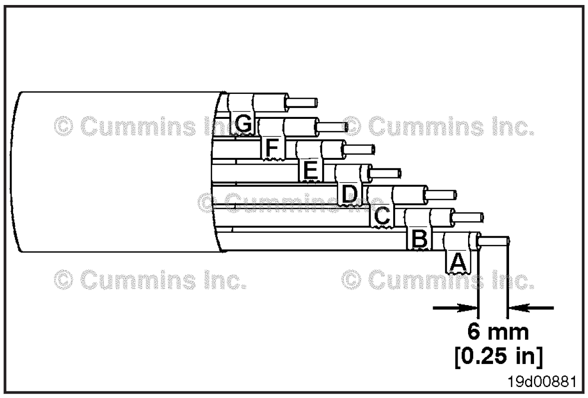
Cut wire C 140 mm [6 in] from the face of the connector.

Cut wire D 130 mm [5-½ in] from the face of the connector.

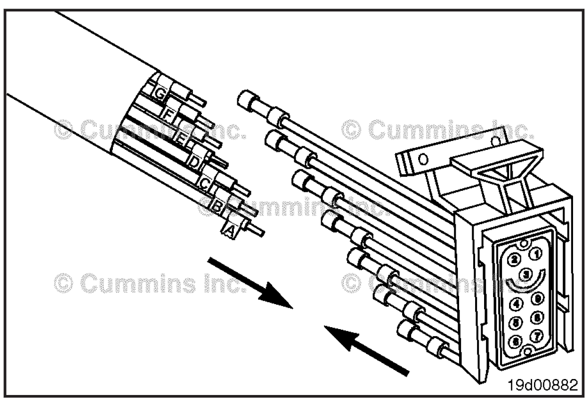
Cut wire E 117 mm [4-½ in] from the face of the connector.

Cut wire F 104 mm [4 in] from the face of the connector.

Cut wire G 91 mm [3-½ in] from the face of the connector.



Use the wire crimping tool to remove 6 mm [¼ in] of insulation from all electrical wires.

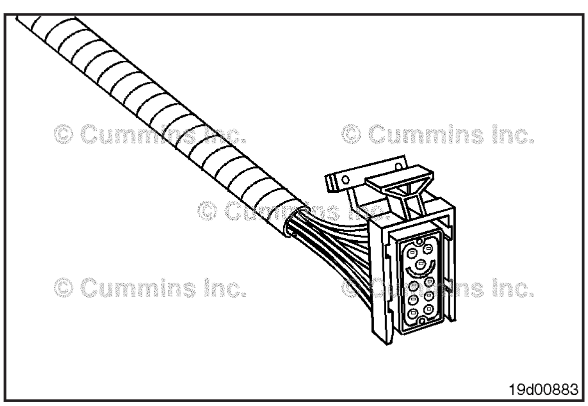


Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

Refer to the wiring diagram in Section E for pin locations.

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.



For added protection, wrap the wires with tape to complete the repair.

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.

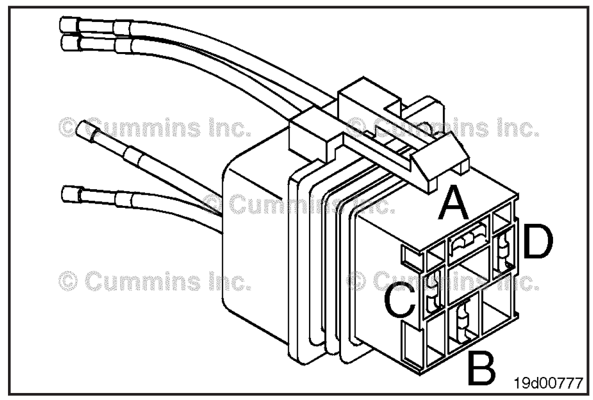
Connector Replacement

Before installing the new connector, perform a test fit to make sure the connector is keyed properly.

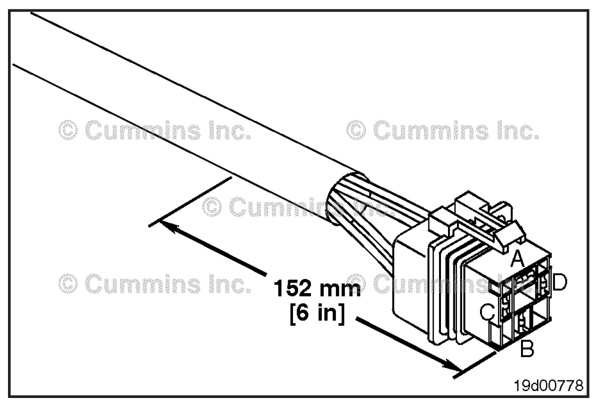
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

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.

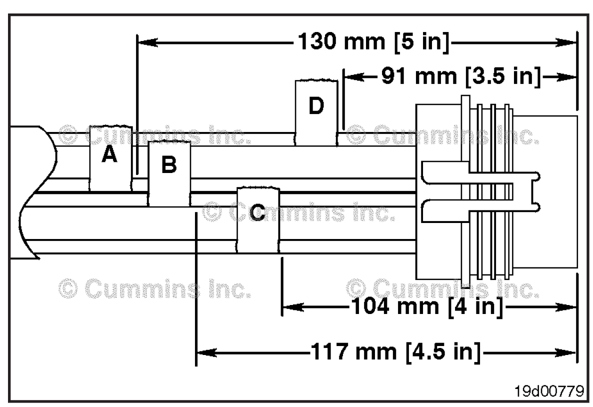
Use wire crimping tool, Part Number 3822930.

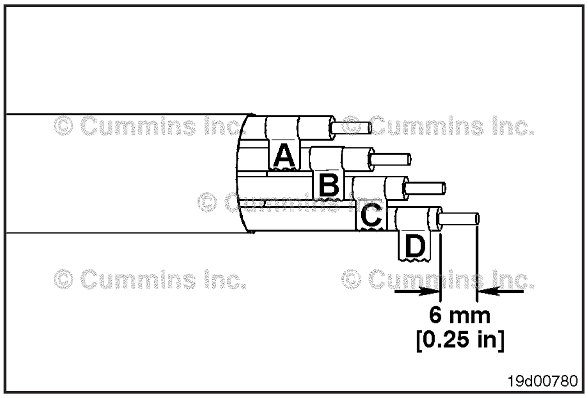
Cut wire A 130 mm [5 in] from the face of the connector.

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.





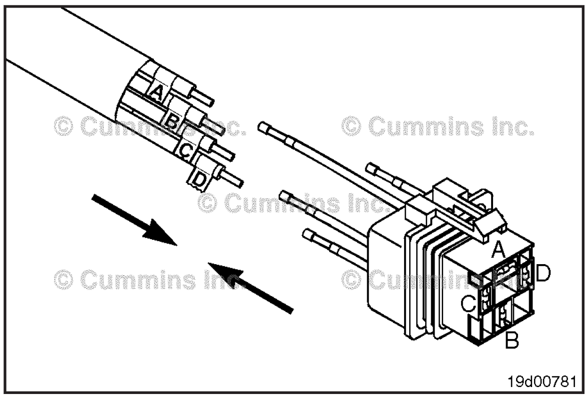
Use crimping tool, Part Number 3822930, to remove 6 mm [¼ inch] of insulation from the electrical wires.

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.

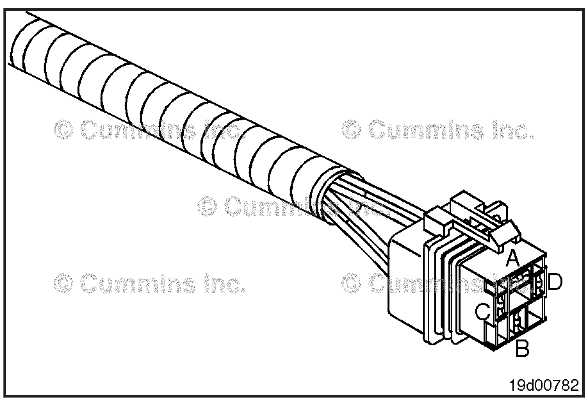
Refer to the wiring diagram for pin locations.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

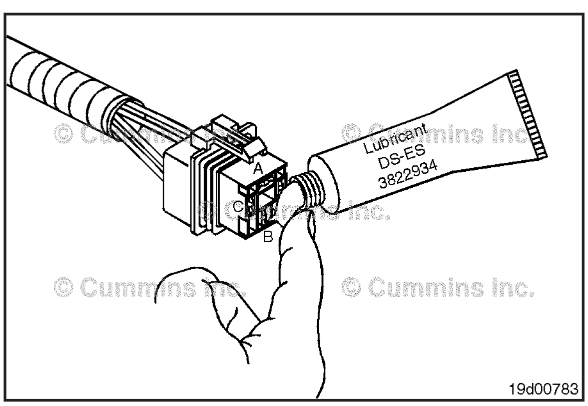


Install the terminal repair wires on the bare wires. Use wire crimping tool, Part Number 3822930, to crimp the terminals.

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⚠

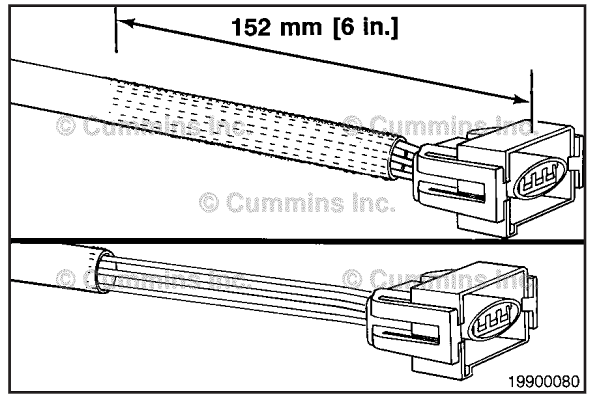
Use only Cummins-recommended lubricant DS-ES, Part Number 3822934, other lubricants, such as lubricating oil or grease, in the connectors can cause electronic control unit damage, poor performance, or premature connector pin wear.

Apply a small amount of lubricant to the connector terminals. Before installing, fill the entire connector cavity with lubricant.

Ford™ Connector Series (019-212)

Connector Replacement

Measure 152 mm [6 in] back from the face of the connector, and using the braid removal tool, Part Number 3822932, remove the wiring harness protective cover.

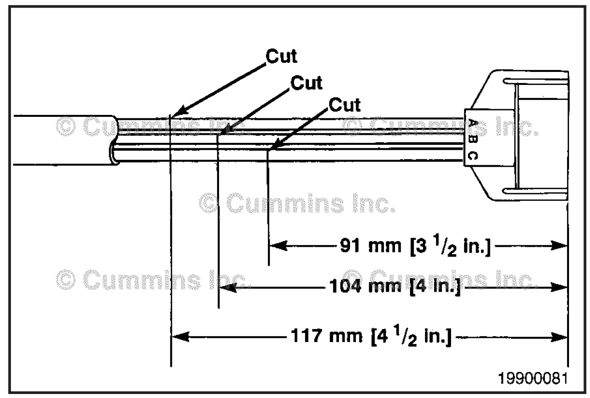


Before cutting the wires, measure and tag the three wires.

Cut wire A 117 mm [4-½ in] from the face of the connector.

Cut wire B 104 mm [4 in] from the face of the connector.

Cut wire C 91 mm [3-½ in] from the face of the connector.



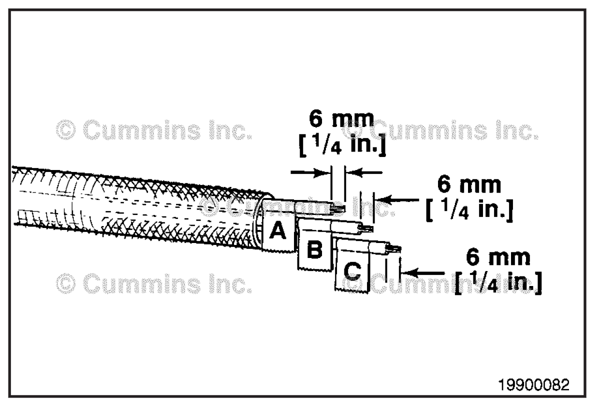
Remove 6 mm [¼ in] of insulation from all three wires using wire crimp tool, Part Number 3822930.

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.

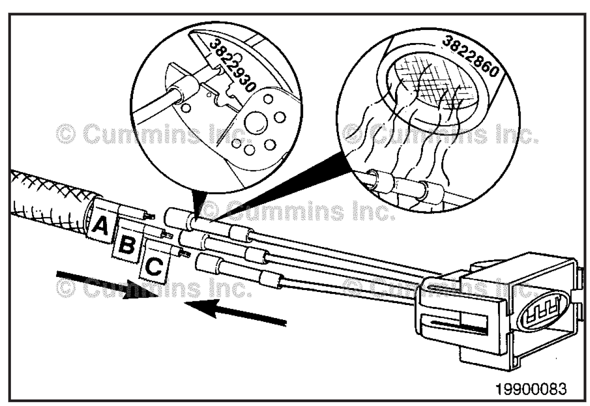
Refer to the wiring diagram in Section E for pin locations.

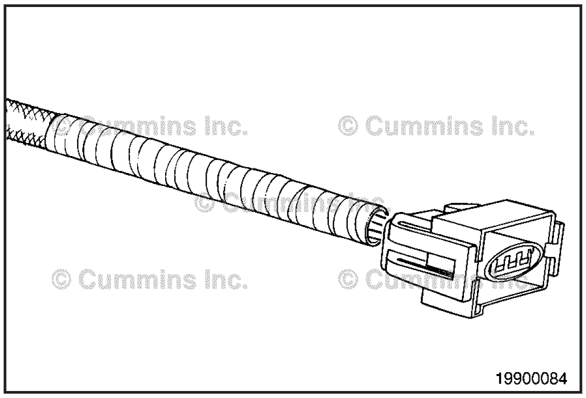
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.



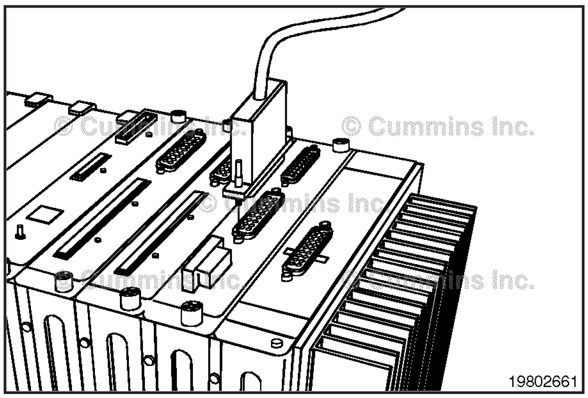
Install the terminal repair wires onto the bare wires and use wire crimping tool, Part Number 3822930, to crimp them together.

Use heat gun, Part Number 3823860, 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.

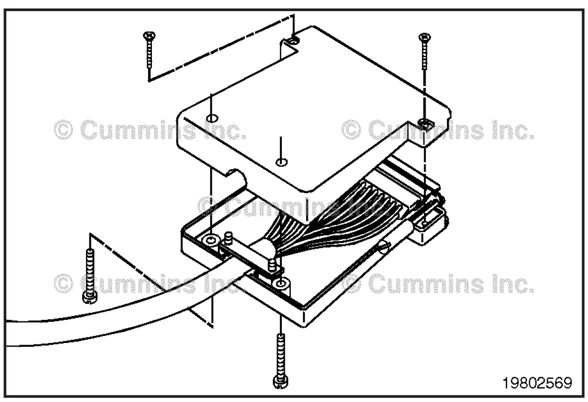


D-Sub Miniature Connector Series (019-213)

Pin Replacement

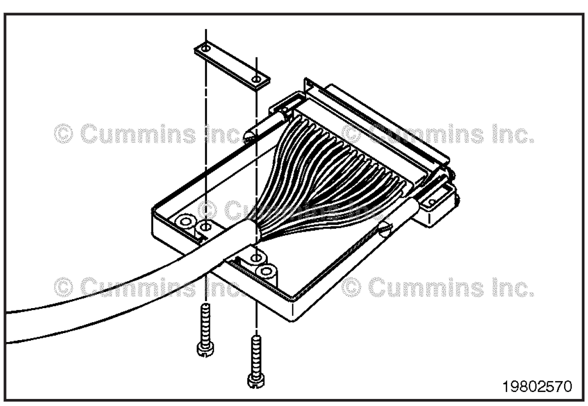
The D-sub miniature connector is used to attach the appropriate harnesses to the ECM.

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.

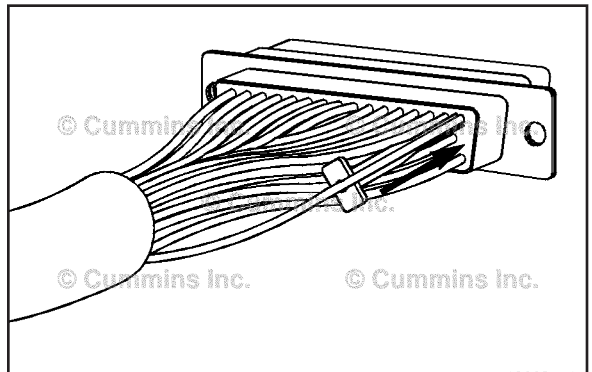
Use the D-sub miniature extraction tool, Part Number 3163971, place over the wire to remove a pin from the connector.

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

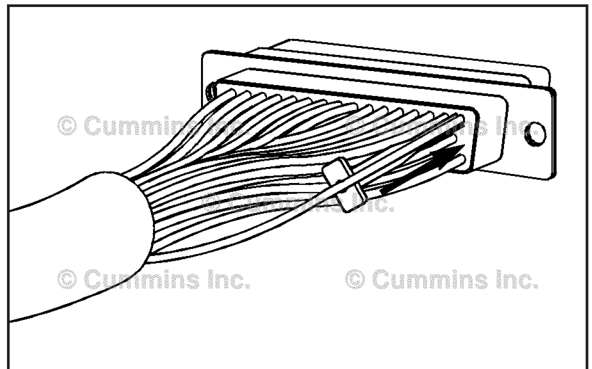
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

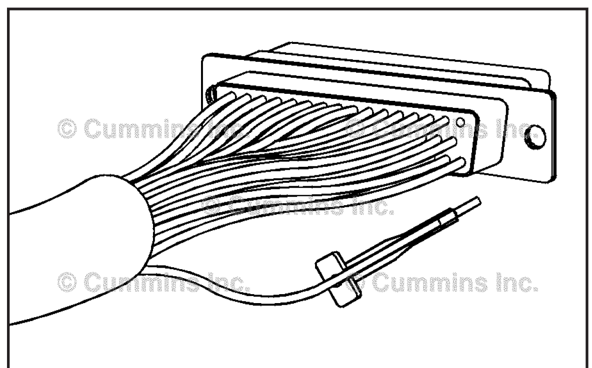
Refer to the wiring diagram in Section E for pin locations.


19802571

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.


19802571

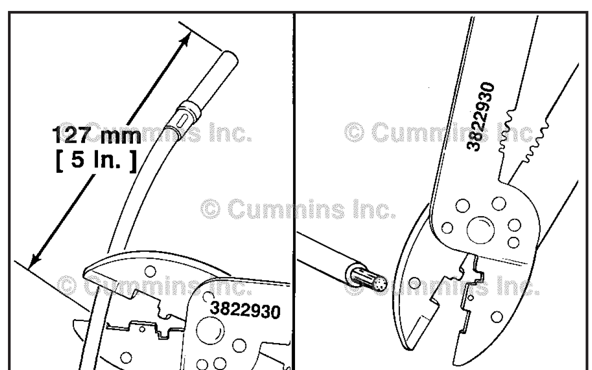
Hold the tool on the terminal flange and pull the wire and connecting pin out of the connector. Note and record the hole from which the pin is removed.


19802572

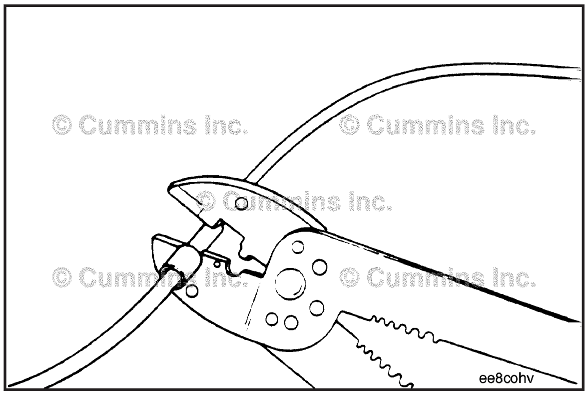
NOTE: The repair wire is 127 mm [5 in] long.

Use wire crimping tool, Part Number 3822930, to cut 127 mm [5 in] off the wire and pin.

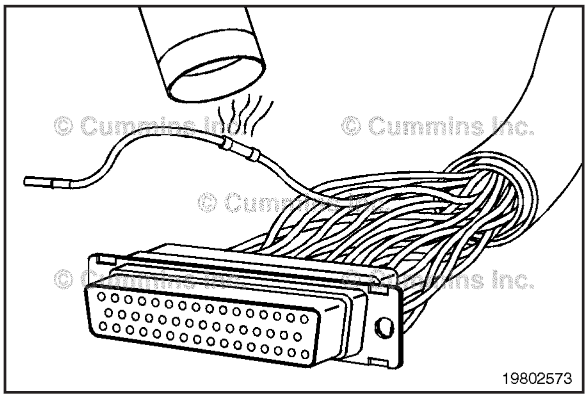
Use the crimping tool to remove 6 mm [¼ in] of insulation from the wire.



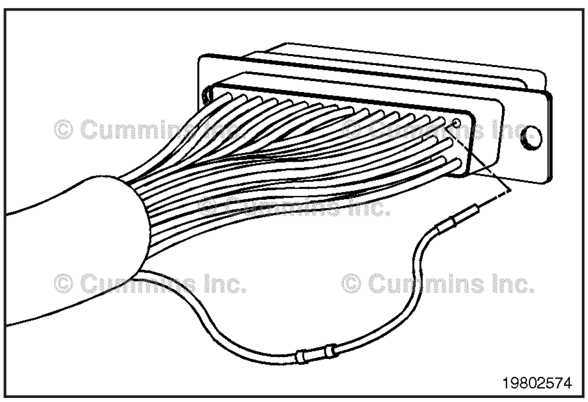
cel37



Use the wire crimping tool to crimp the repair wire onto the bare wire.



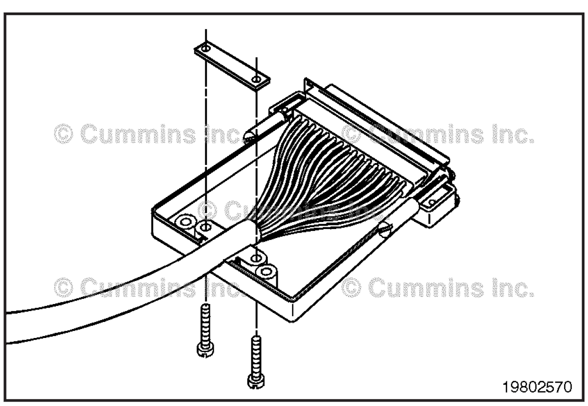
Use heat gun, Part Number 3822860, to heat shrink the tubing around the wire. The tubing will shrink and make the connection waterproof.



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.



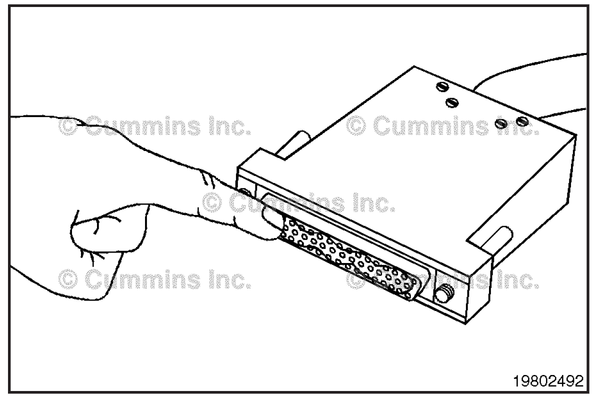
Tighten the strain relief.

Complete the assembly of the backshell by placing the two halves together 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.



Connector Replacement

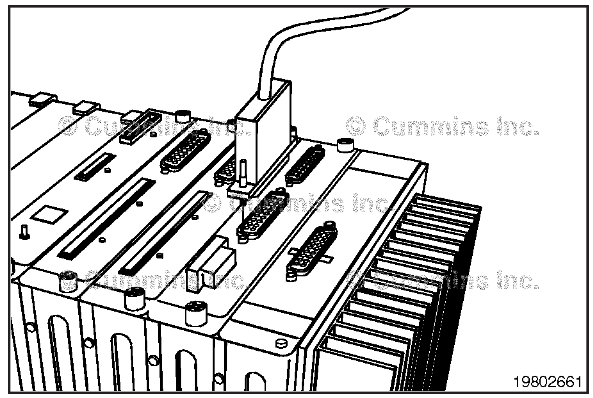
The 50-pin D-sub miniature connector is used to attach the appropriate harnesses to the ECM.

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

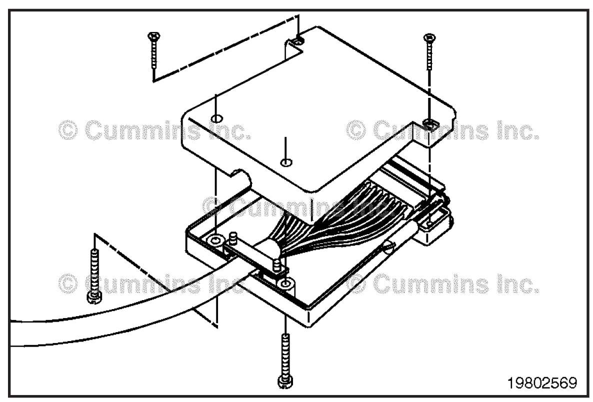
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

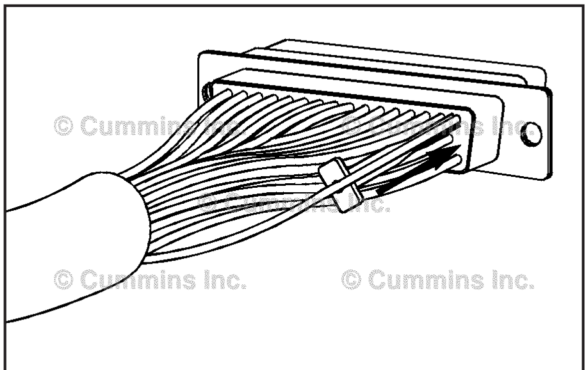
Refer to the wiring diagram in Section E for pin locations.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.



Remove the backshell from the connector. Remove the stain relief.




19802571

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.

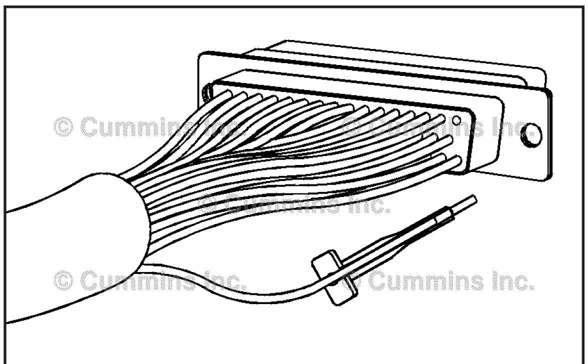
Before installing the new connector, perform a fit test to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

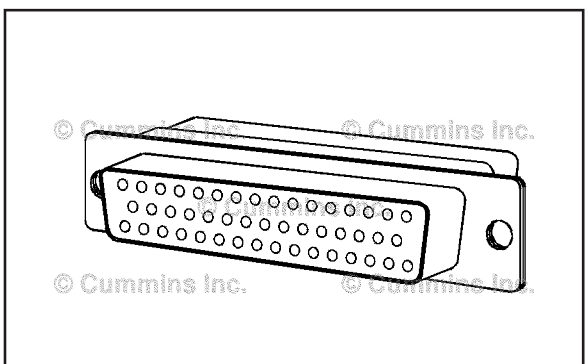
Refer to the wiring diagram in Section E for pin locations.

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.


19802572

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.

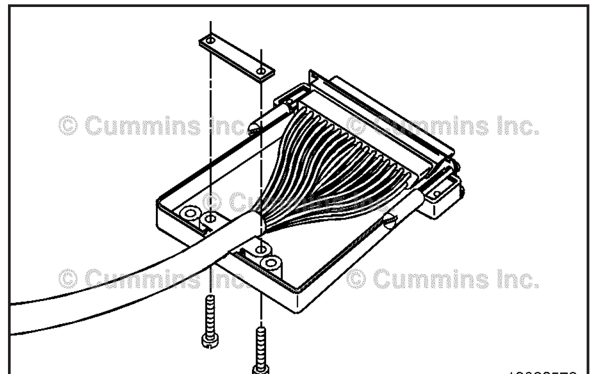

19802575

Insert the pins into the correct holes of the replacement connector.

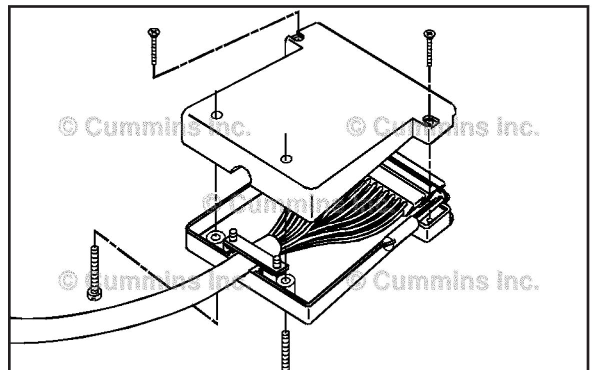
Each pin **must** click into place and hold the wires in the connector.

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.

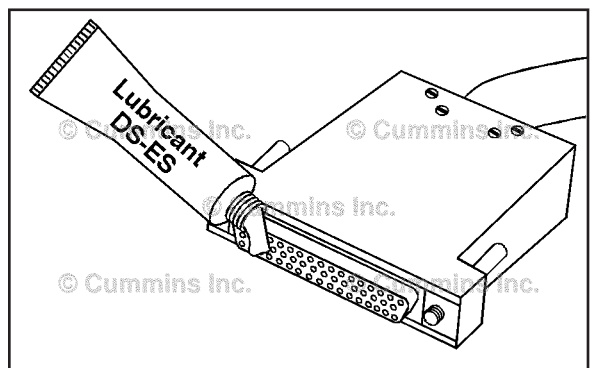

19802570

Complete the assembly of the connector by placing the upper half of the backshell onto the lower half and tightening the screws.


19802569

⚠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.

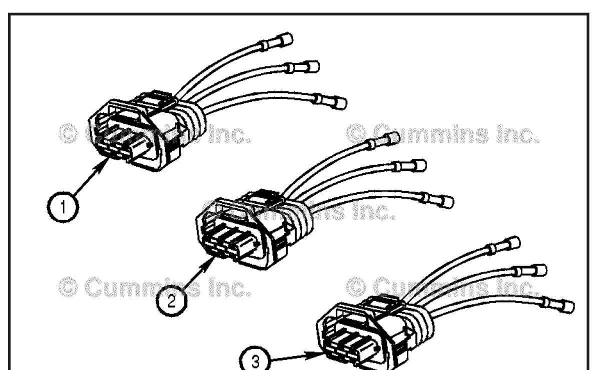


19802491

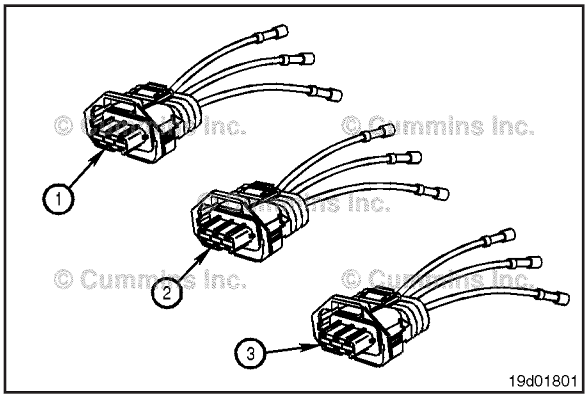
Bosch™ Actuator and Sensor Connector Series (019-214)

Pin Replacement

The connector is **not** repairable. If any part of the connector becomes damaged, replace the connector with the appropriate repair connector.



19d01801



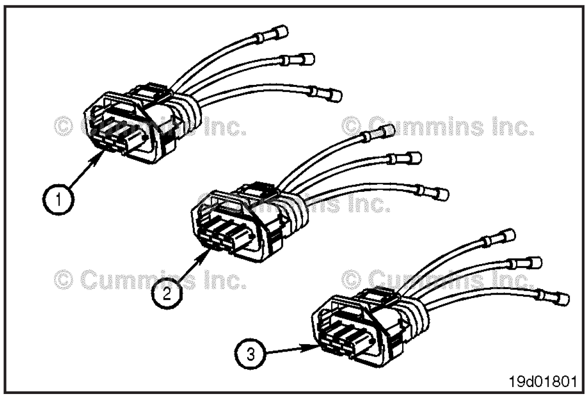
Connector Replacement

Before installing the new connector, perform a test fit to make sure the connector is keyed correctly.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair connector.

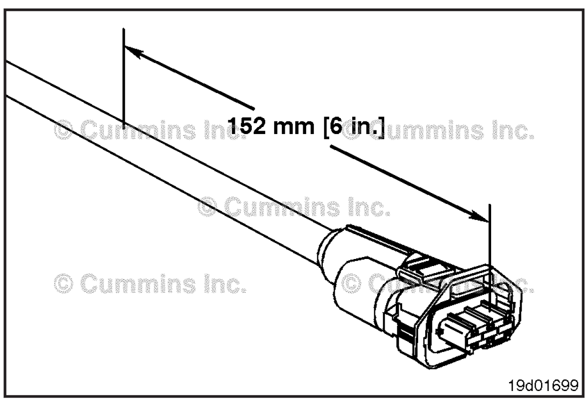
Refer to the wiring diagram in Section E for pin locations.

The connector is **not** repairable. If any part of the connector becomes damaged, replace the connector with the appropriate repair connector.

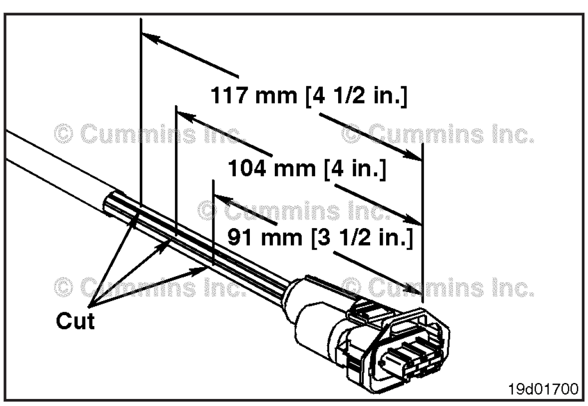


The connectors have different keying and can **not** be interchanged with each other.

Make sure the correct wires are connected to pin 1, pin 2, and pin 3, when replacement is necessary.



Measure 152 mm [6 in] back from the face of the connector, and remove the wiring harness protective cover.



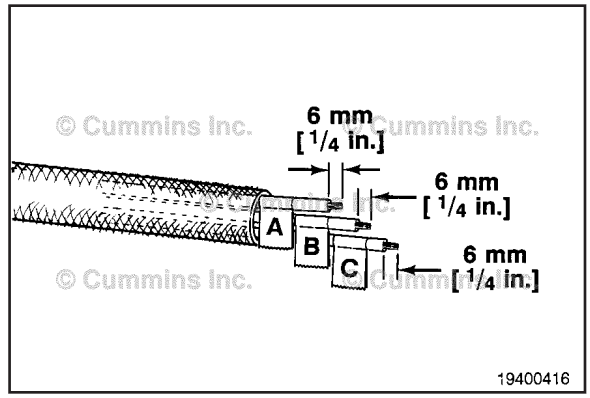
Before cutting the wires, measure and tag the three wires.

Use wire cutters to cut wire 1 117 mm [4-½ in] from the face of the connector.

Use wire cutters to cut wire 2 104 mm [4 in] from the face of the connector.

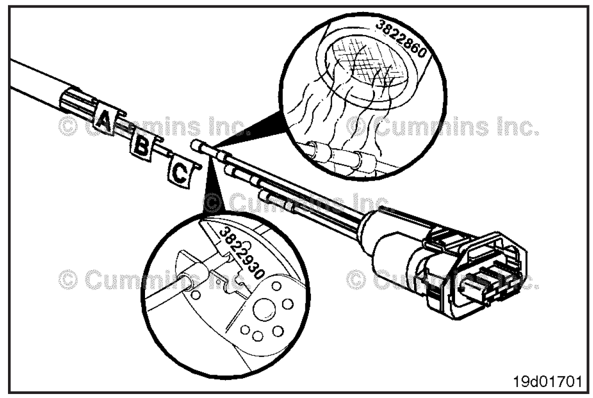
Use wire cutters to cut wire 3 91 mm [3-½ in] from the face of the connector.

Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from all electrical wires.

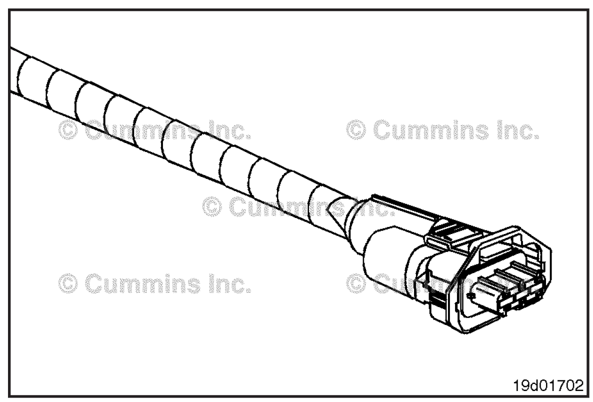


Install the pin repair wires and connector onto the bare wires of the harness and use the wire crimping tool to crimp each repair wire onto the harness.

Use heat gun, Part Number 3822860, to shrink the tubing. The tubing will shrink and make the connection waterproof.



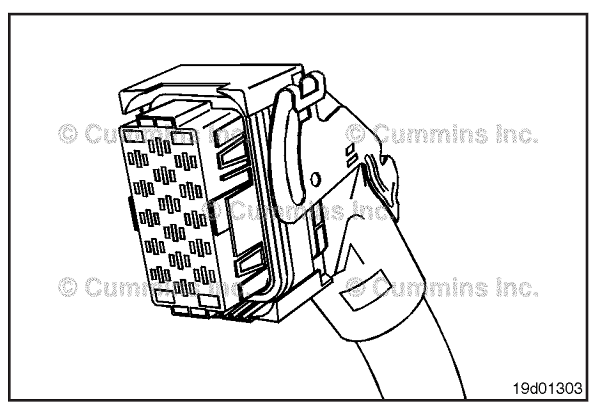
Wrap the wires with tape, for added protection, to complete the repair.

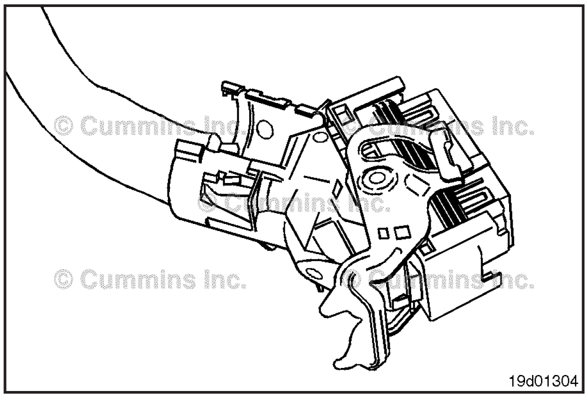


Bosch™ ECM Injector Driver Connector Series (019-215)

Pin Replacement

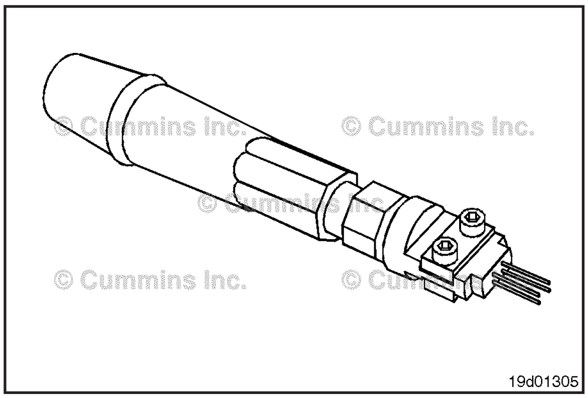
This connector is used to attach the appropriate harness to the ECM.




19d01304

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).

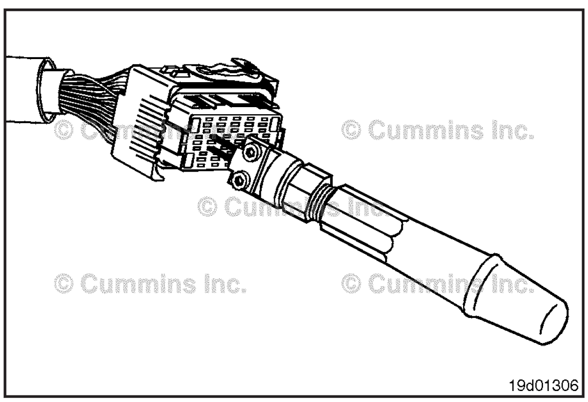
Before pins can be removed, they **must** be unlocked. Slide the purple tabs on the edges of the connector sideways at the same time. When unlocked, the purple tab will align with a slot, making the entire length of the purple tab visible.


19d01305

Use Bosch® extraction tool, Part Number 3164091, place over the wire to remove a pin from the connector.

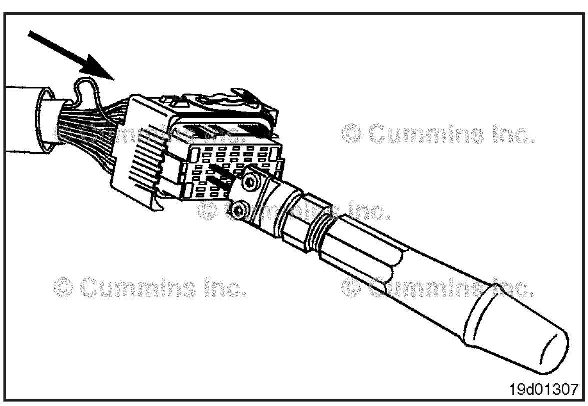
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.


19d01306

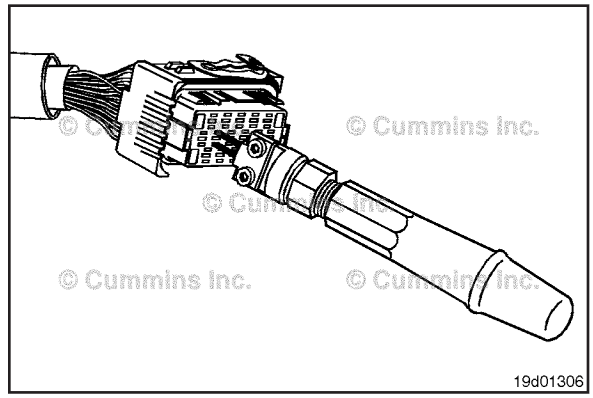
Insert the pin extraction tool into the unlocking holes in the connector.

Do **not** push the tool all the way into the connector.


19d01307

Push the corresponding wire toward the pin extraction tool.

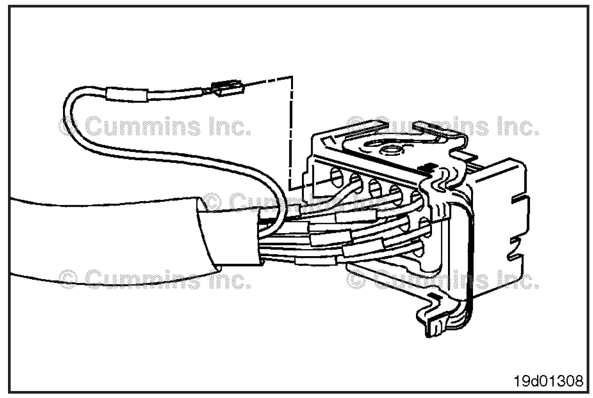
Press the pin extraction tool all the way into the connector.



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.

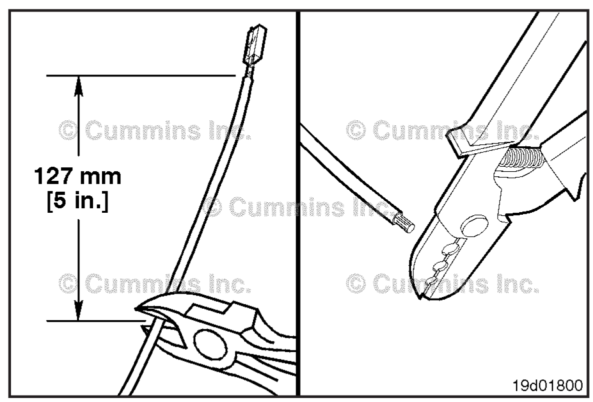


NOTE: The repair wire is 127 mm [5 in] long.

Use wire cutters to cut 127 mm [5 in] off the wire and pin.

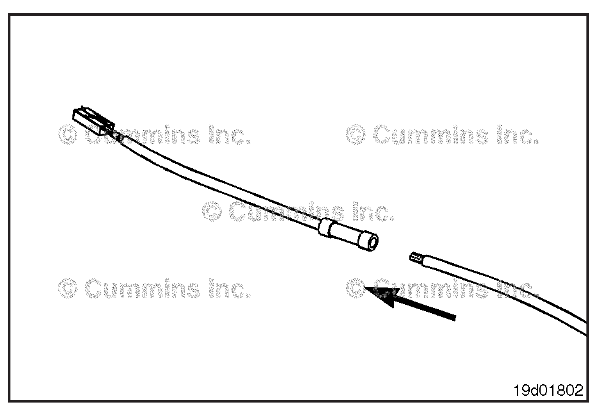
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

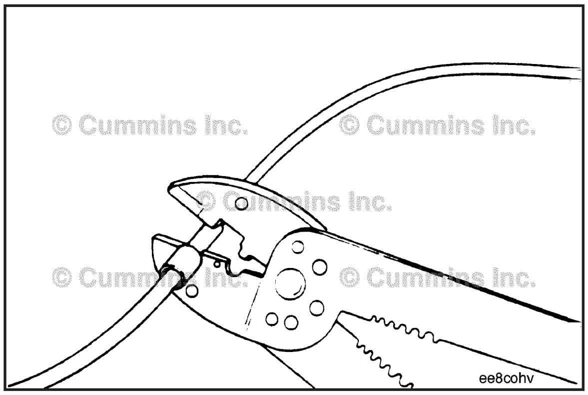
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.



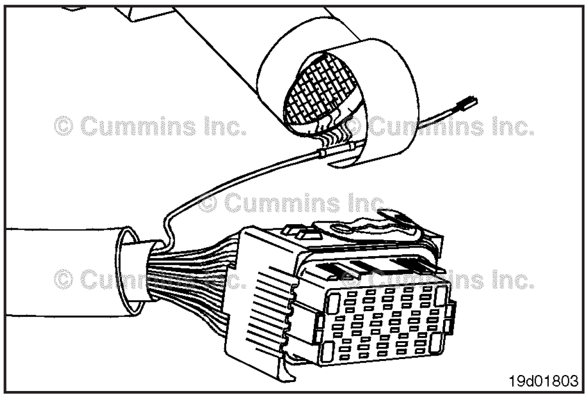
Install the repair wire on the bare wire.

Make sure the bare wire extends into the splice connector.

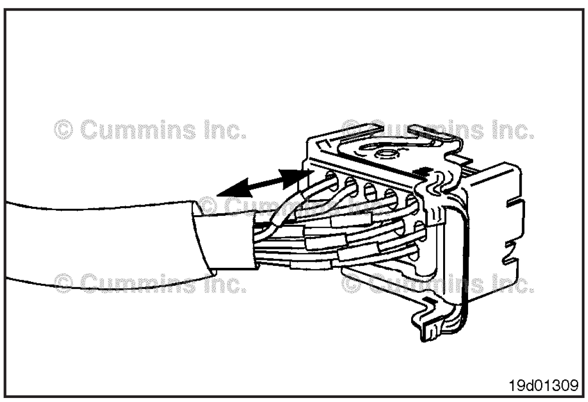




Use the wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



Use heat gun, Part Number, 3822860, to heat the shrink tubing around the wire. The tubing will shrink and make the connection waterproof.



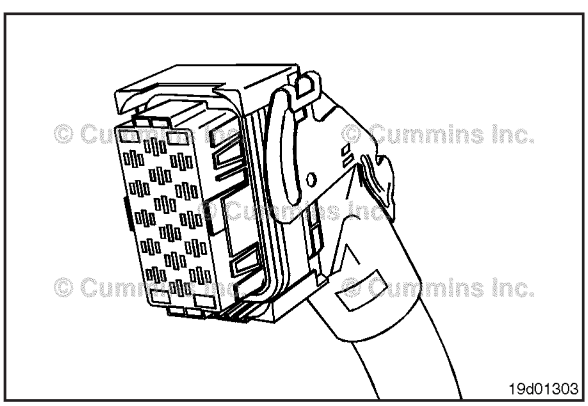
The wire terminal has locating pins that **only** allow it to be inserted in a certain orientation.

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.

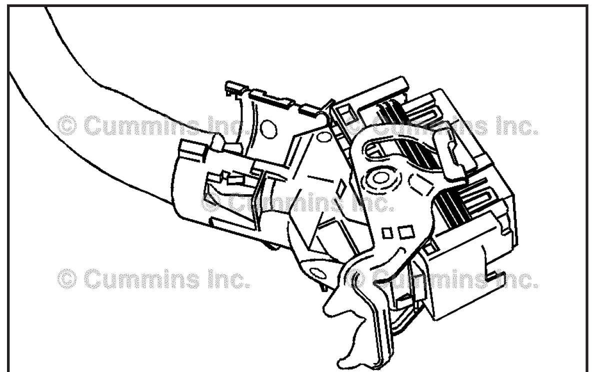


Connector Replacement

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.



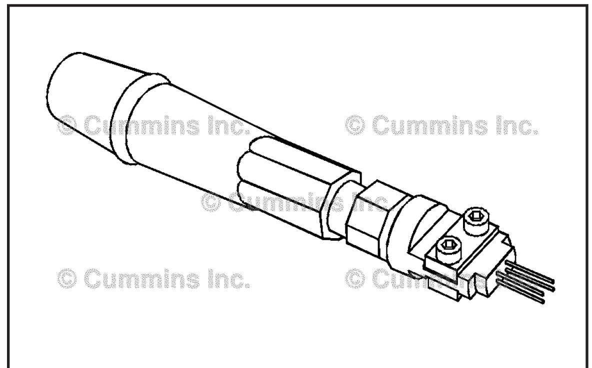
19d01304

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.

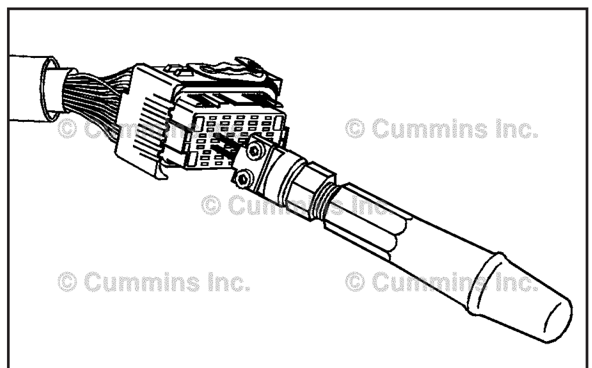
To replace the connector, use Bosch® extraction tool, Part Number 3164091, over each wire to remove all pins from the connector.



19d01305

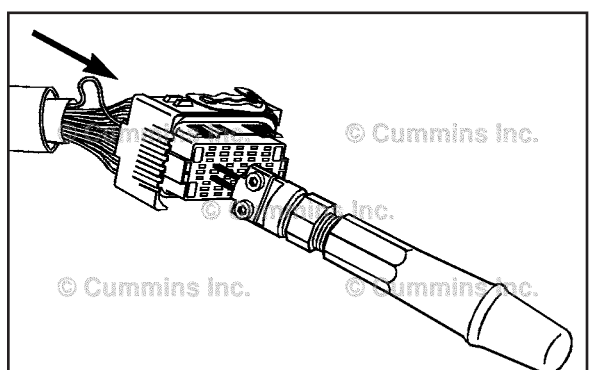
Insert the pin extraction tool into the unlocking holes in the connector.

Do **not** push the tool all the way into the connector.

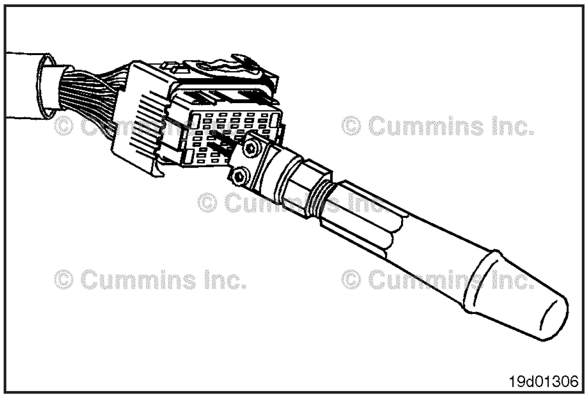


19d01306

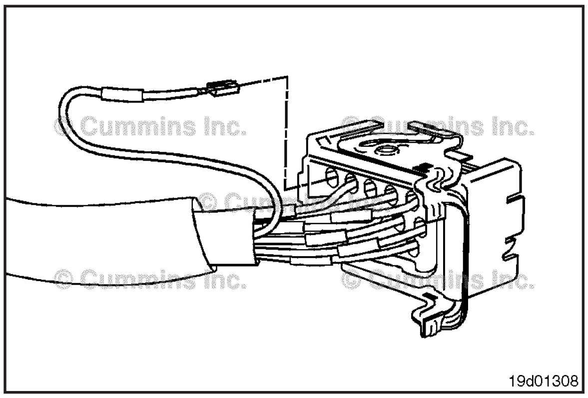
Push the corresponding wire toward the pin extraction tool.



19d01307



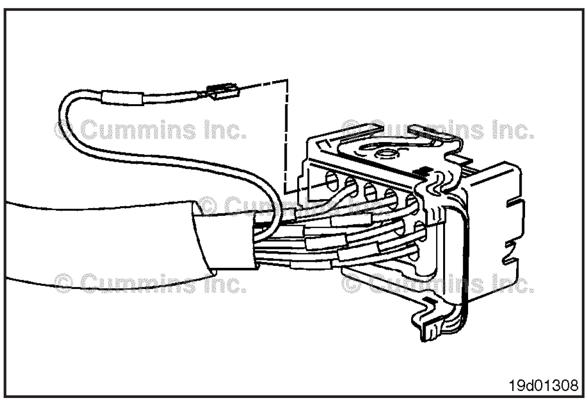
Press the pin extraction tool all the way into the connector.



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.

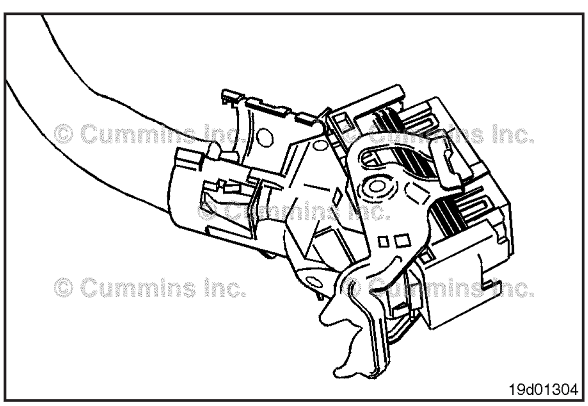
Refer to the wiring diagram in Section E for pin locations.

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.



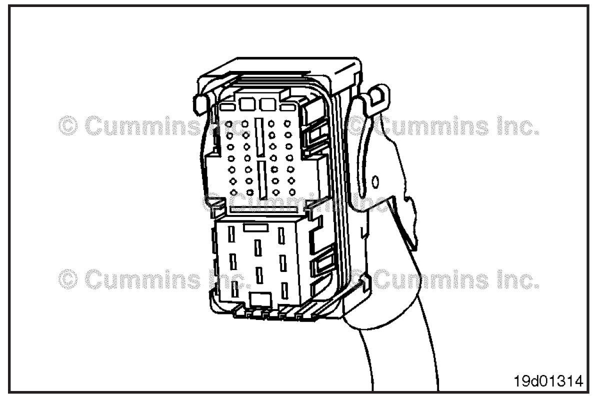
Replace the connector shell by inserting the hinge of the connector shell (black) into the hinge of the connector (red).

Close the connector shell onto the connector and wiring harness by pressing it onto the tang of the connector until a click is heard.

Bosch™ ECM Actuator and Sensor Connector Series (019-216)

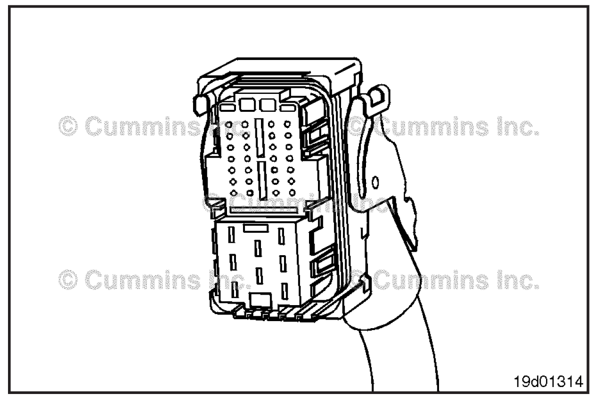
Pin Replacement

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.

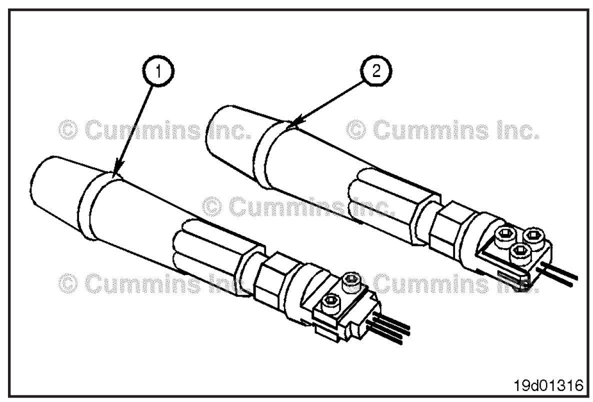


Use Bosch® extraction tool (2), Part Number 3164093, (small terminals), or use Bosch® extraction tool (1), Part Number 3164091 (large terminals), over the wire to remove a pin from the connector.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

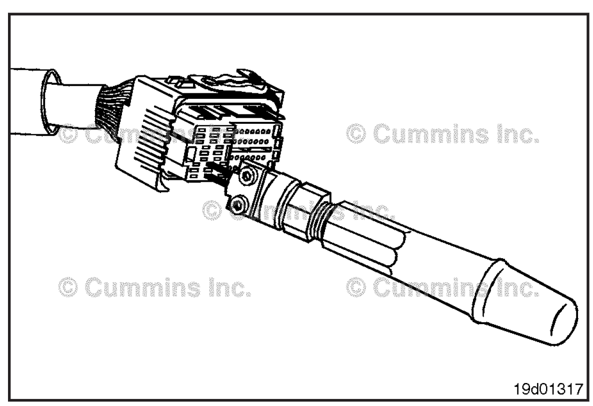
Refer to the wiring diagram in Section E for pin locations.

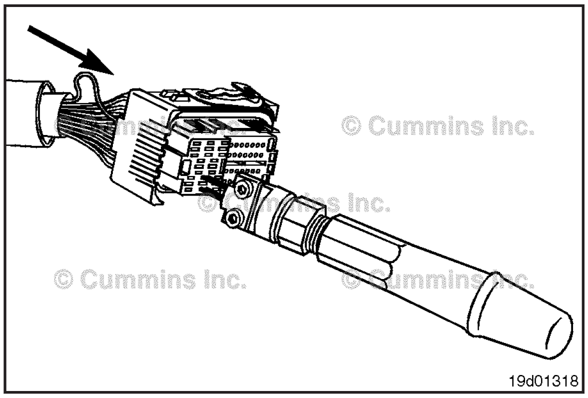
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.



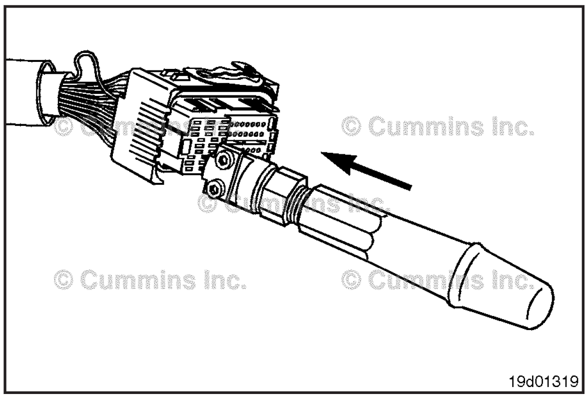
Insert the pin extractor tool into the unlocking holes in the connector.

Do **not** push the tool all the way into the connector.

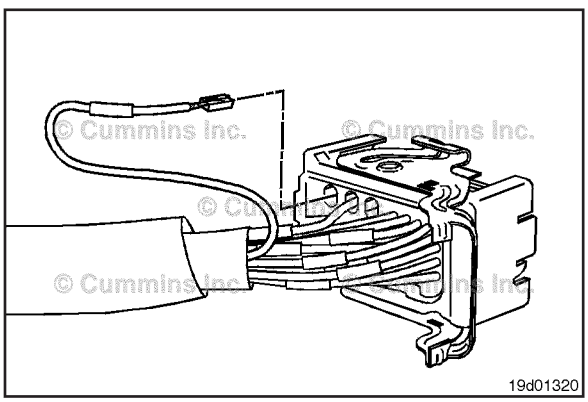




Push the corresponding wire toward the pin extraction tool.



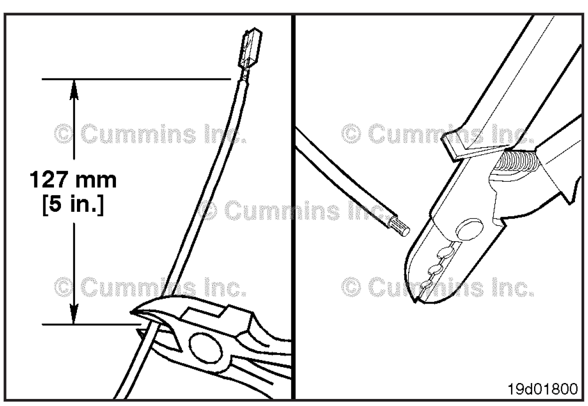
Press the pin extraction tool all the way into the connector.



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.



NOTE: The repair wire is 127 mm [5 in] long.

Use wire cutters to cut 127 mm [5 in] of the wire and pin.

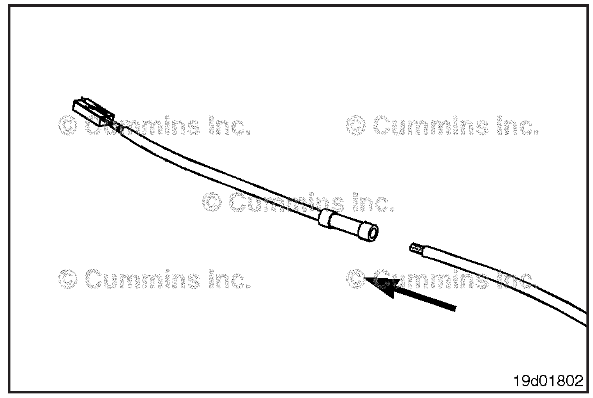
Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from the wire.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

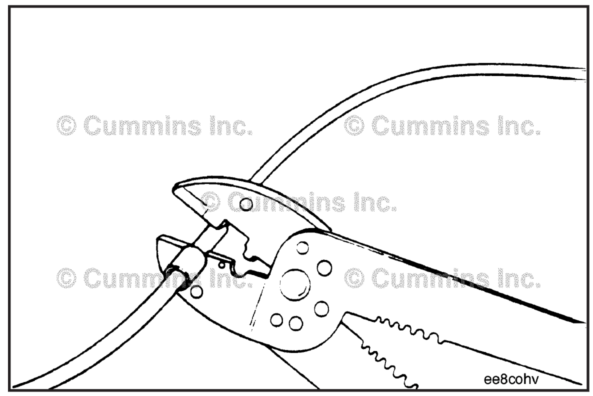
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

Install the repair wire on the bare wire.

Make sure the bare wire extends into the splice connector.

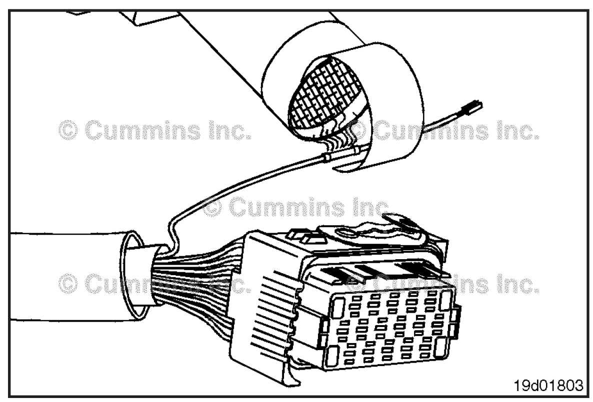


Use wiring crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.



Use heat gun, Part Number 3822860, to heat the shrink tubing around the wire.

The tubing will shrink and make the connection waterproof.



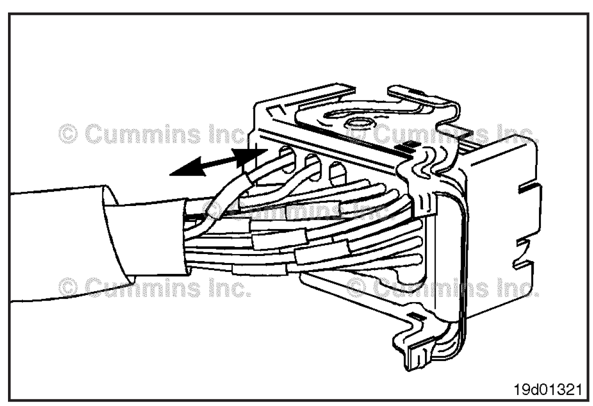
The wire terminal has locating pins that **only** allow it to be installed in a certain orientation.

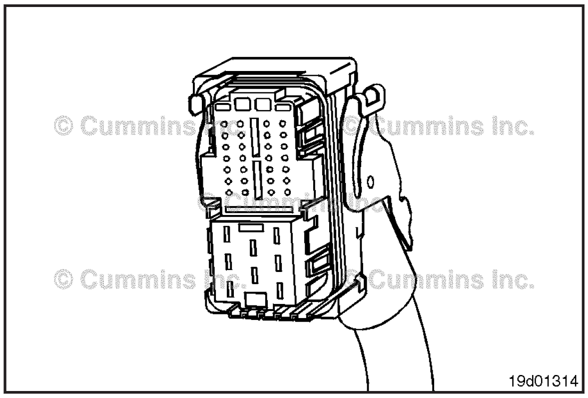
Insert the wire from the backside of the connector.

Push the wire into the connector.

Pull the wire gently to make sure it is locked into the connector.

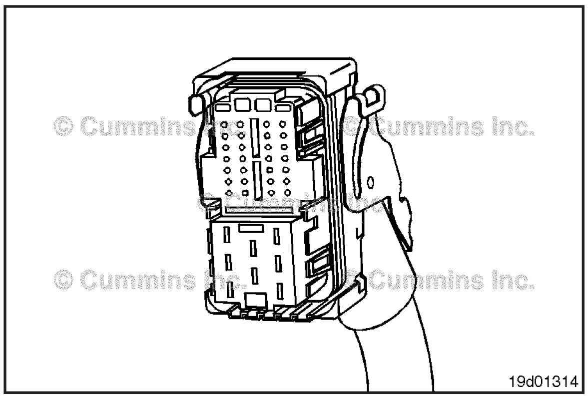
NOTE: If the wire's locking tang has **not** latched, then remove the wire, pry the tang away from the terminal, and repeat this step.





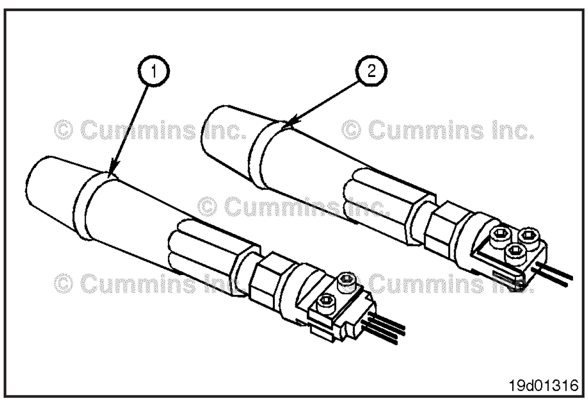
Connector Replacement

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.

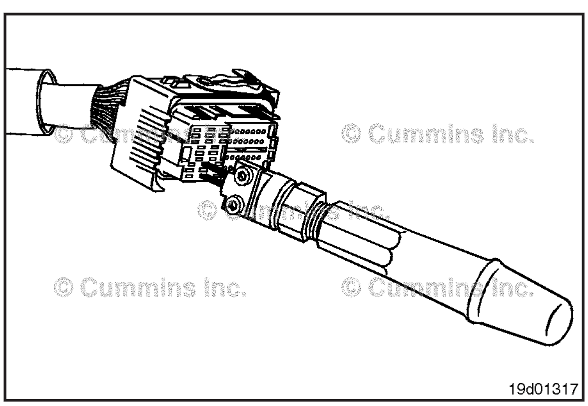


Use Bosch® extraction tool (2), Part Number 3164093, (small terminals), or use Bosch® extraction tool (1), Part Number 3164091 (large terminals), over the wire to remove a pin from the connector.

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.

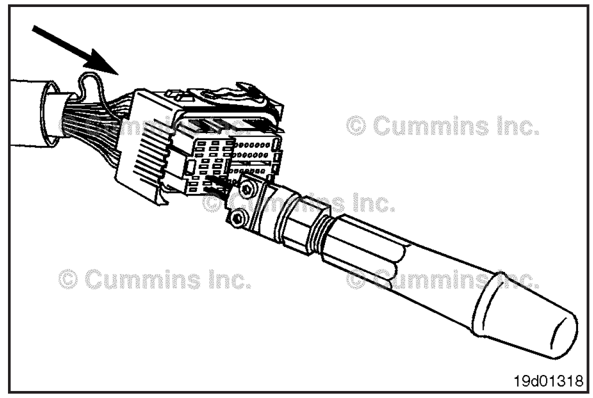
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.



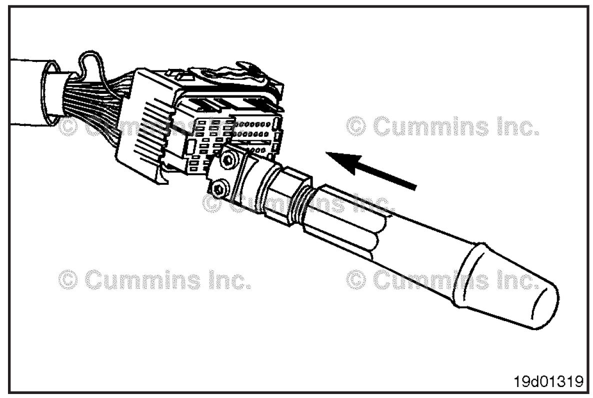
Insert the pin extraction tool into the unlocking holes in the connector.

Do **not** push the tool all the way into the connector.

Push the corresponding wire toward the pin extraction tool.


19d01318

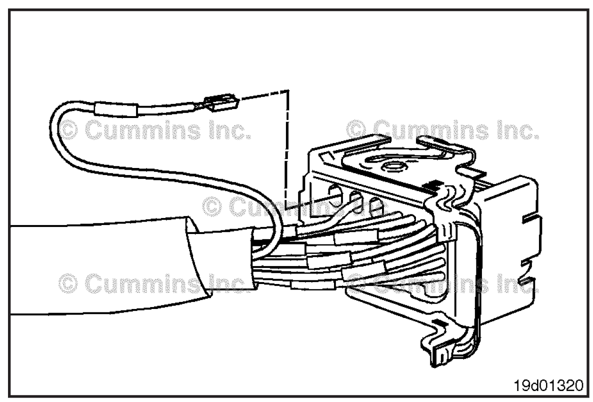
Press the pin extraction tool all the way into the connector.


19d01319

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.

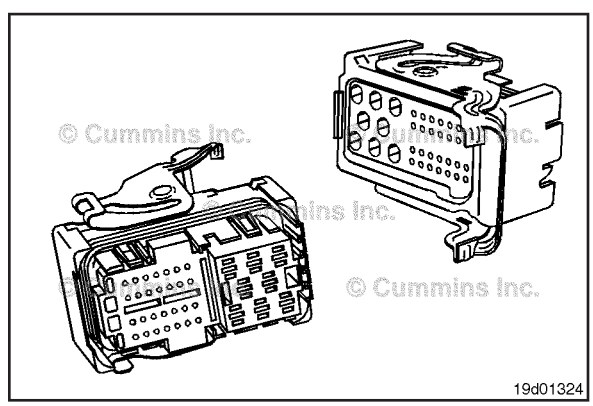
Carefully pull the wire out of the connector and record the hole from which the pin is removed. If it is difficult to remove, repeat the entire procedure.

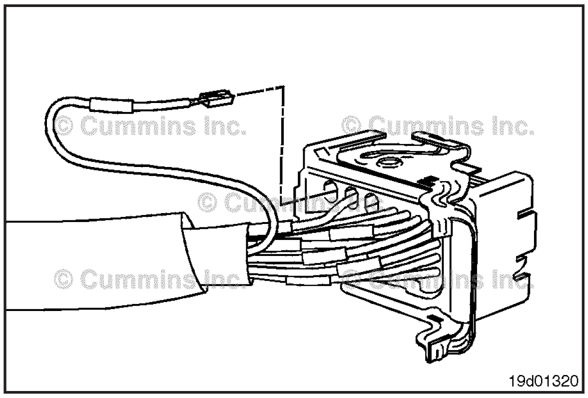

19d01320

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.

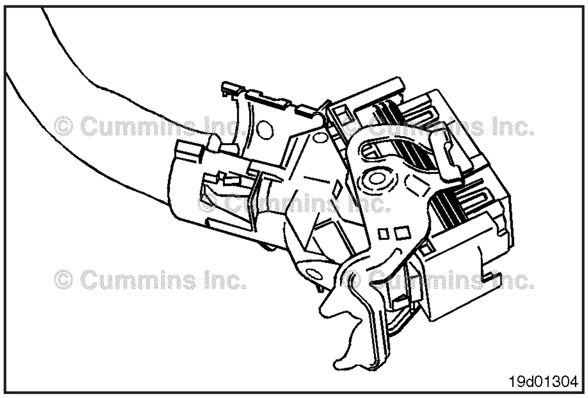

19d01324



Insert the pins into the correct hole of the replacement connector.

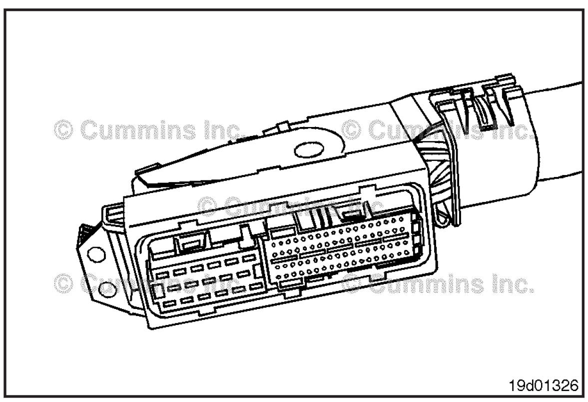
Each pin **must** click into place and hold the wires in the connector.

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).

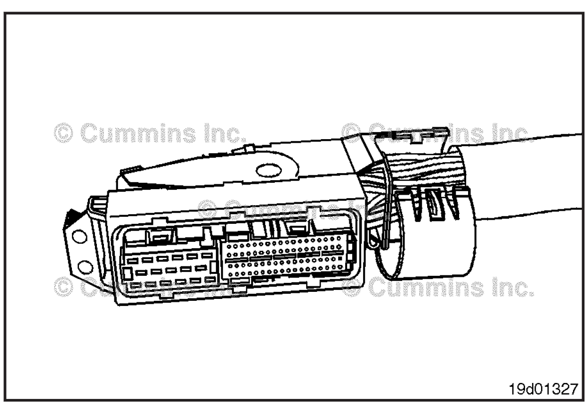
Close the connector shell onto the connector and wiring harness by pressing it on the tang of the connector until a click is heard.



Bosch™ ECM OEM Connector Series (019-217)

Pin Replacement

This connector is used to attach the appropriate harness to the ECM.



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).

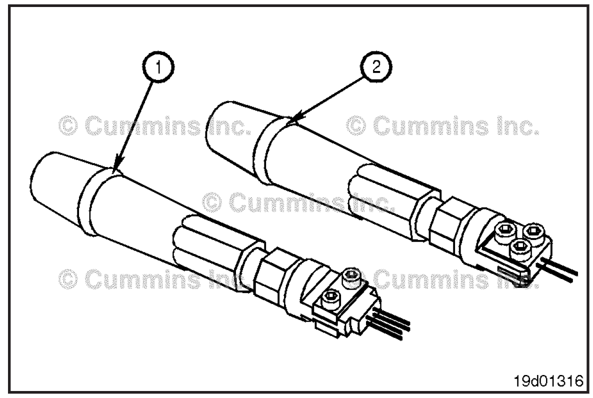
Before pins can be removed, they **must** be unlocked. Slide the purple tabs on the edges of the connector sideways at the same time. When unlocked, the purple tab will align with a slot, making the entire length of the purple tab visible.

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.

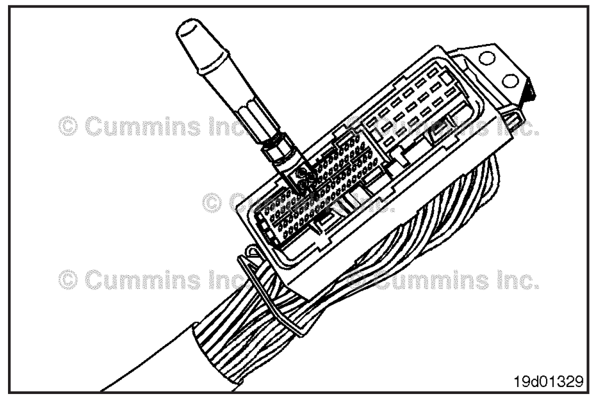
Refer to the wiring diagram in Section E for pin locations.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

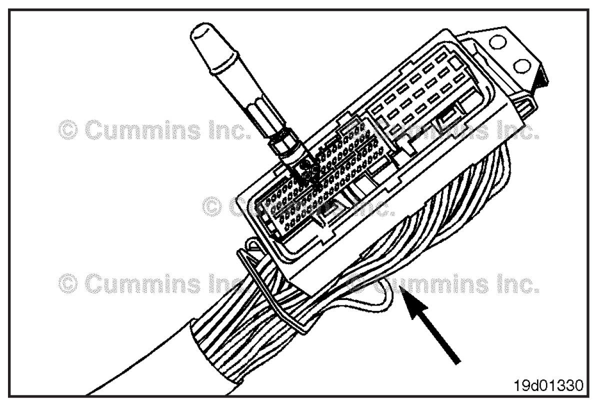


Insert the pin extraction tool into the unlocking holes in the connector.

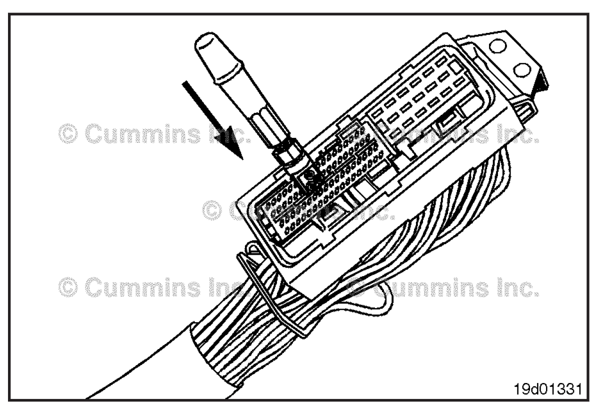
Do **not** push the tool all the way into the connector.

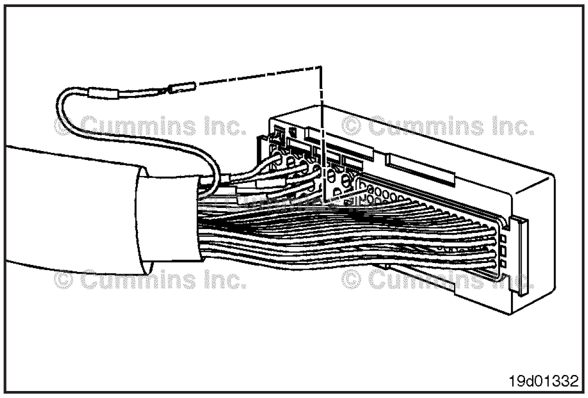


Push the corresponding wire toward the pin extraction tool.



Press the pin extraction tool all the way into the connector.

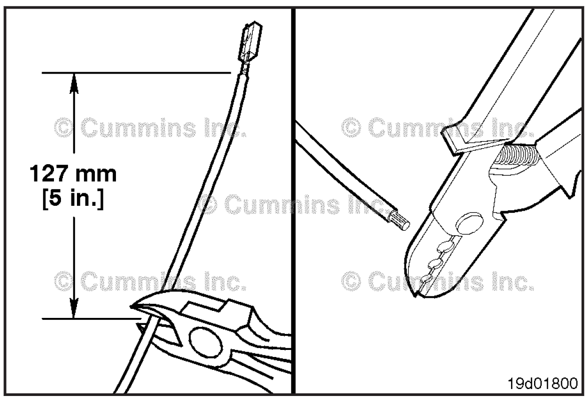




⚠CAUTION⚠

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.



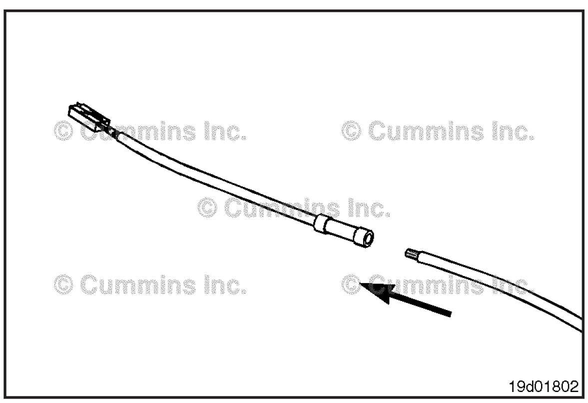
NOTE: The repair wire is 127 mm [5 in] long.

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.

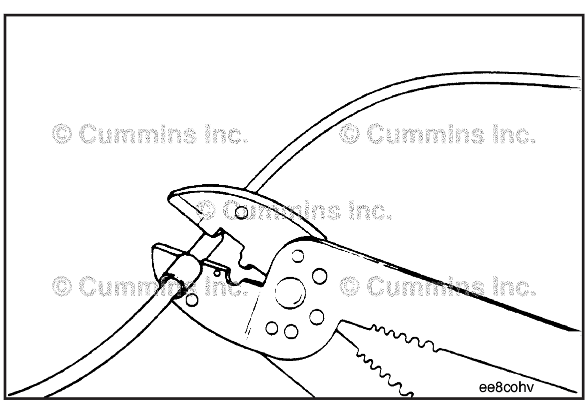
Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.

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.

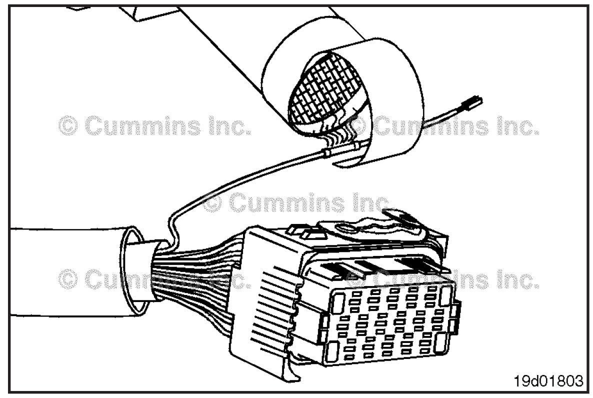
Make sure the bare wire extends into the splice connector.



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.


19d01803

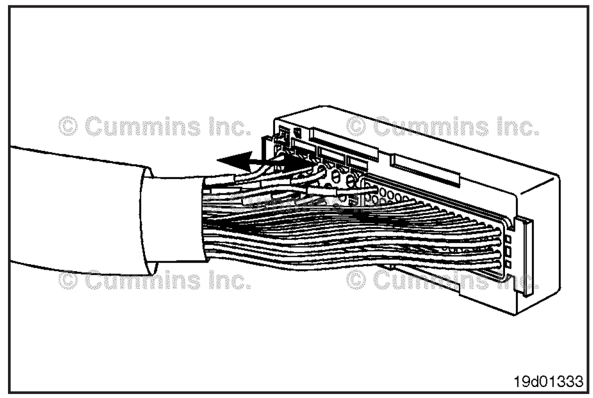
The wire terminal has locating pins that **only** allow it to be installed in a certain orientation.

Insert the wire from the backside of the connector.

Push the wire into the connector.

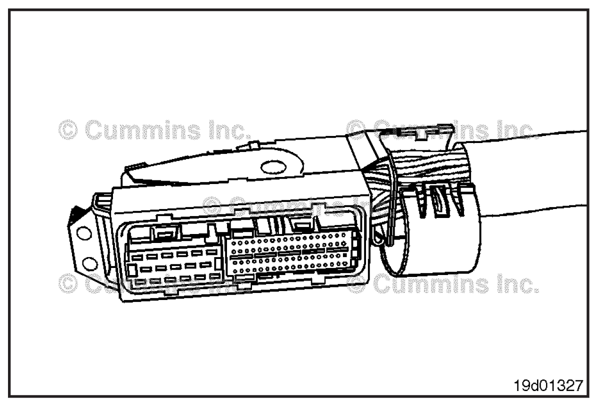
Pull the wire gently to make sure it is locked into the connector.

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.


19d01333

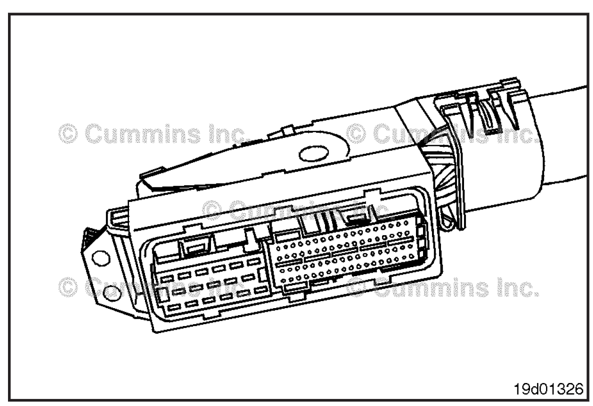
Replace the connector shell by inserting the hinge of the connector shell (black) into the hinge of the connector (red).

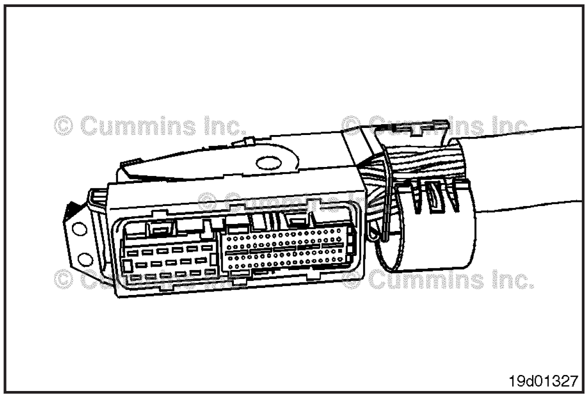
Close the connector shell onto the connector and wiring harness by pressing it onto the tang of the connector until you hear it click.


19d01327

Connector Replacement

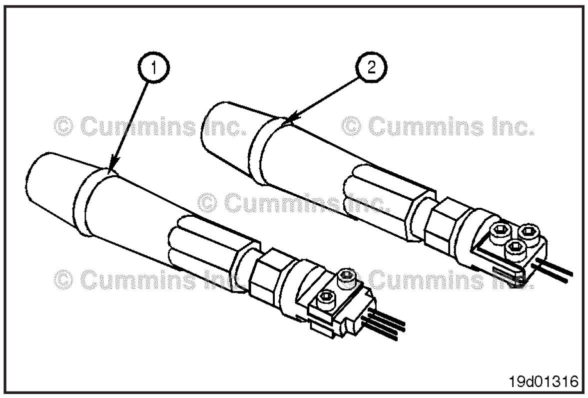
This connector is used to attach the appropriate harness to the ECM.


19d01326



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.

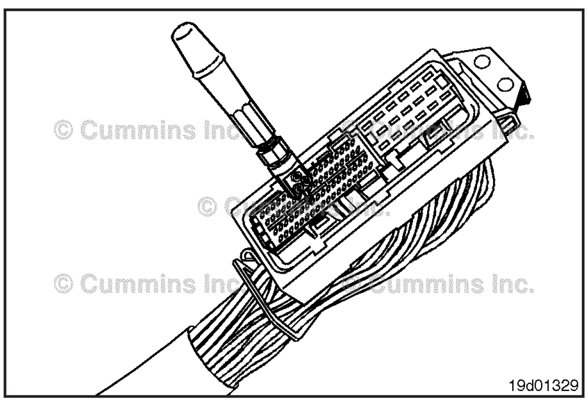


Use Bosch® extraction tool (2), Part Number 3164093, (small terminals), or use Bosch® extraction tool (1), Part Number 3164091 (large terminals), over the wire to remove a pin from the connector.

Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

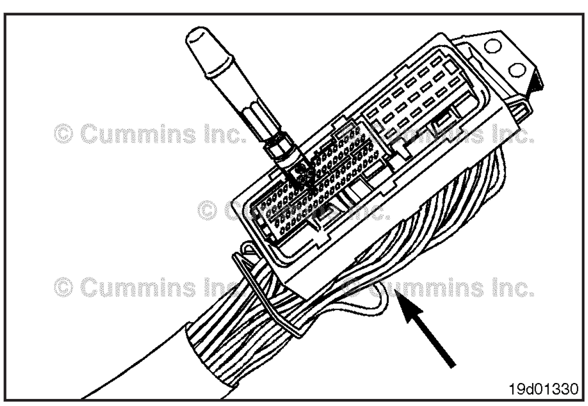
Refer to the wiring diagram in Section E for pin locations.

Refer to the appropriate wiring repair kit in the service tools table in the front of Section 19 for the correct repair wire.



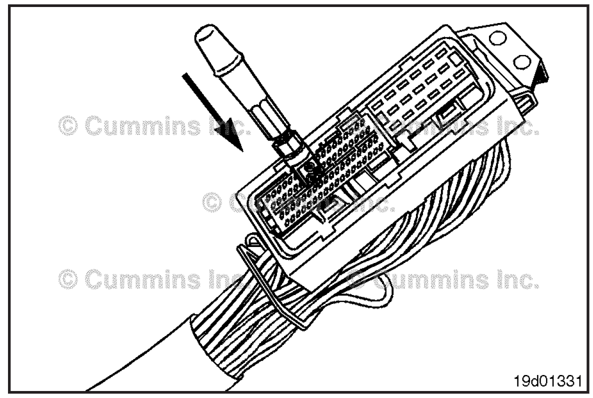
Insert the pin extraction tool into the unlocking holes in the connector.

Do **not** push the tool all the way into the connector.



Push the corresponding wire toward the pin extraction tool.

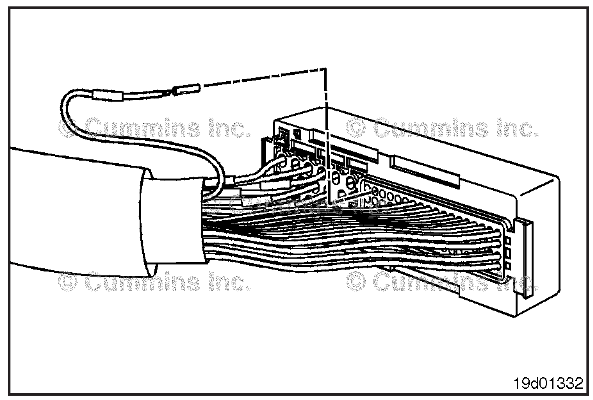
Press the pin extraction tool all the way into the connector.



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.

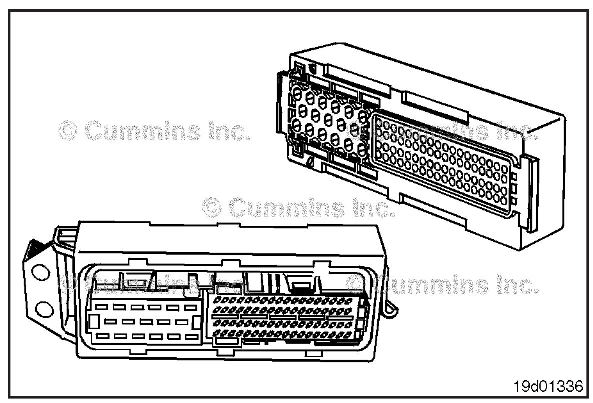
Carefully pull the wire out of the connector. If it is difficult to remove, repeat the entire procedure.



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.

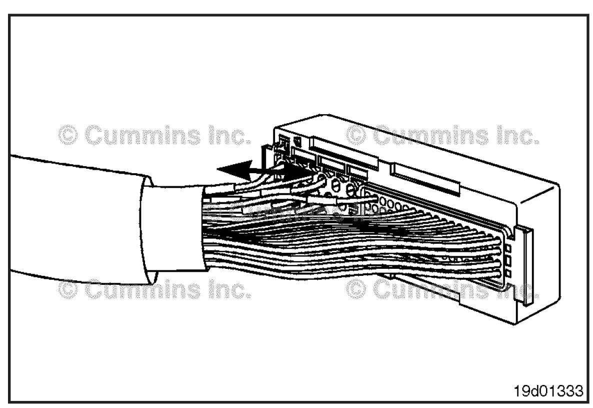
Refer to the wiring diagram in Section E for pin locations.

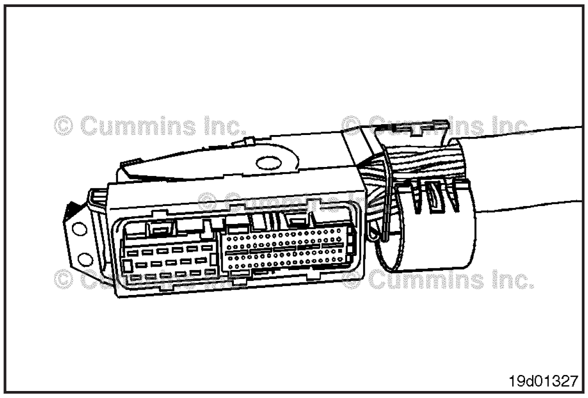


Insert the pins into the correct hole of the replacement connector.

Each pin **must** click into place and hold the wires in the connector.

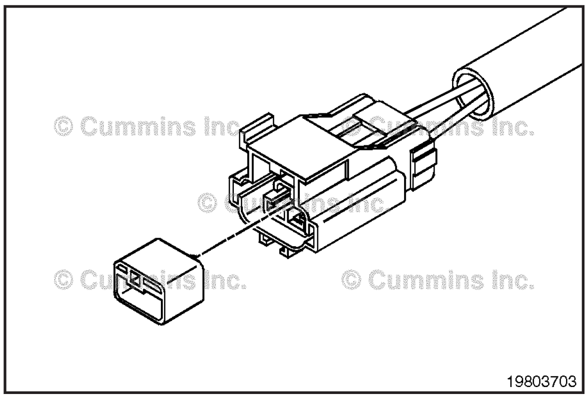
Pull each wire gently to make sure it is seated in the connector.




19d01327

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.


19803703

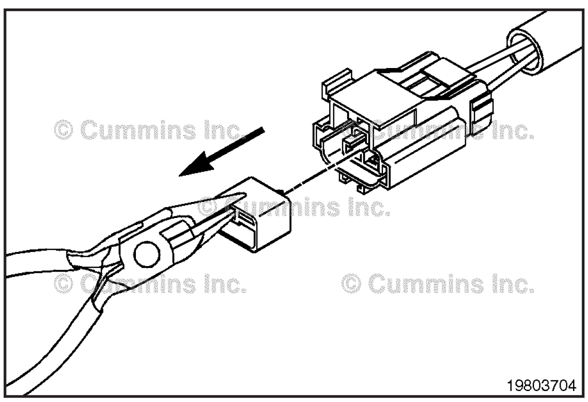
Framatome Connector Series (019-218)

Pin Replacement

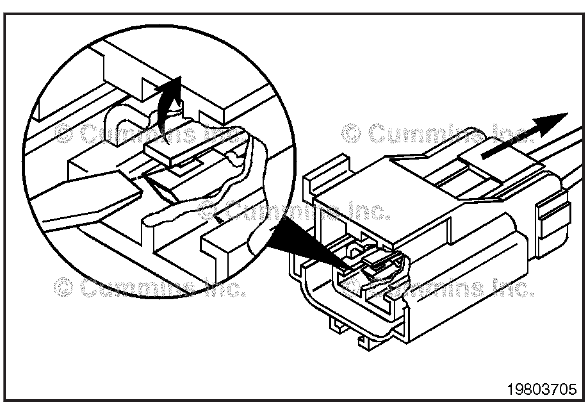
The connector can have multiple pin configurations. All type of connectors are repaired in the same manner.

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.


19803704

To replace the pin in the receptacle connector, remove the blue inter connector lock using needle nose pliers.


19803705

△CAUTION△

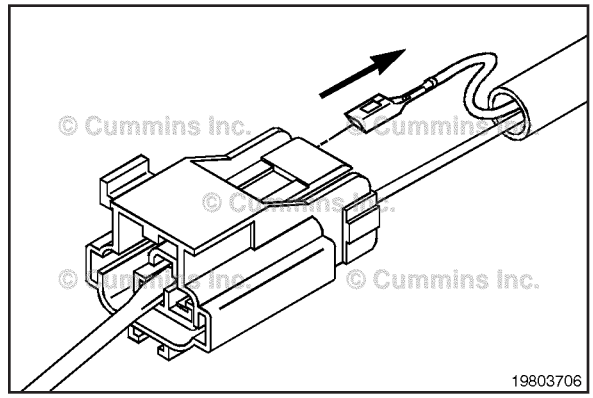
The locking finger can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

To remove the contact out of the connector body, gently pull wire backward, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.

CAUTION

If more than one wire is being repaired, tag each wire and install it in the original location. Electrical damage can occur if a wire is installed in the incorrect location.

Pull the wire and the terminal out of the connector body.



Refer to the appropriate wiring repair kit in the service tools table in the front of this section for the correct repair wire.

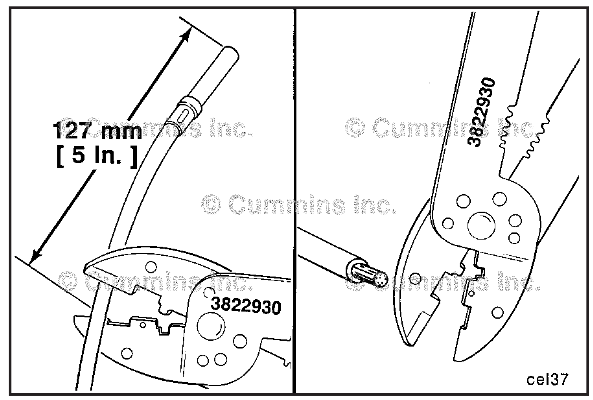
Replace one contact wire at a time. If more than one wire needs replaced, attach a lettered tag to each wire removed.

Refer to the wiring diagram in Section E for pin locations.

Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

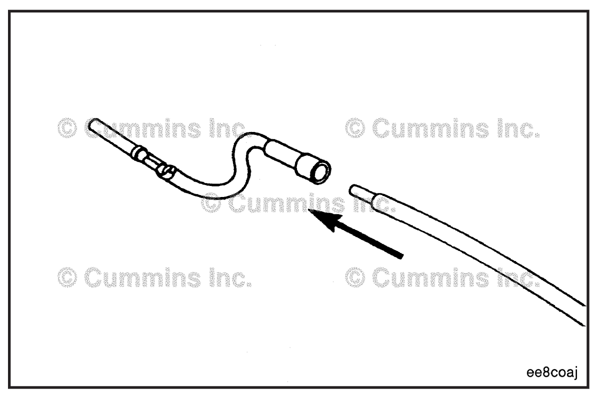
Use wire crimping tool, Part Number 3822930, to cut 127 mm [5 in] off the wire and pin.

Use wire crimping tool, Part Number 3822930, to remove 6 mm [¼ in] of insulation from the wire.

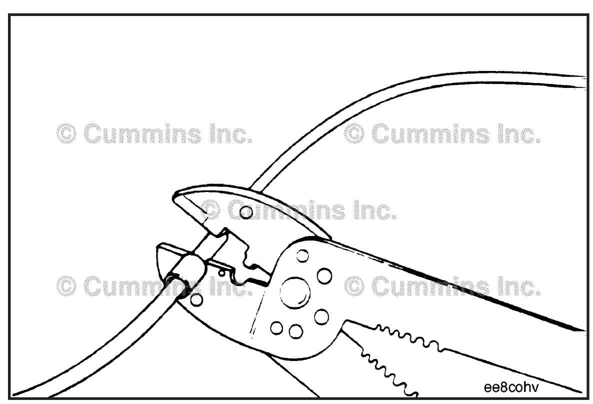


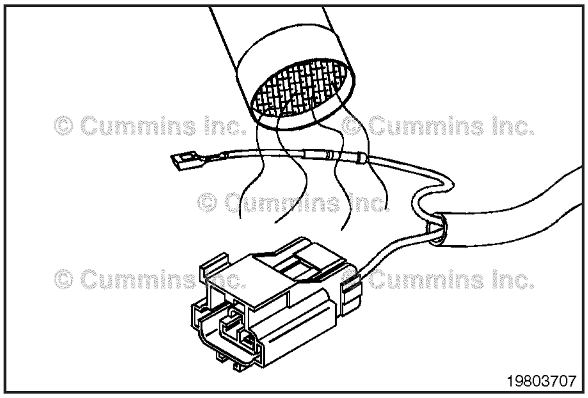
Install the correct repair wire on the bare wire.

Make sure the bare wire extends into the splice connector.



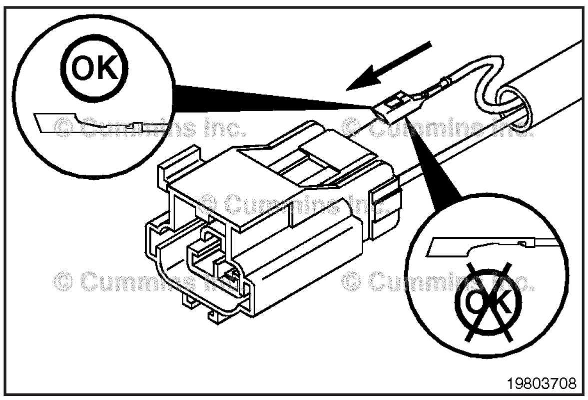
Use wire crimping tool, Part Number 3822930, to crimp the repair wire onto the bare wire.





Use heat gun, Part Number 3822860, to heat shrink the tubing around the wire.

The tubing will shrink and make the connection waterproof.

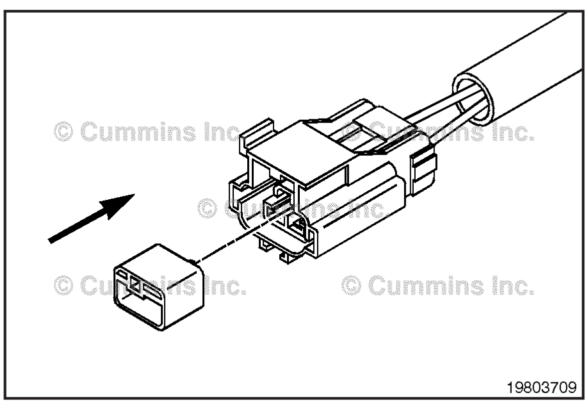


CAUTION

If more than one wire is repaired or if the connector body is replaced, make sure to insert wires into the same locations as they are in the original connector. If wires are not in the original location, electrical damage can occur.

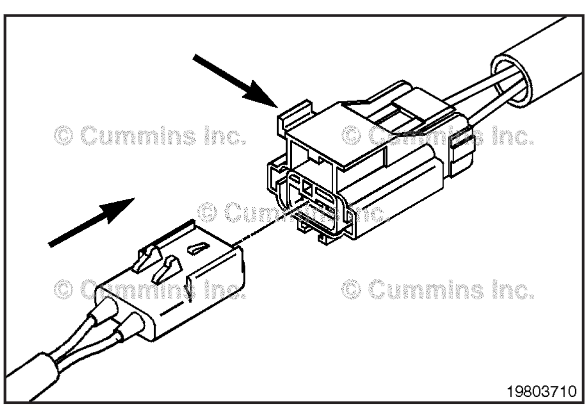
Install the wire and terminal into the connector body. Push the wire and terminal into the seal at the back of the connector. Install the replacement terminal and wire so that the longest point of the terminal is closest to the connector locking tab.

Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.



Once the wires are in place, insert the blue inter connector lock with the locking tab positioned towards the connector locking tab.

Push the blue inter connector lock in until it snaps in place.



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.

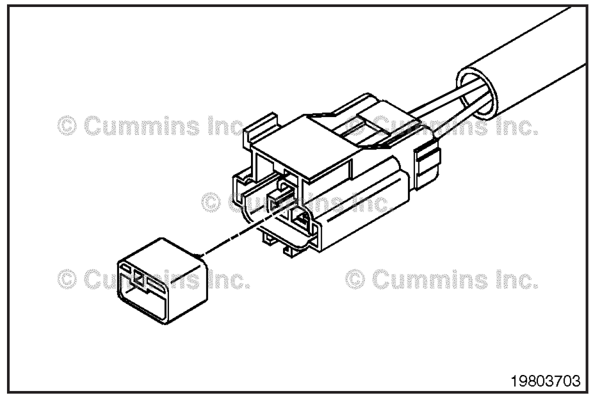
Connector Replacement

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.

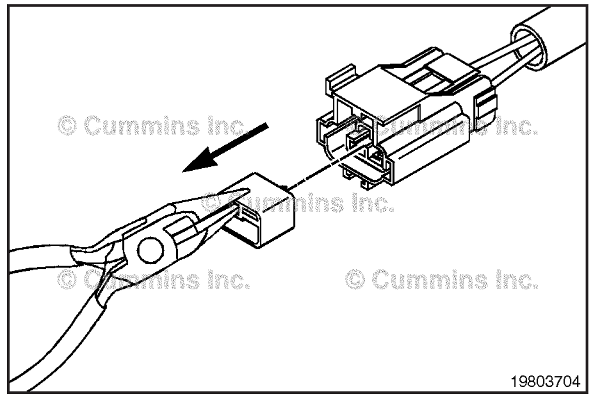
Refer to the wiring diagram in Section E for pin locations.



⚠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.

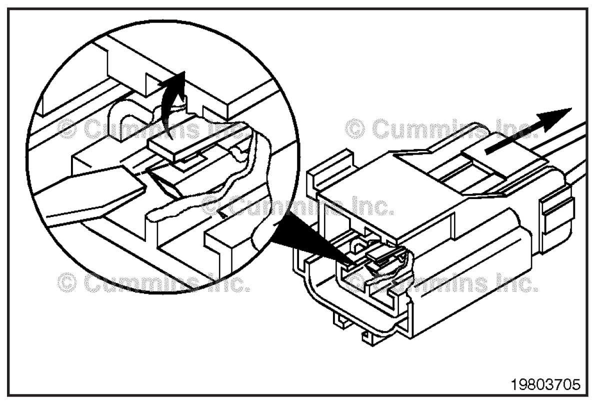
To replace the connector, grasp the blue inter connector and pull it straight out.



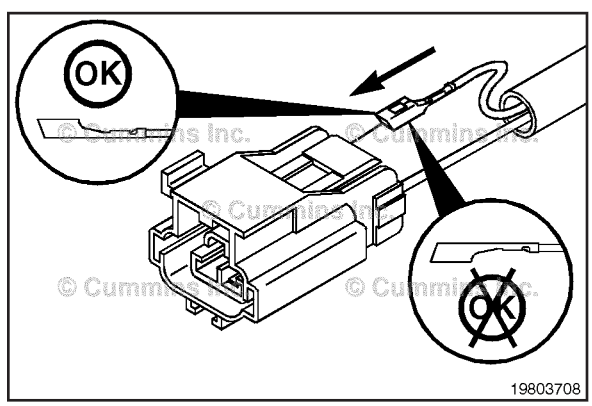
⚠CAUTION⚠

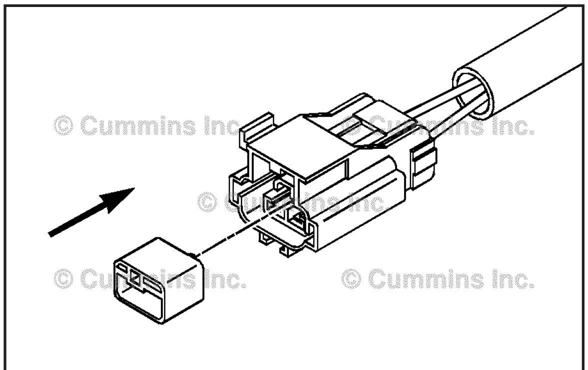
The locking finger can be easily broken. Care must be taken when using this tool. Do not force the tool into place.

To remove the contact out of the connector body, gently pull wire backward, while at the same time releasing the locking finger by moving it away from the contact with a screwdriver.



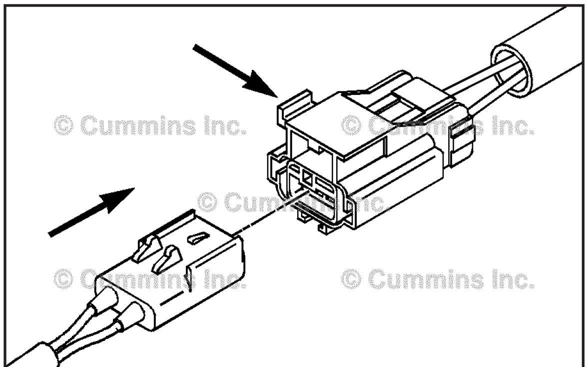
Replace the connector and install the wires and terminals into the seal at the back of the connector. Push the wires straight in until a click is felt. A slight tug will confirm that it is properly locked in place.




19803709

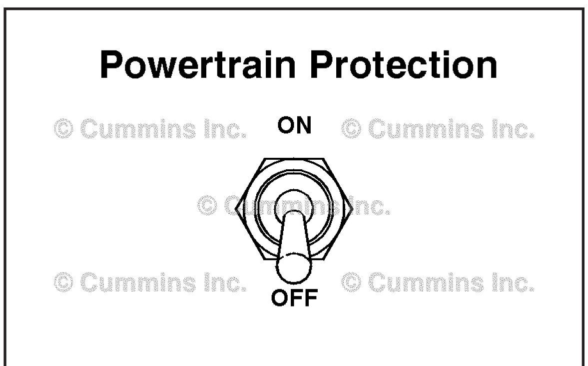
Once the wires are in place, insert the blue inter connector lock with the locking tab positioned towards the connector locking tab.

Push the blue inter connector lock in until it snaps in place.


19803710

Push the connector plug into the connector receptacle until the external locking clip snaps into place.

Slide the connector locking tab to the locked position.

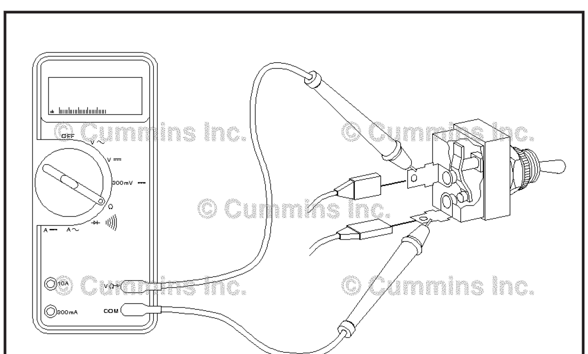


19d00838

Power Train Protection Switch (019-253)

General Information

The powertrain protection switch circuit signals the system to protect the drivetrain when lower gears are engaged. The powertrain protection feature can limit engine output torque depending upon transmission gear ratio. Engine torque limits based on transmission gear ratio can be adjusted using the INSITE™ electronic service tool.

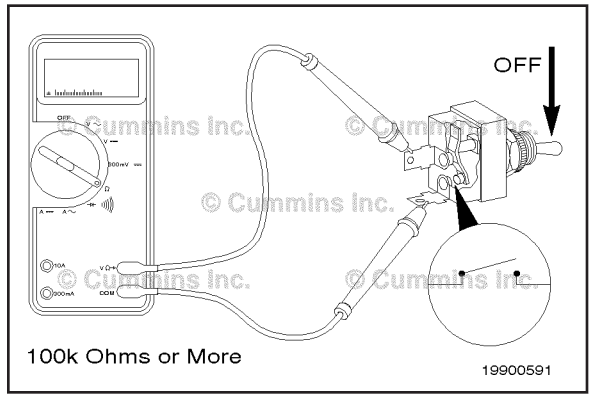

19900590

Resistance Check

If INSITE™ electronic service tool is available, monitor the powertrain protection switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

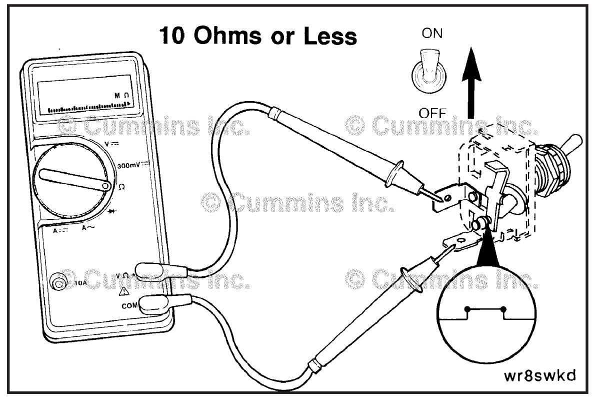
Locate the powertrain protection switch. Remove and tag the two connectors from the terminals on the switch. Touch the multimeter probes to the terminals on the switch.

Move the switch to the OFF position, and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual for the replacement instructions.



Move the switch to the ON position, and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement instructions.

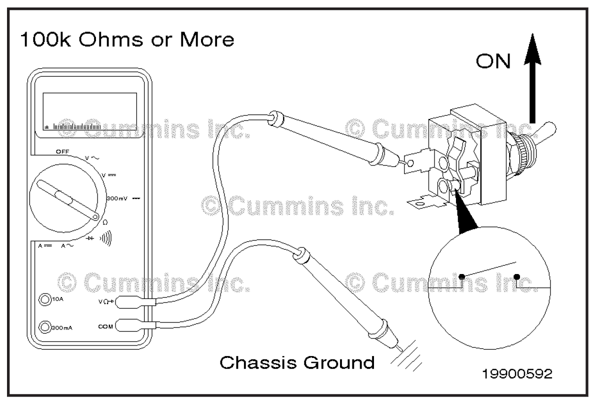
If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

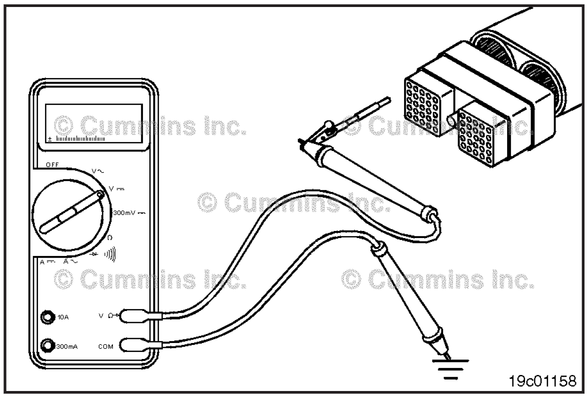


Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position, and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.





Check for Short Circuit to External Voltage Source

CAUTION

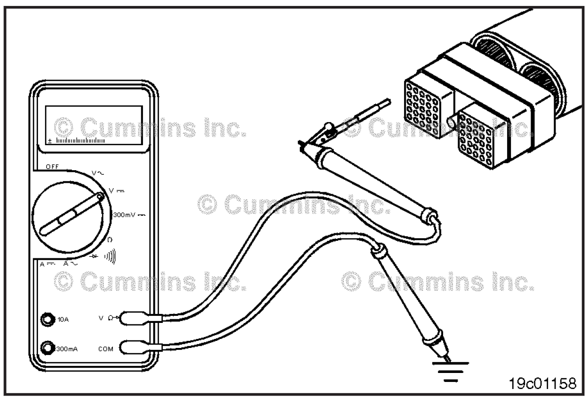
The leads must fit tightly in the connector without expanding the pins in the connector otherwise the connector will be damaged.

Isolate the powertrain protection switch circuit. Turn the vehicle keyswitch to the ON position. Adjust the multimeter to measure VDC.

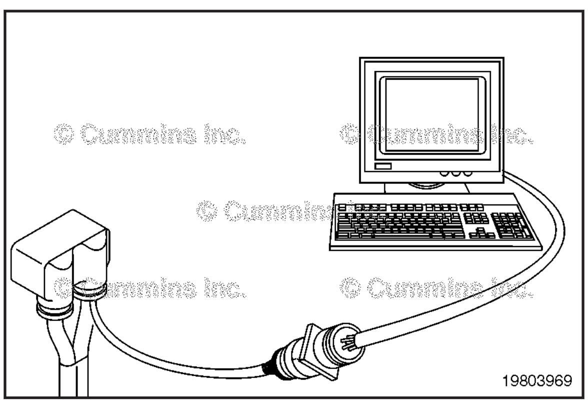
Insert the test lead connected to the positive (+) multimeter probe into the powertrain protection switch signal pin of the OEM harness.

Disconnect the negative (-) multimeter probe from the test lead, touch it to the engine block ground, and measure the voltage. The voltage **must** be 1.5 VDC or less.

NOTE: An external voltage source is any wire in the OEM harness wiring that carries the voltage.



If the voltage value is more than 1.5 VDC, there is a short circuit between the wire connected to the powertrain protection switch signal pin and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.



Power Train Protection Switch Circuit (019-254)

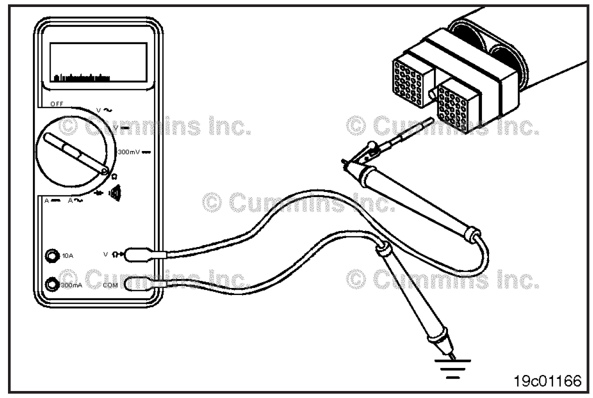
Resistance Check

CAUTION

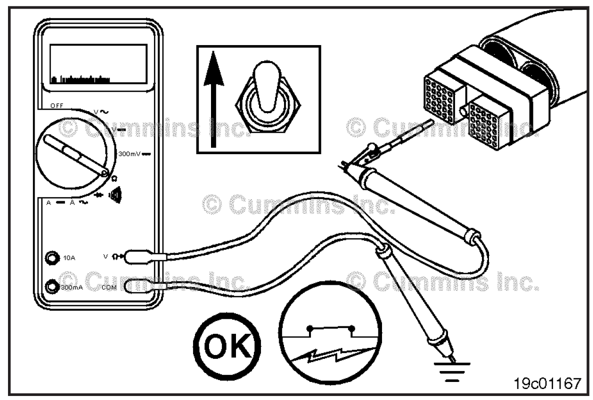
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

If INSITE™ electronic service tool is available, monitor the powertrain protection switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.

Disconnect the original equipment manufacturer (OEM) harness from the electronic control module (ECM). Insert the multimeter probe into powertrain protection switch signal pin in the OEM harness. Touch the other probe to the engine block ground.



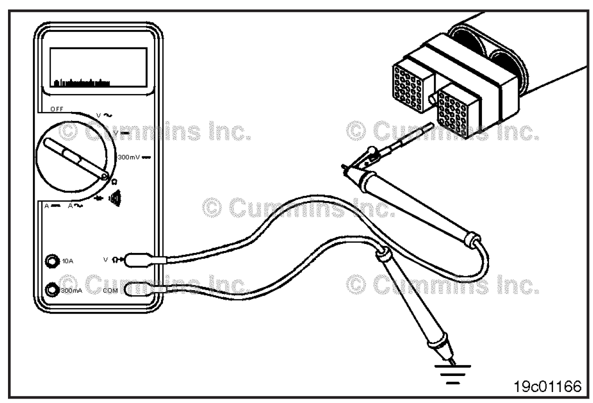
Move the powertrain protection switch to the ON position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the signal wire for an open circuit. Refer to the OEM troubleshooting and repair manual. If the resistance is within specification, the signal pin **must** be checked for a short circuit to ground, a short circuit from terminal to terminal, and a short circuit to an external voltage source.



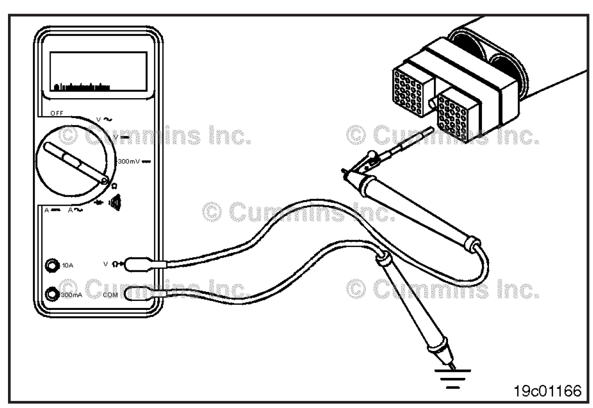
Check for Short Circuit to Ground

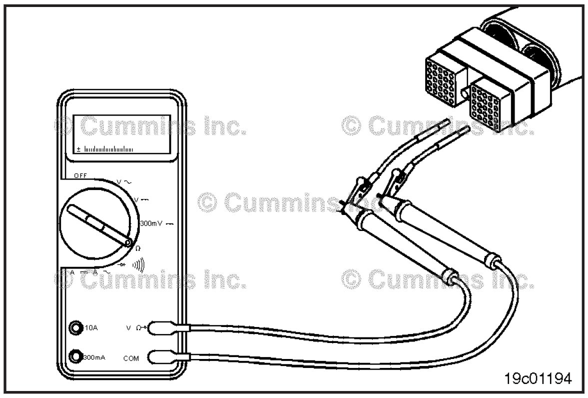
Isolate the powertrain protection switch circuit.

Touch multimeter probe to the engine block. With the other electrical lead inserted into powertrain protection switch signal pin, measure the resistance.



The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the powertrain protection switch circuit, provided that the switch has been previously checked. Repair or replace the wire connected to powertrain protection switch signal pin according to the vehicle manufacturer's instructions.

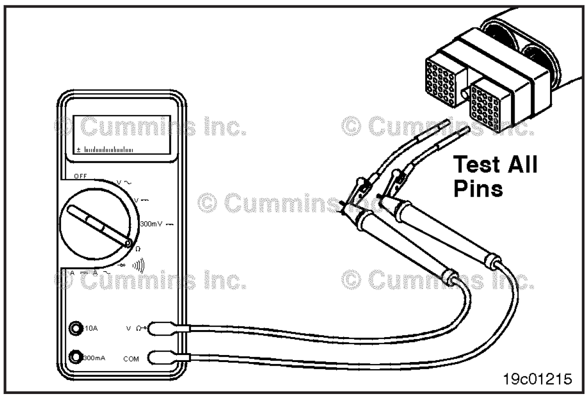




Check for Short Circuit from Pin to Pin

Isolate the powertrain protection switch circuit. Place one of the leads into power train protection switch signal pin. Insert the pin of the other lead into pin 1. Connect the alligator clips to the multimeter probes. Measure the resistance.

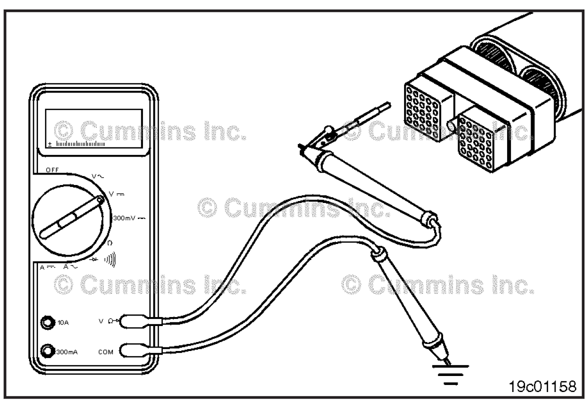
The multimeter **must** show an open circuit (100k ohms or more).



Remove the lead from pin 1, and check all other pins. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, there is a short circuit from the wire connected to powertrain protection switch signal pin and any pin that measured less than 100k ohms.

Repair or replace the wires in the OEM harness according to the vehicle manufacturer's instructions.



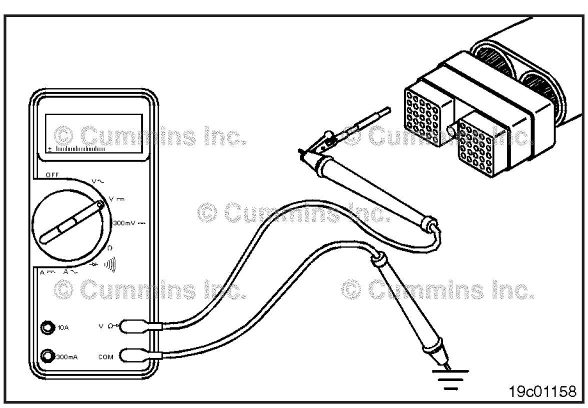
Check for Short Circuit to External Voltage Source

Isolate the powertrain protection switch circuit. Turn the vehicle keyswitch to the ON position. Set the multimeter to measure VDC.

Insert the test lead connected to the positive (+) multimeter probe into powertrain protection switch signal pin of the OEM harness.

Disconnect the negative (-) multimeter probe from the test lead, touch it to the engine block ground, and measure the voltage. The voltage **must** be 1.5 VDC or less.

NOTE: An external voltage source is any wire in the OEM harness wiring that carries the voltage.

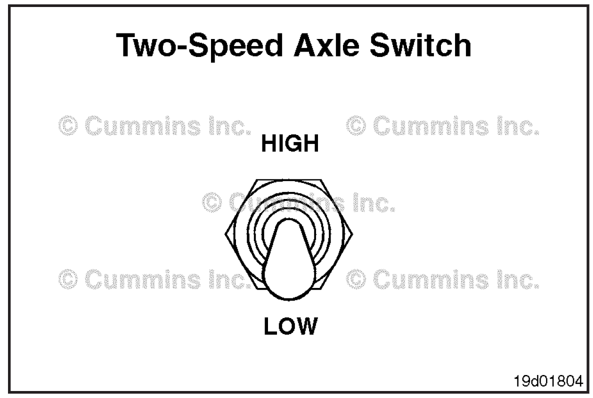


If the voltage value is more than 1.5 VDC, there is a short circuit between the wire connected to powertrain protection switch signal pin and a wire carrying power in the OEM harness. Repair the OEM harness according to the vehicle manufacturer's procedures.

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.



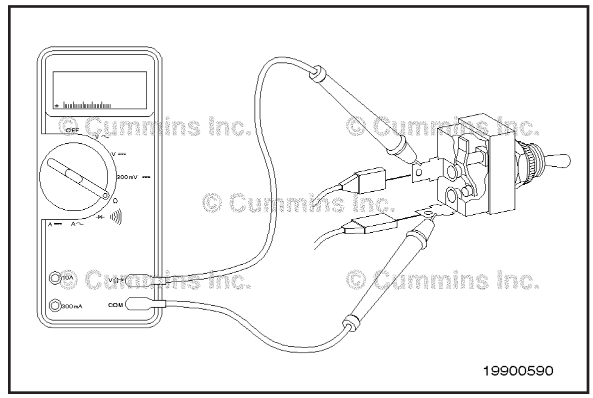
Resistance Check

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.

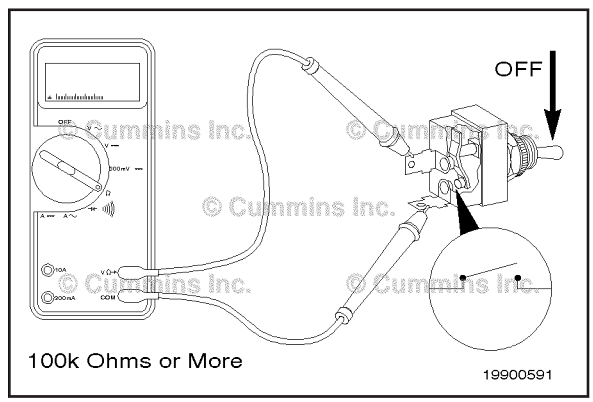


Move the switch to the OFF position, and measure the resistance.

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.



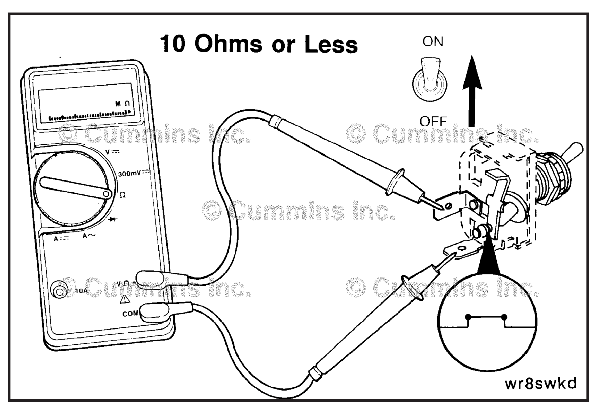
Move the switch to the ON position, and measure the resistance.

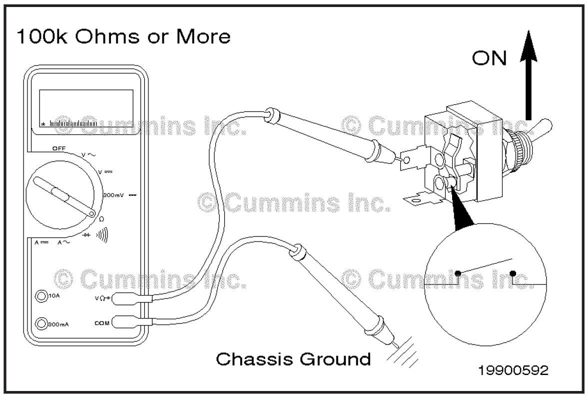
The multimeter **must** show a closed circuit (10 ohms or less).

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

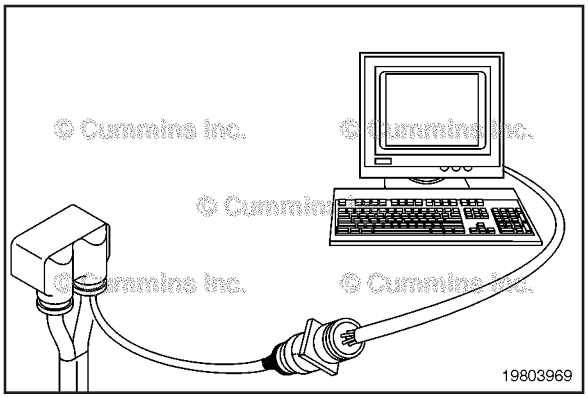
Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground.

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)

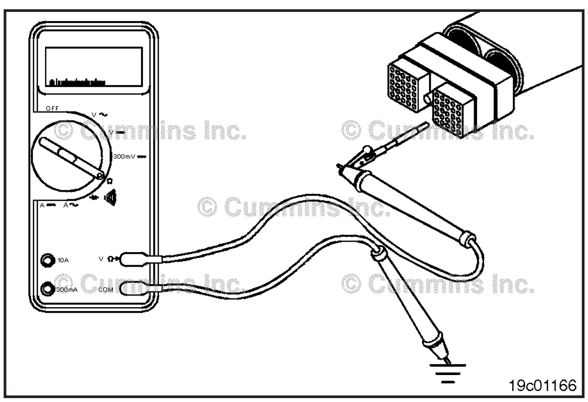
Resistance Check

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.

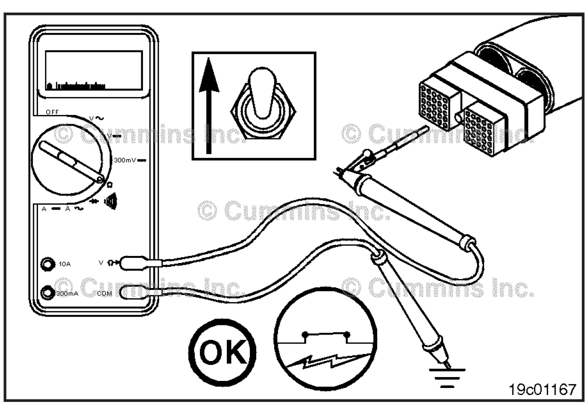
If **not**, follow the troubleshooting procedures in this section.



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.

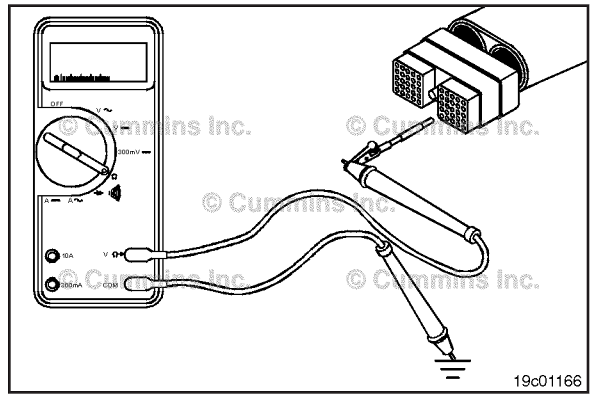
If the resistance is within specification, the 2-speed axle switch signal pin **must** be checked for a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.

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.

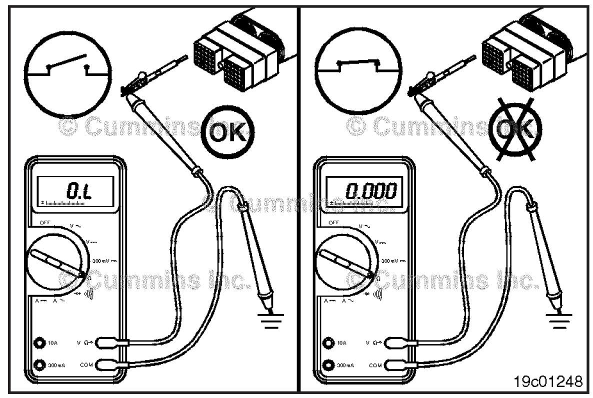
Touch the other multimeter probe to the engine block, and measure the resistance.



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.



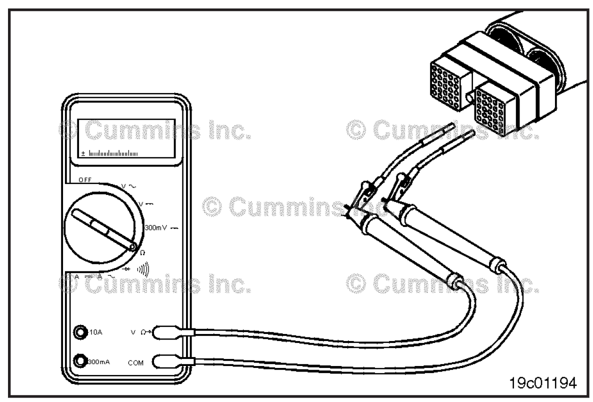
Check for Short Circuit from Pin to Pin

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).

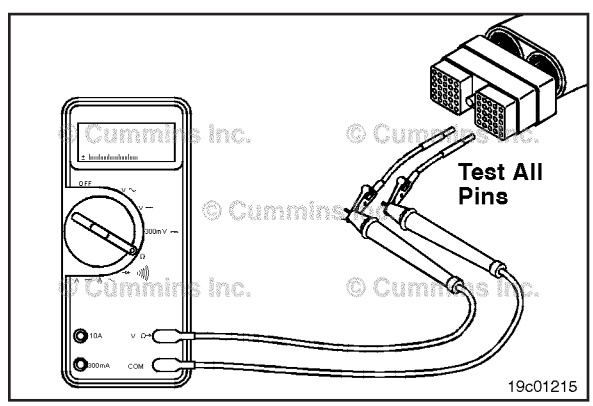


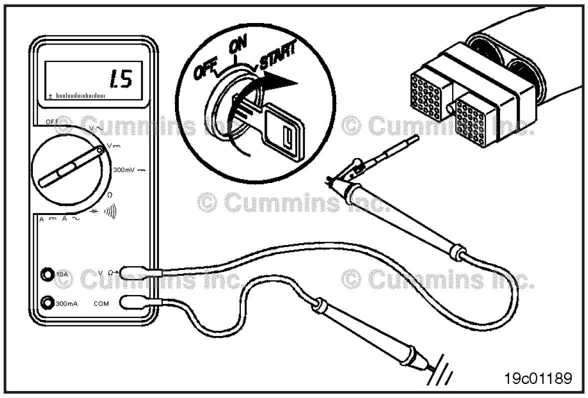
Remove the lead and check all other pins.

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

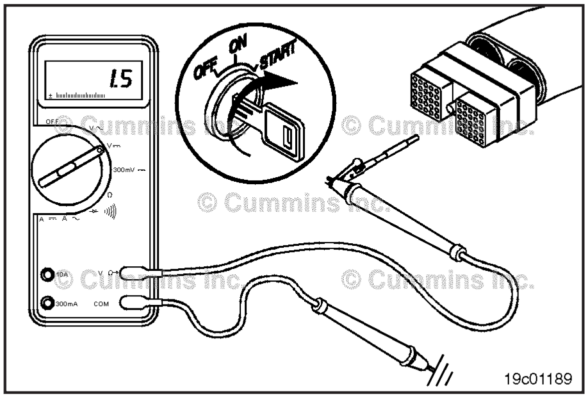
Isolate the 2-speed axle switch circuit. Turn the keyswitch to the ON position. Set the multimeter to measure VDC.

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.

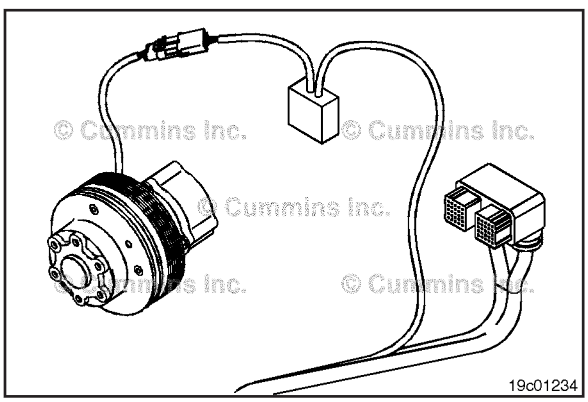
NOTE: An external voltage source is any wire in the OEM harness wiring that carries the voltage.



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.

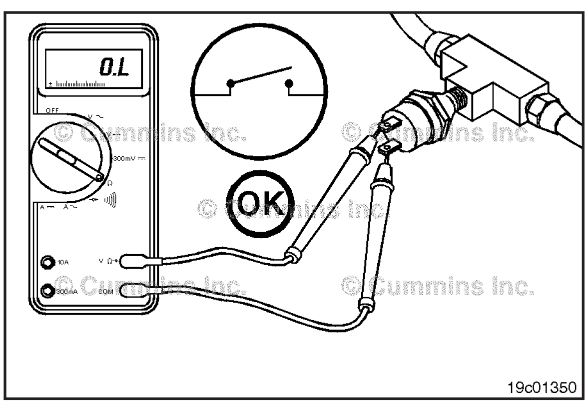
Connect all components after completing the repairs.



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).

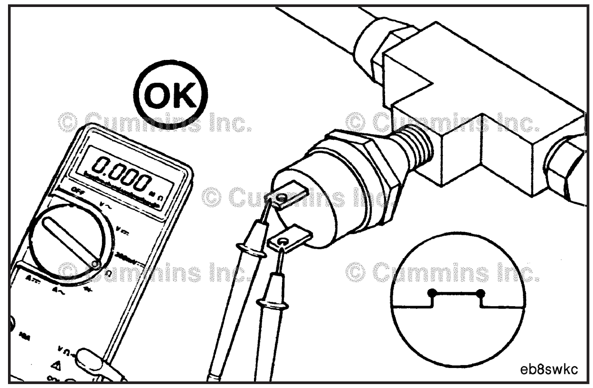


Resistance Check

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.

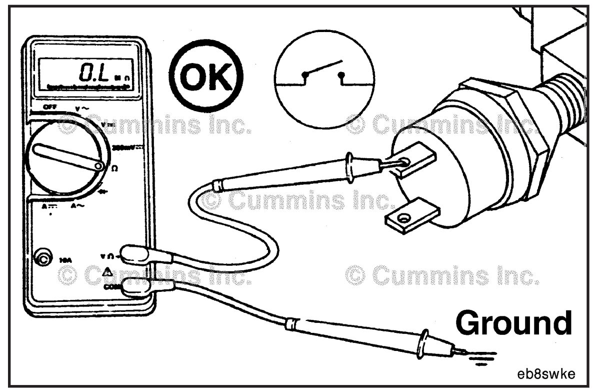
When the system head pressure is high, the multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual for replacement procedures.

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.

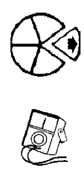


Check for Short Circuit to Ground

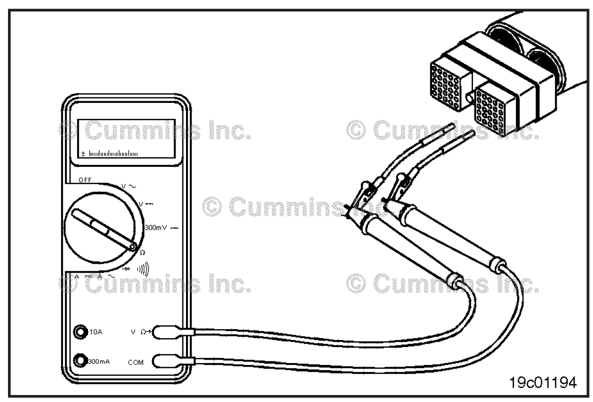
When the system head pressure is low, touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and 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

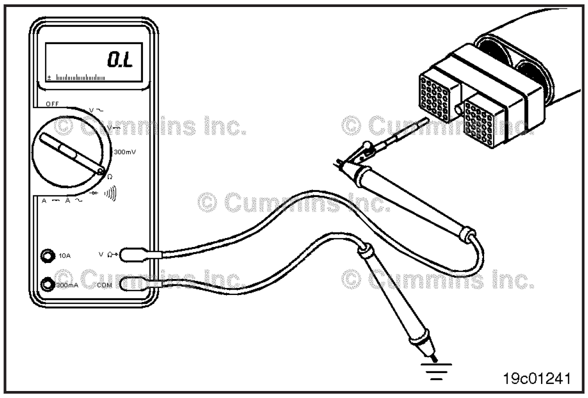


⚠CAUTION⚠

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.

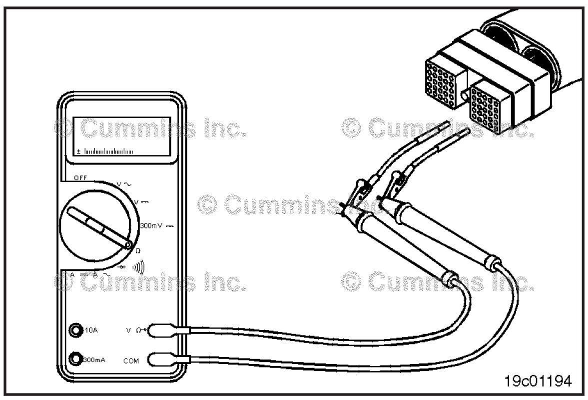


Check for Short Circuit to Ground

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.

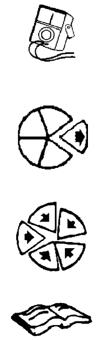


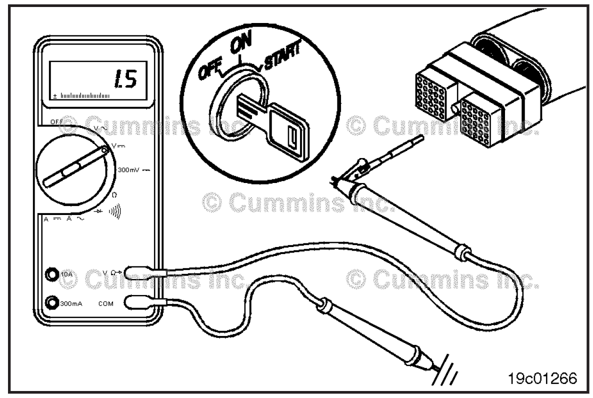
Check for Short Circuit from Pin to Pin

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.

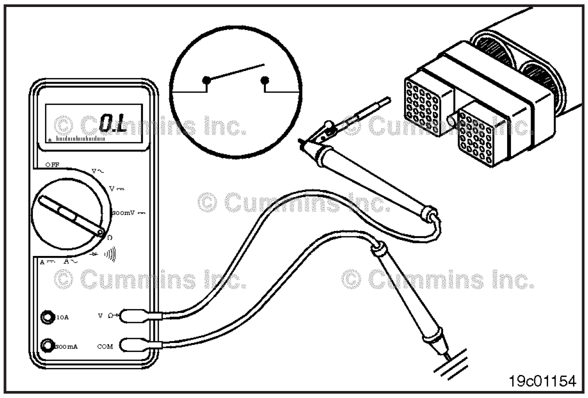
Accelerator Interlock Switch (019-264)

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⚠

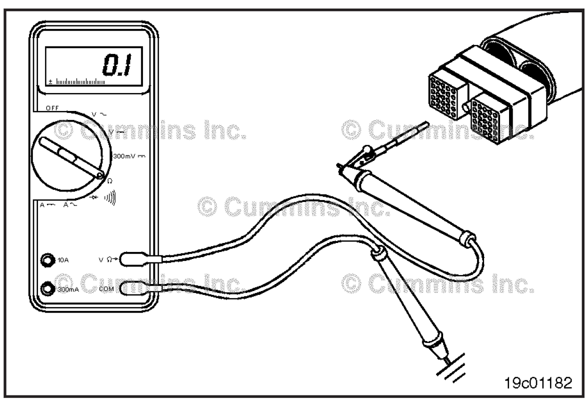
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

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.

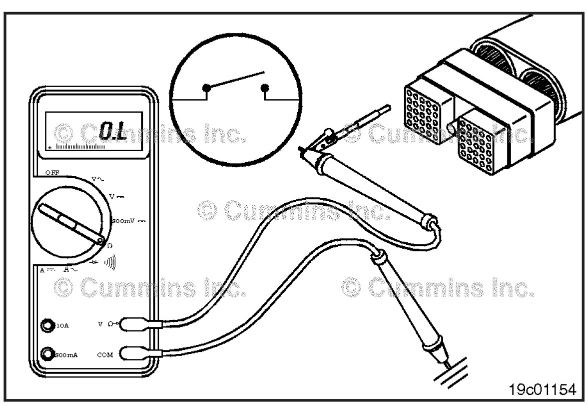
NOTE: The accelerator interlock signal input can also be used as the engine torque limit switch signal as well.

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.



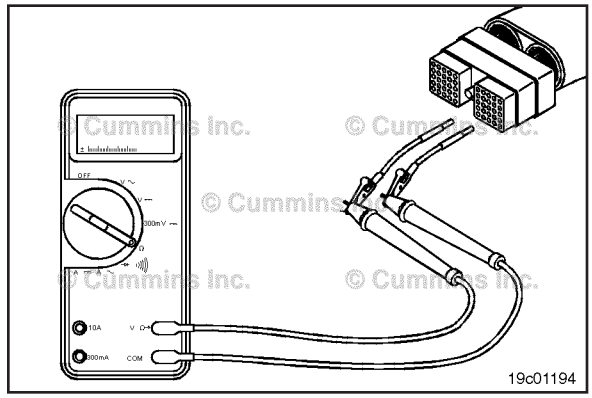
Check for Short Circuit to Ground

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

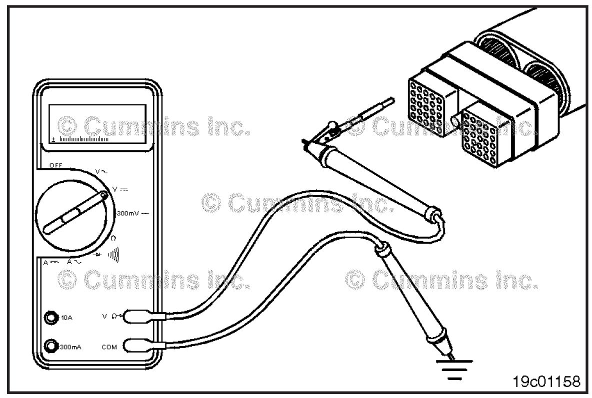


Check for a short circuit from pin-to-pin. Insert a test lead into the accelerator interlock switch signal pin. Insert the other test lead into the switch return pin. Measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

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



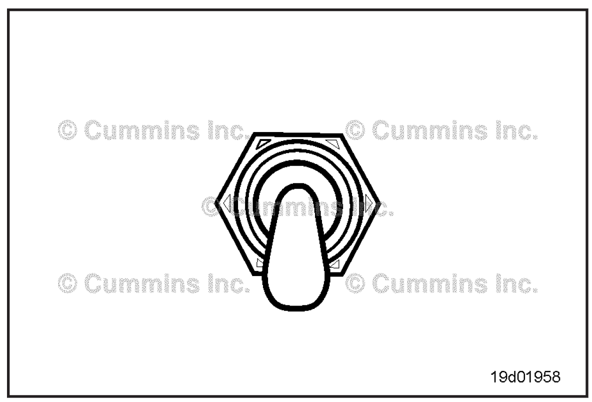
Set the switch to normal position and set the multimeter to read VDC. Insert one test lead into the accelerator interlock switch signal pin and connect a multimeter lead to it. Touch the other multimeter lead to engine block ground. Measure the voltage.

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.

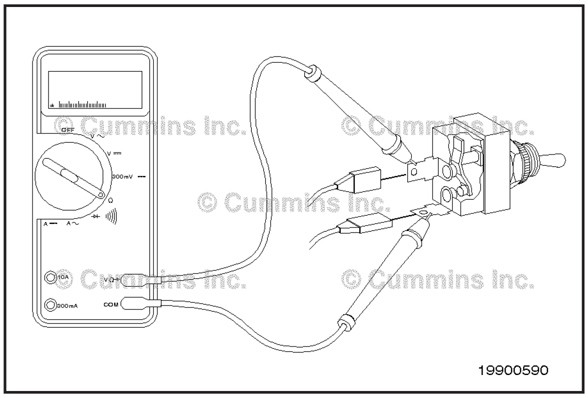
Cab Switchable Governor Switch (019-266)

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.



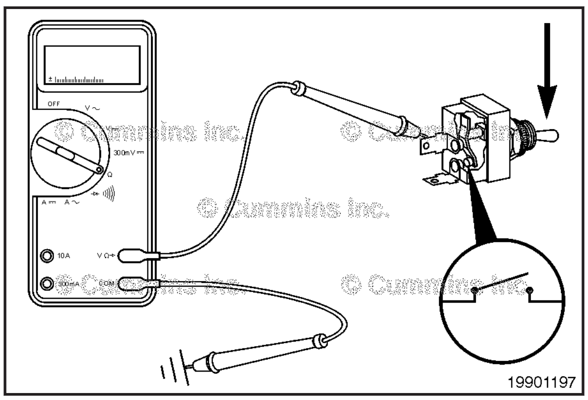
Resistance Check

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.

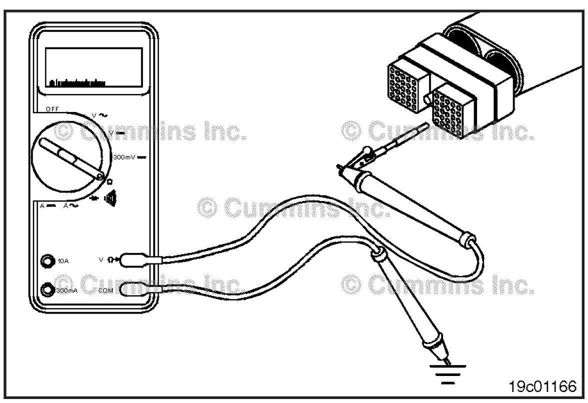
If the switch does **not** transition from an open to a closed circuit when flipped from one position to the other, the switch is defective. Replace the switch. Refer to the original equipment manufacturer (OEM) troubleshooting and repair manual.



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⚠

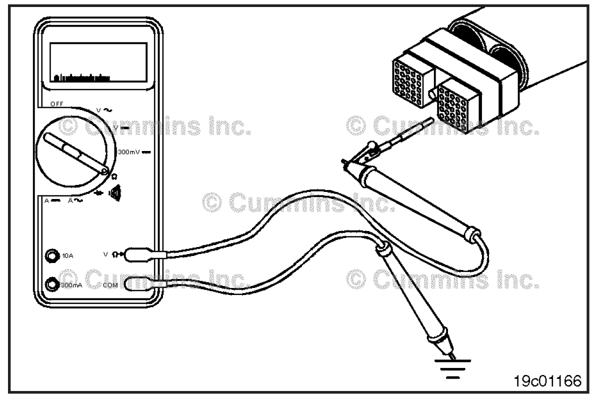
Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

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.

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.



Check for Short Circuit to Ground

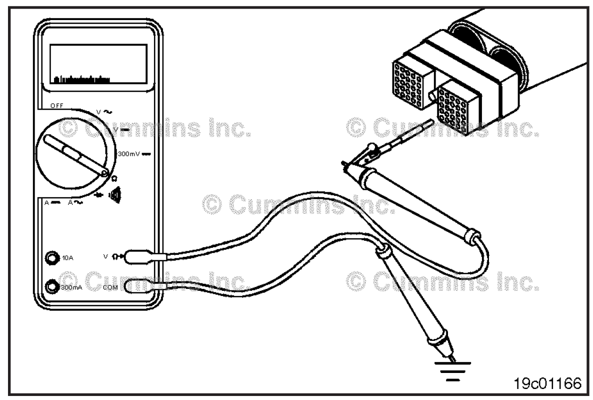
⚠CAUTION⚠

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.

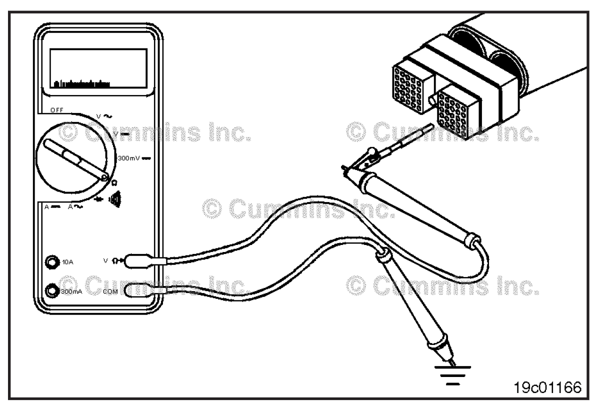
Touch the other multimeter probe to engine block ground. Move the switch from its present position to the other position, and measure the resistance.

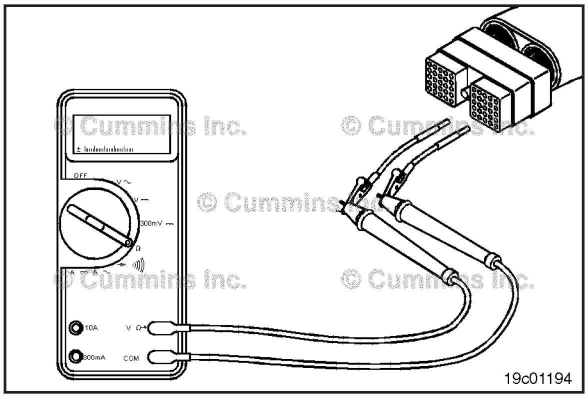


The multimeter **must** show a value of 100k ohms or more (open circuit).

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.





Check for Short Circuit from Pin to Pin

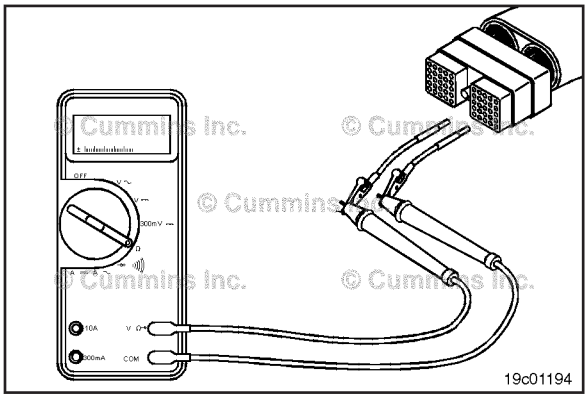
CAUTION

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.

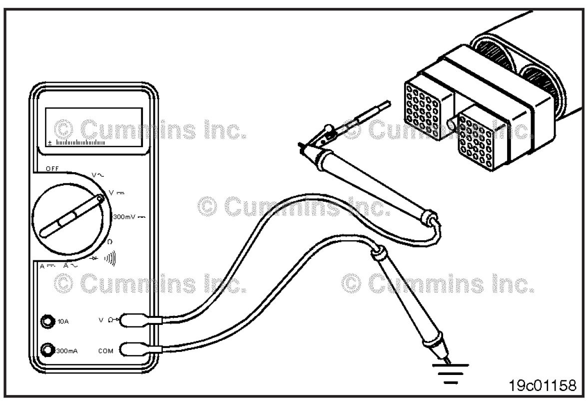
Touch the other multimeter probe with attached test lead to all other pins in the connector. Measure the resistance.



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.

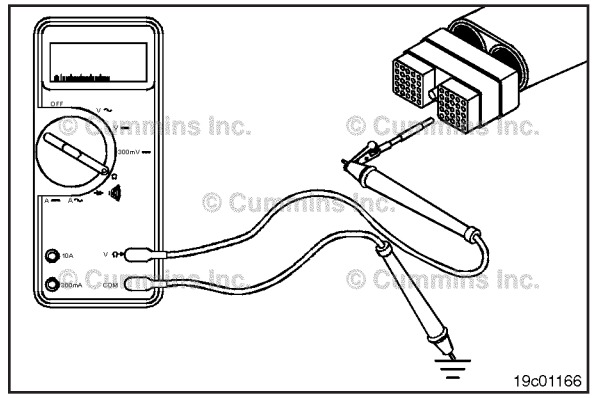
Insert a test lead into the accelerator governor switch input pin of the OEM harness connector, and attach the alligator clip to a multimeter probe.

Touch the other multimeter probe to engine block ground and measure the voltage.

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.

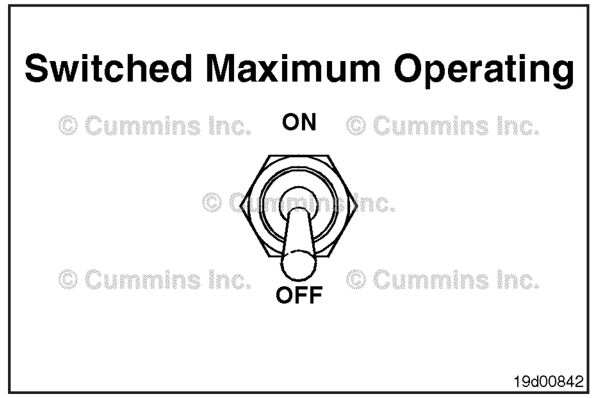


Switched Maximum Operating Speed Switch (019-268)

General Information

The maximum engine speed switch is an original equipment manufacturer (OEM) installed switch that allows a driver to select a lower, programmable maximum engine speed.

Certain applications, such as one that uses a hydraulic system, can possibly need to be protected from an overspeed condition. The operator can toggle this switch and limit the maximum engine rpm to a lower value in which the hydraulic system can safely operate.



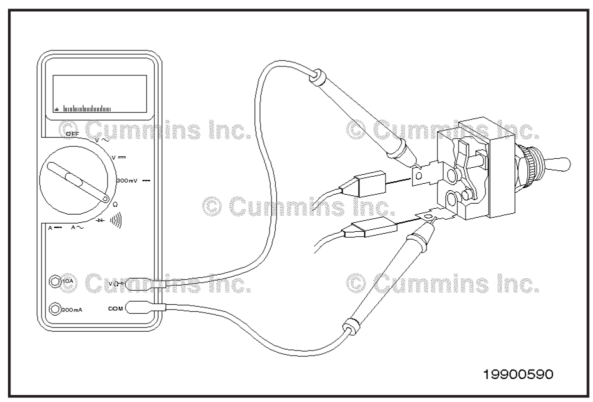
Resistance Check

If 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.

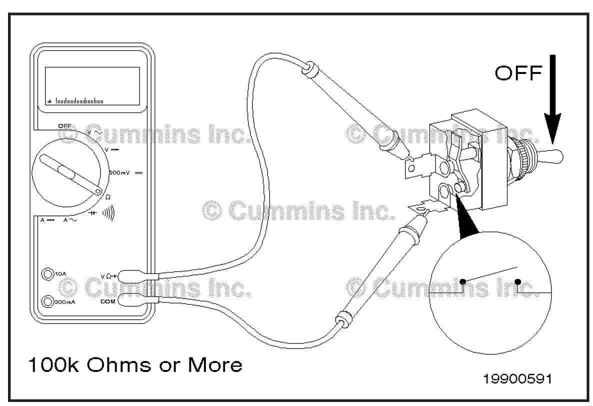
Remove the electrical connectors from the switch.

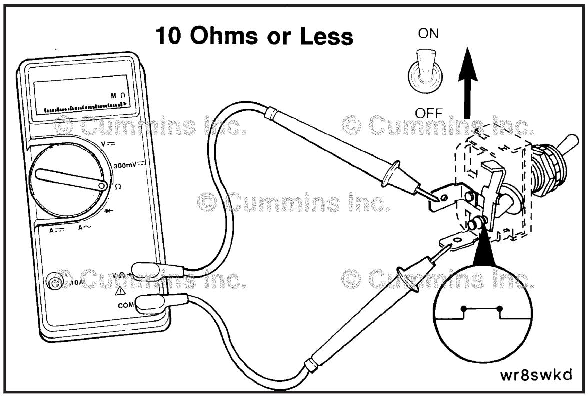
Set the multimeter to measure resistance. Touch the other multimeter probe to the other terminal of the switch.



Place the switch in the OFF position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

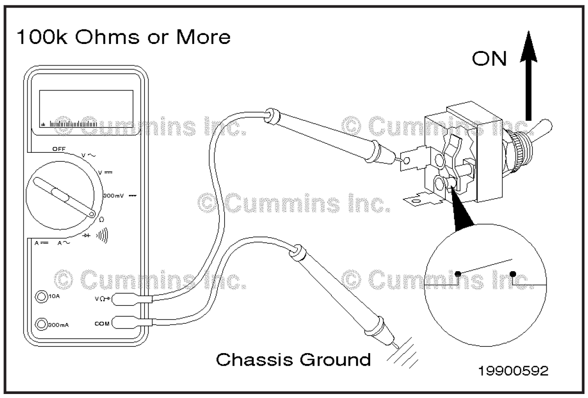
If the circuit is **not** open, the switch is defective. Refer to the OEM troubleshooting and repair manual for replacement procedures.





Place the switch in the ON and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch is defective. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.

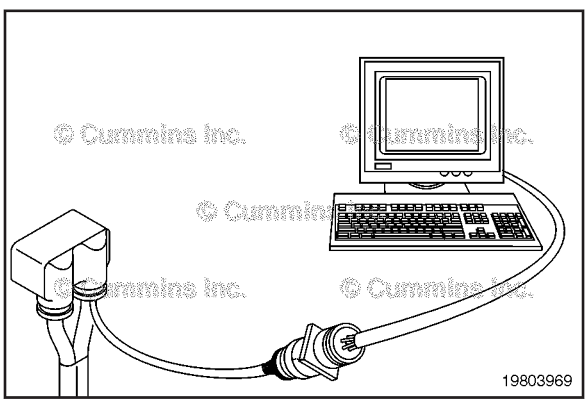


Check for Short Circuit to Ground

Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the normal position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures.

If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.



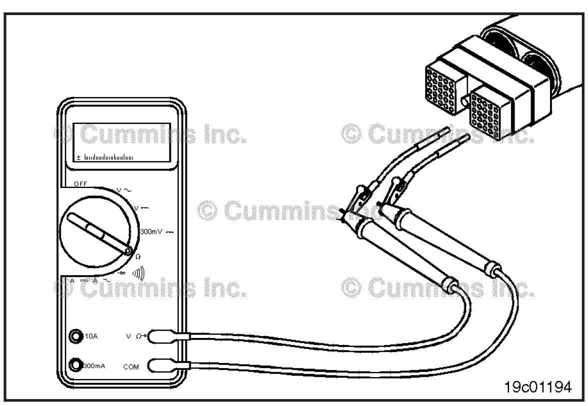
Switched Maximum Operating Speed Switch Circuit (019-269)

Resistance Check

⚠CAUTION⚠

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.

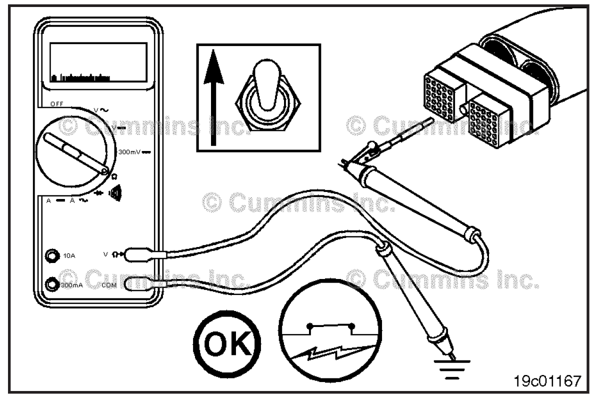


Disconnect the original equipment manufacturer (OEM) harness from the electronic control module (ECM). Set the multimeter to measure resistance.

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.

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.

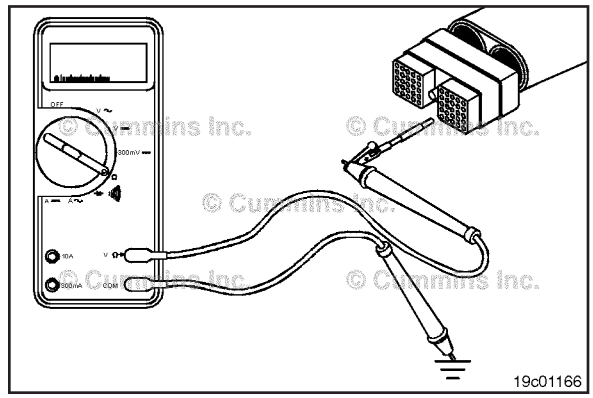
Refer to the OEM troubleshooting and repair manual. If the resistance is within specification, both the return (-) wire and the input wire **must** be checked for a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.



19c01167

Check for Short Circuit to Ground

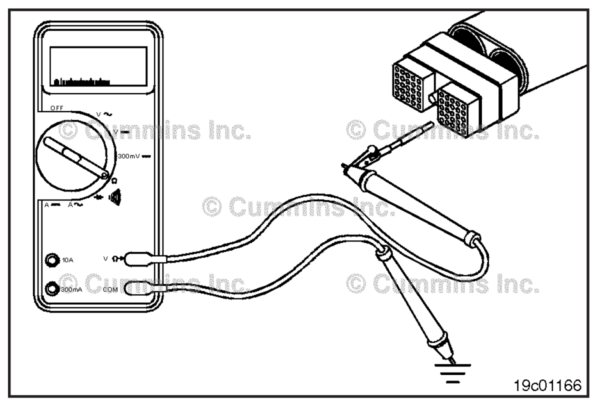
Isolate the switched maximum operating speed switch circuit.


19c01166

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.

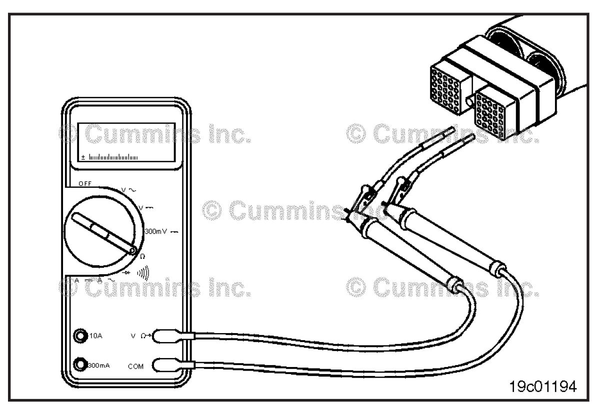
The multimeter **must** show 100k ohms or more (open circuit). If the circuit is **not** open, there is a short circuit to ground in the switched maximum operating speed switch circuit, provided that the switch has been previously checked.

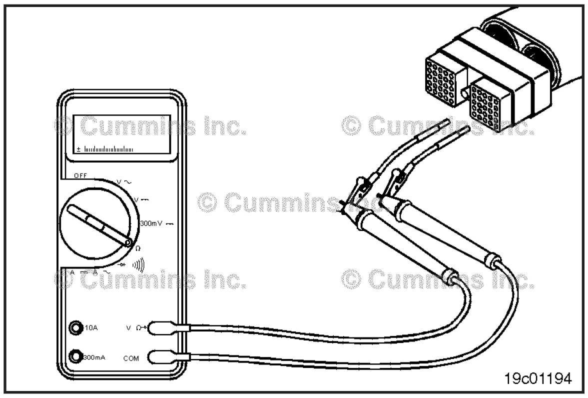
Repair or replace the wire connected to the return (-) pin according to the vehicle manufacturer's instructions.


19c01166

Check for Short Circuit from Pin to Pin

Isolate the switched maximum operating speed switch circuit. Disconnect the OEM harness connector from the ECM. Set the multimeter to measure resistance.

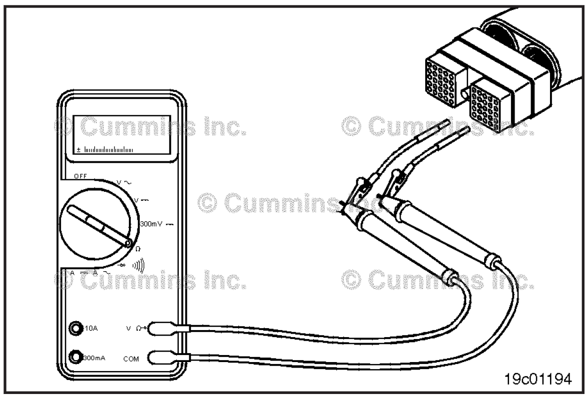

19c01194



Insert a test lead into the maximum operating speed switch input pin of the OEM harness connector. Insert the other test lead into the switch return pin of the connector. Connect the alligator clips to the multimeter probes.

Measure the resistance.

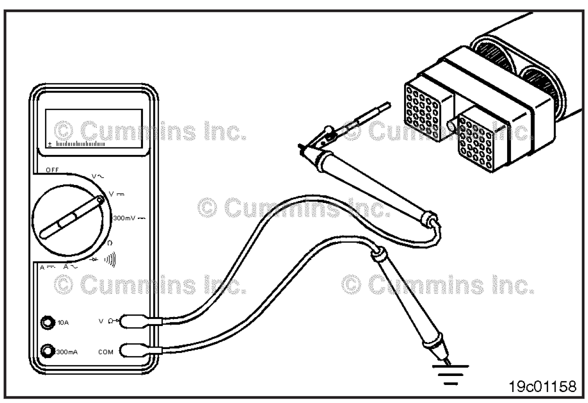
The multimeter **must** show 100k ohms or more (open circuit).



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.



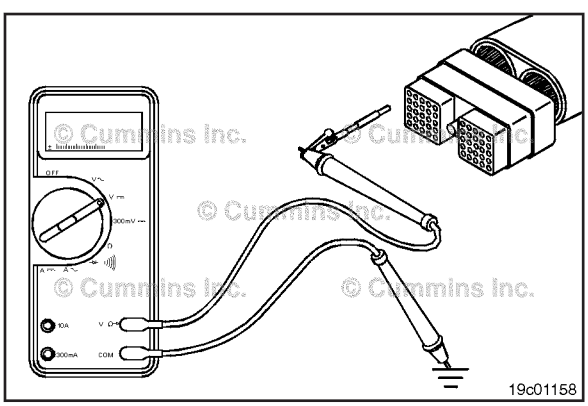
Check for Short Circuit to External Voltage Source

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.



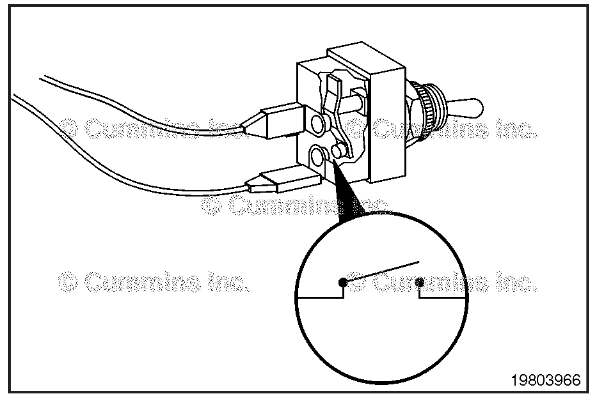
If the voltage value is more than 1.5 VDC, there is a short circuit between the wire connected to the switched maximum operating speed switch input pin and a wire carrying power in the OEM harness. Repair the OEM harness. Refer to Procedure 019-071.

Connect all components after completing the repairs.

Multi Unit Synchronization Switch (019-270)

General Information

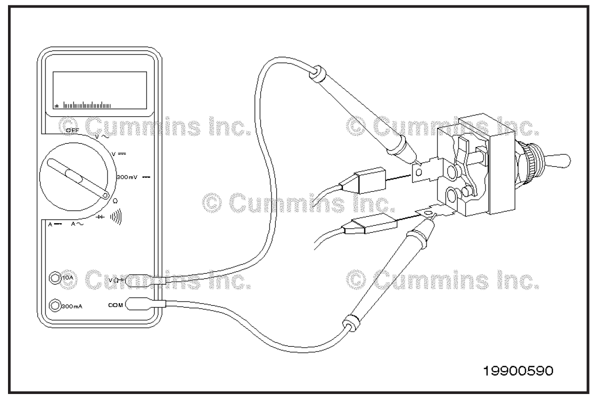
The Multiple Unit Synchronization feature allows two or more engines to be controlled by a single throttle input. One engine is configured as the primary engine, all other engines **must** be configured as secondary.



Resistance Check

If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

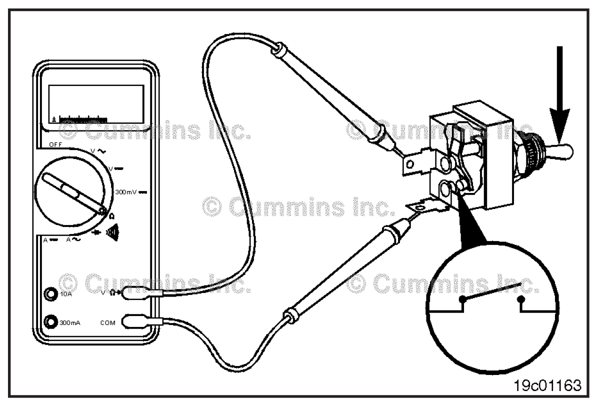
Locate the desired ON/OFF toggle switch. Remove and tag the two connectors from the terminals on the switch. Touch the multimeter probes to the terminals on the switch.



Move the switch to the OFF position and measure the resistance.

The multimeter **must** show an open circuit (100K ohms or more).

If the circuit is **not** open, the switch is damaged and **must** be replaced. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

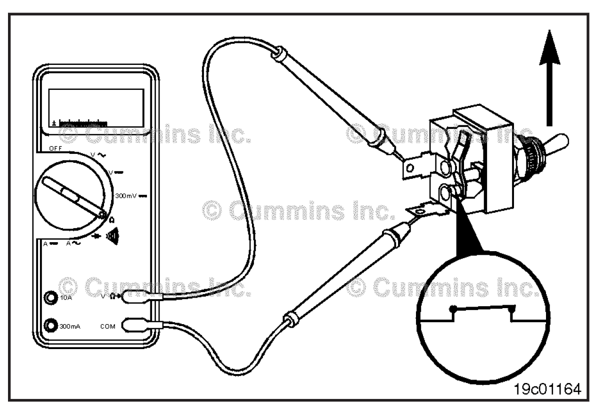


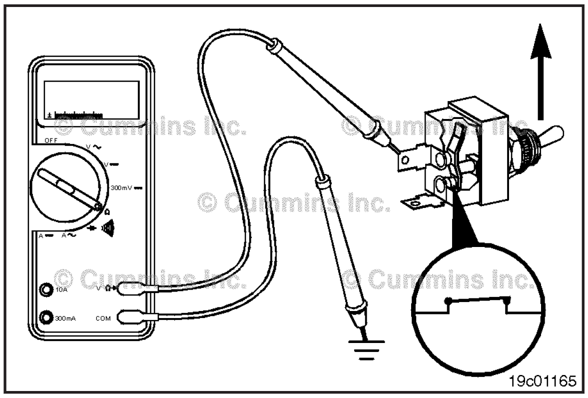
Move the switch to the ON position and measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch is damaged and **must** be replaced. 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.





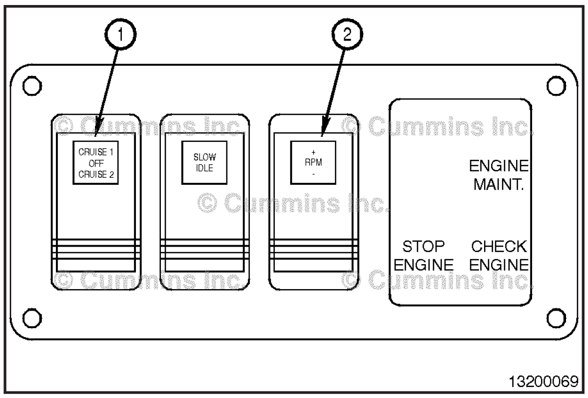
Check for Short Circuit to Ground

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 is damaged and **must** be replaced. Refer to the OEM troubleshooting and repair manual for replacement procedures.

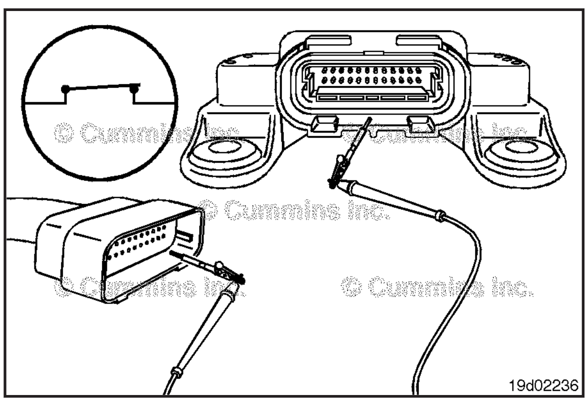
If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin-to-pin, and a short circuit to an external voltage source.



Multi Unit Synchronization Switch Circuit (019-271)

General Information

The synchronization switch is located on the control panel and has two settings, ON and OFF.

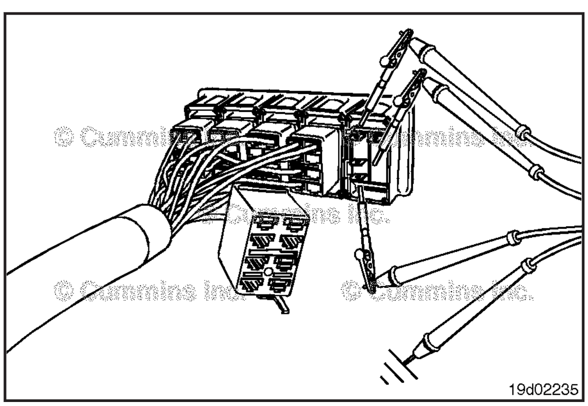


Resistance Check

Disconnect the Smart Multiplex module connector from the Smart Multiplex module.

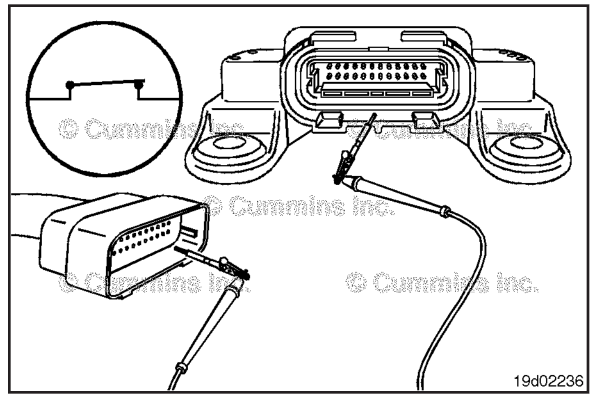
Touch the probe to the synchronization switch signal pin of the Smart Multiplex module connector. Touch the other probe to the unswitched battery (-) pin of the Smart Multiples module connector.

Move the switch to the ON position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the synchronization switch for an open circuit. Refer to Procedure 019-270.



If the resistance is within specification, the synchronization switch circuit **must** be checked for a short circuit to ground, and a short circuit from terminal to terminal.

Check for Short Circuit to Ground



Disconnect the Smart Multiplex module connector from the Smart Multiplex module.

Adjust the multimeter to measure resistance.

Touch the multimeter probe to the synchronization switch signal pin of the Smart Multiplex module connector. Touch the other probe to the unswitched battery (-) pin of the Smart Multiplex module connector.

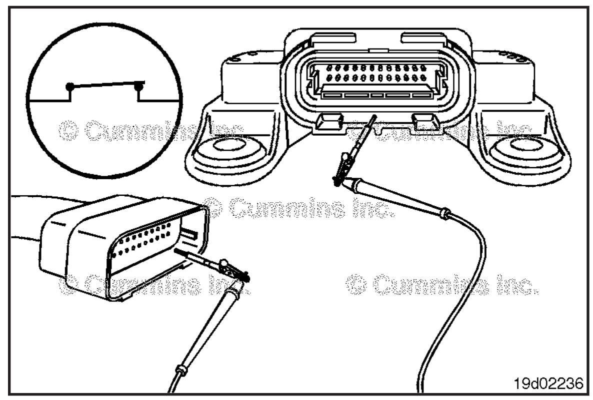
Move the synchronization switch to the OFF position.

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 signal wire connected to the synchronization switch and/or the signal wire connected to the Smart Multiples module.

Check for Short Circuit from Pin to Pin



Check for a short circuit from pin to pin. Set all switches to the C-Cruise Switch control module to the OFF position. Touch the multimeter probe to the synchronization switch signal pin on the Smart Multiplex module connector. Touch the other probe to all of the other signal pins of the Smart Multiplex module connector in succession.

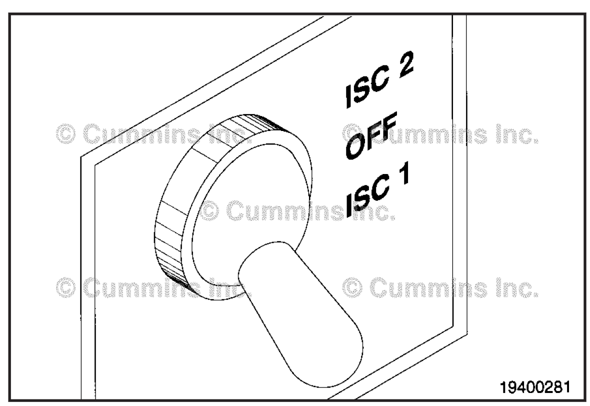
The multimeter **must** show an open circuit (100k ohms or more) for each pin check.

If the circuit is **not** open, there is a short circuit between the synchronization circuit and any pin that shows a closed circuit, provided the switch has previously checked.

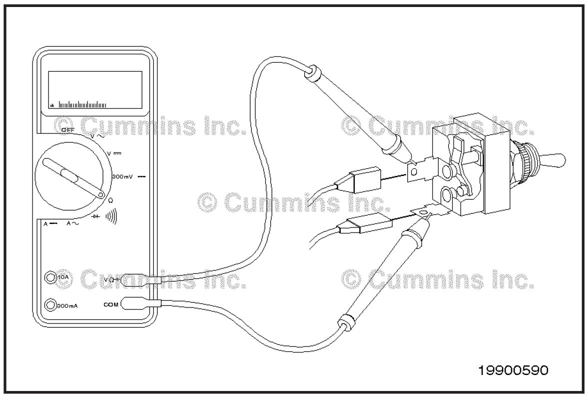
Repair or replace the appropriate wire in the Smart Multiplex module harness or C-Cruise switch panel harness.

Intermediate Speed Control 1 Switch (019-274)

General Information



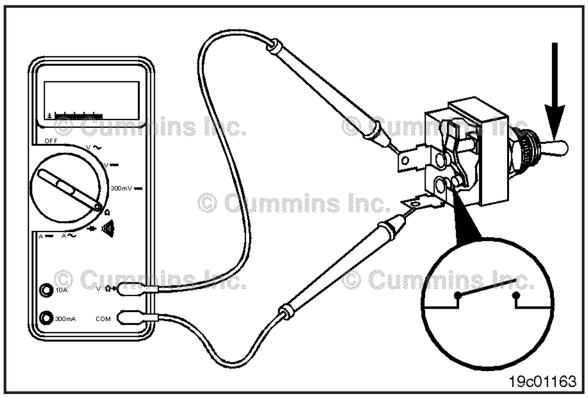
The Intermediate Speed Control is a fixed engine speed governor that can be activated by up to three switches. When activated, the intermediate speed control feature governs engine speed to the corresponding preset speed depending on the priority of individual intermediate speed control inputs and also of the main accelerator.



Resistance Check

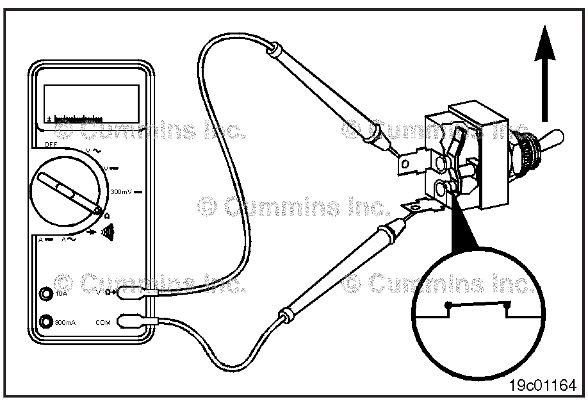
If INSITE™ electronic service tool is available, monitor the switch for proper operation. If not, follow the troubleshooting procedures in this section.

Locate the desired ON/OFF toggle switch. Remove and tag the two connectors from the terminals on the switch. Touch the multimeter probes to the terminals on the switch.



Move the switch to the OFF position and measure the resistance. The multimeter **must** show an open circuit (100K ohms or more).

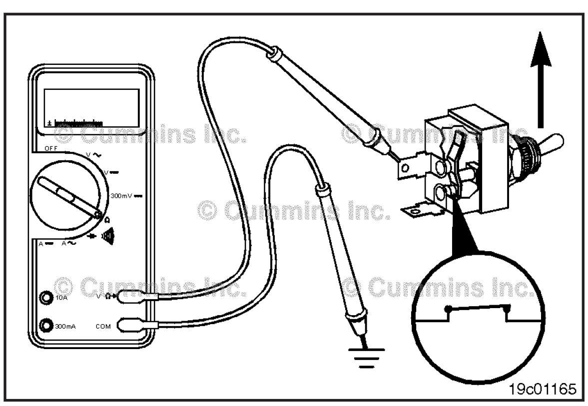
If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.



Move the switch to the ON position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

If the resistance value is correct, the switch **must** still be checked for a short circuit to ground.



Check for Short Circuit to Ground

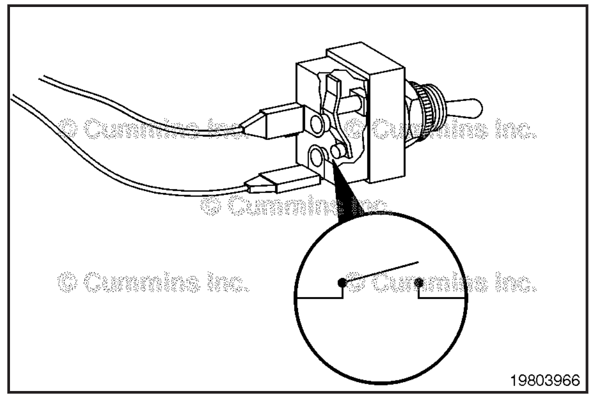
Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the ON position and measure the resistance. The multimeter **must** show an open circuit (100K ohms or more). If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the switch passes all of the previous checks, the circuit **must** be checked for an open circuit, a short circuit to ground, a short circuit from pin to pin, and a short circuit to an external voltage source.

Alternate Torque Switch (019-282)

General Information

This switch is used to enable the alternate torque curve feature and switch up to and between two derated torque curves.

NOTE: This switch can be a simple ON/OFF switch or an optional 3-position switch. Use the correct section for the particular switch on your application.

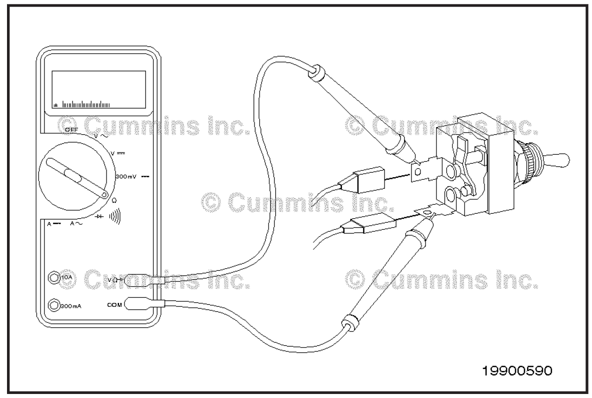


Resistance Check

ON/OFF Type of Switch

If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

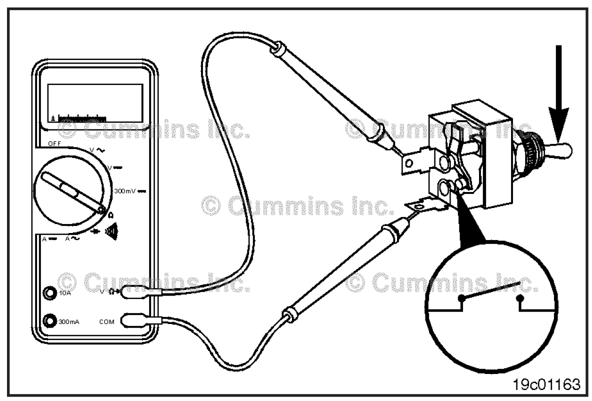
Locate the desired ON/OFF toggle switch. Remove and tag the two connectors from the terminals on the switch. Touch the multimeter probes to the terminals on the switch.



Move the switch to the OFF position and measure the resistance.

The multimeter **must** show an open circuit (100K ohms or more).

If the circuit is **not** open, the switch is damaged and **must** be replaced. Refer to the OEM troubleshooting and repair manual for the replacement procedures.

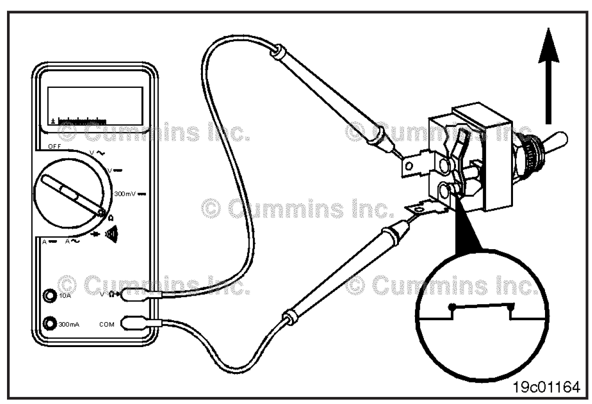


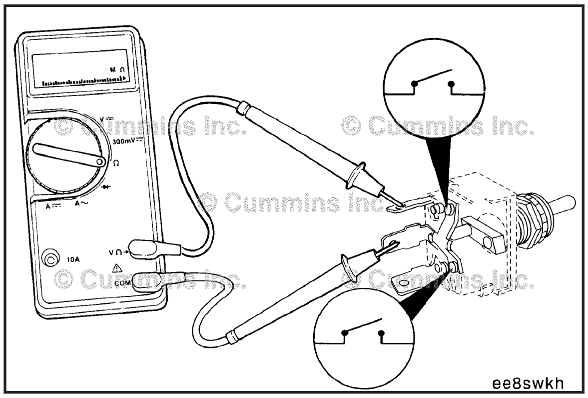
Move the switch to the ON position and measure the resistance.

The multimeter **must** show a closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch is damaged and **must** be replaced. 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.



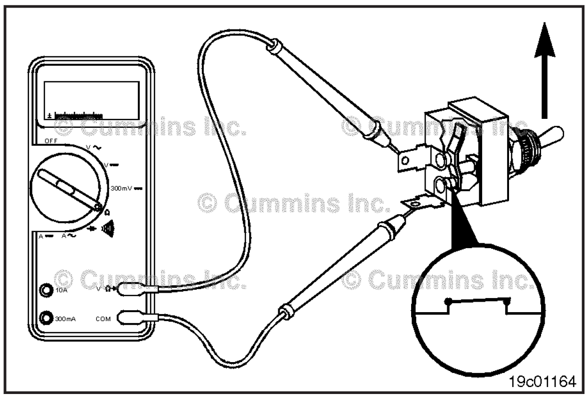


3-Position Type of Switch

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.

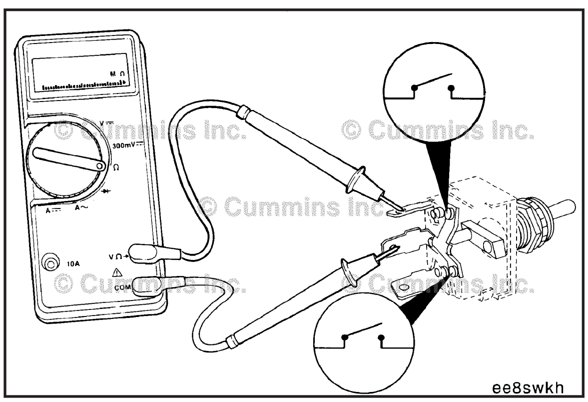


Move the switch to the ON position, and measure the resistance.

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.

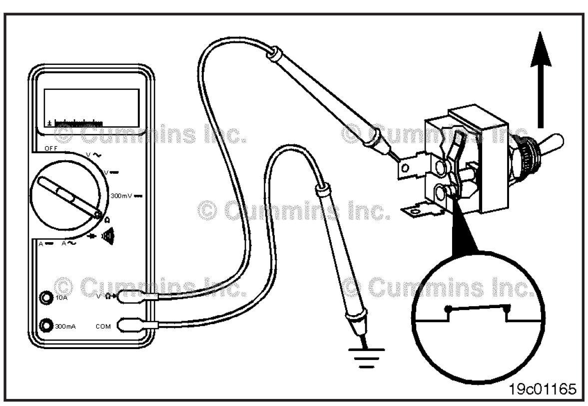


Move the switch to the center position, and measure the resistance.

The multimeter **must** show 1000 to 2000 ohms.

If **not**, 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.

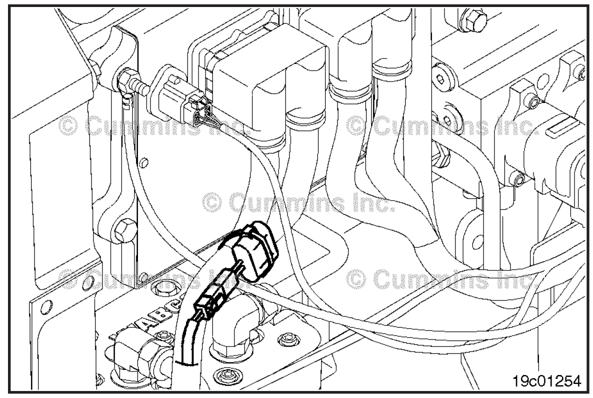
The multimeter **must** show an open circuit (100K ohms or more).

If the circuit is **not** open, the switch is damaged and **must** be replaced. Refer to the OEM 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.

Real-Time Clock Battery (019-311)

General Information



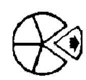
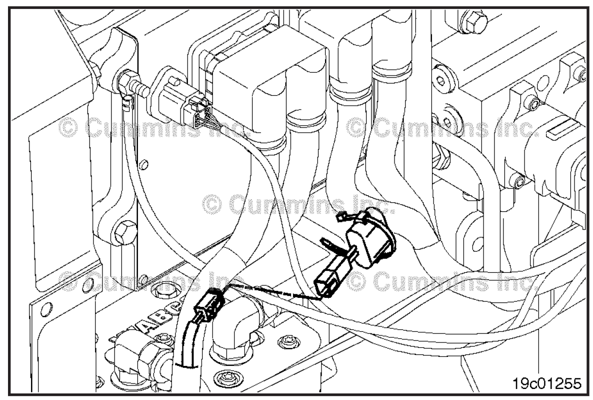
The real-time clock battery is connected to the engine harness main branch directly under the 50-pin engine ECM connector.

The ECM uses the real-time clock feature to time-stamp faults and other data with the time and date. The battery is used to power the real-time clock circuitry in the ECM when vehicle battery power is removed from the ECM. If a battery is installed, the ECM clock will maintain the correct time and date with power removed from the ECM, provided the engine harness connector remains plugged into the ECM.

If a real-time clock battery is **not** installed on the engine, it will be necessary to set the time and date using INSITE™ whenever the real-time clock feature is enabled in the ECM and vehicle battery power is removed from the ECM.

Remove



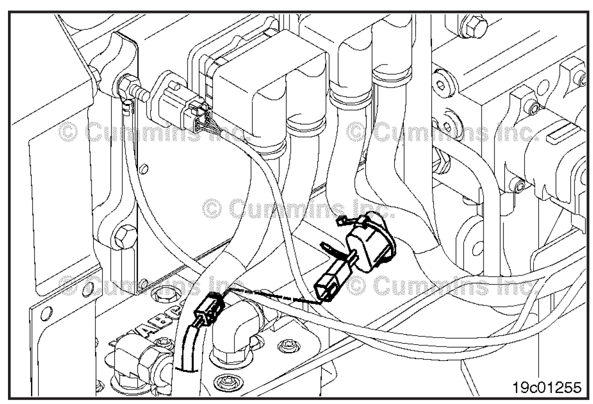
Locate the real-time clock battery on the main engine harness. Cut the wire tie securing the module case to the harness.

Clean the area around the battery harness connector.

Disconnect the battery from the engine harness.

Install



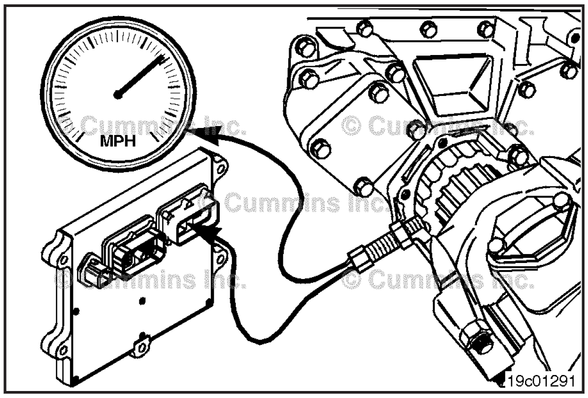


Use quick-dry electrical contact cleaner, Part Number 3824510, to clean all dirt and moisture from the battery and harness connector.

Do **not** apply grease or oil to either the harness connector or battery.

Connect the battery to the engine harness.

Secure the battery to the main engine harness using wire ties.

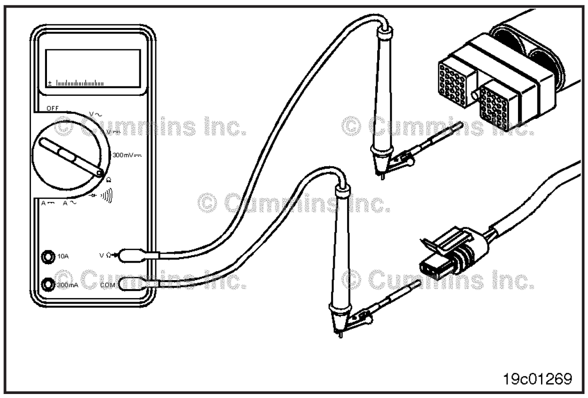


Tachograph Circuit (019-325)

General Information

The 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.

Refer to the OEM troubleshooting and repair manual for troubleshooting instructions.

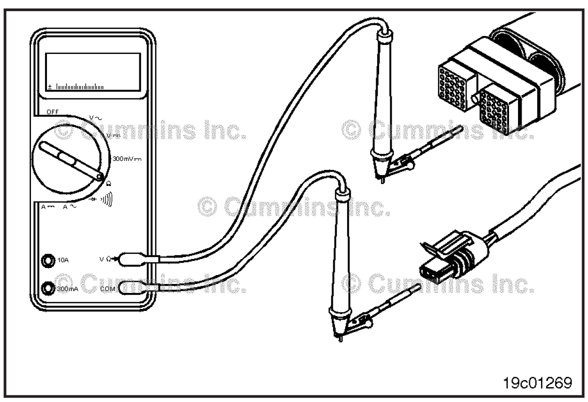


Resistance Check

⚠CAUTION⚠

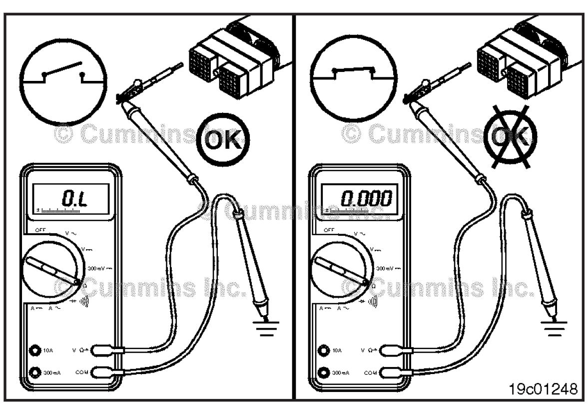
To reduce the possibility of pin and connector damage, use test lead, Part Number 3822758, when taking a measurement.

Disconnect the 50-pin OEM harness connector from the ECM. 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 50-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 50-pin OEM harness connector. Refer to the OEM troubleshooting and repair manual.



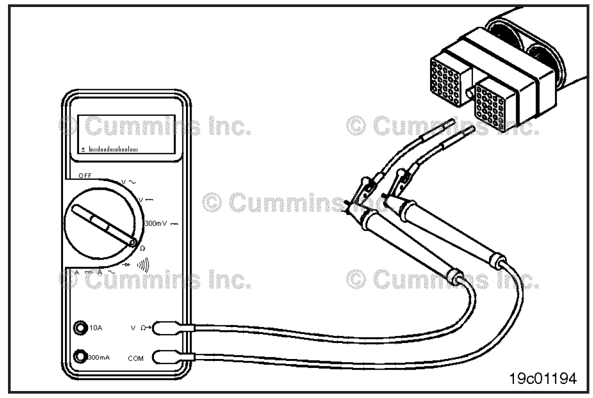
Check for Short Circuit to Ground

Disconnect the 50-pin OEM harness connector from the ECM. Disconnect the tachograph from the OEM harness. Set the multimeter to measure resistance.

Touch the test lead to the tachograph signal pin of the 50-pin OEM harness connector. Touch the other multimeter lead to the engine block. Measure the resistance.

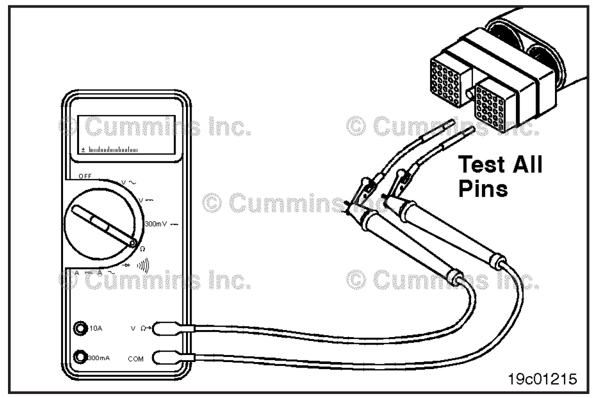
The multimeter **must** show 100k ohms or more (open circuit).

Check for Short Circuit from Pin to Pin



Disconnect the 50-pin OEM harness connector from the ECM. Set the multimeter to measure resistance. Insert a test lead into the tachograph signal pin of the 50-pin OEM harness connector. Insert the other test lead into the first pin of the 50-pin OEM harness connector, and measure the resistance.

The multimeter **must** show 100k ohms or more (open circuit).

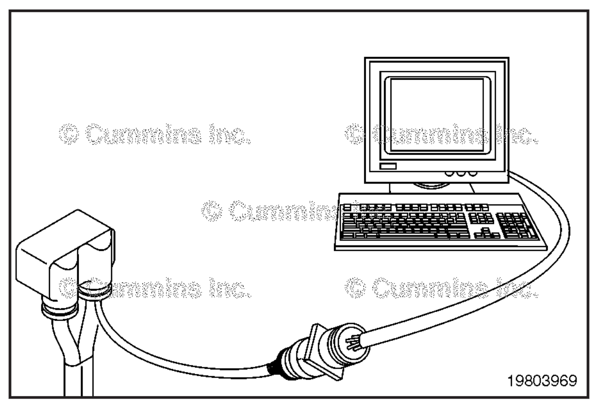


Remove the lead from the first pin and check all other pins, one at a time.

The multimeter **must** show 100k ohms or more (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. Refer to the OEM troubleshooting and repair manual.

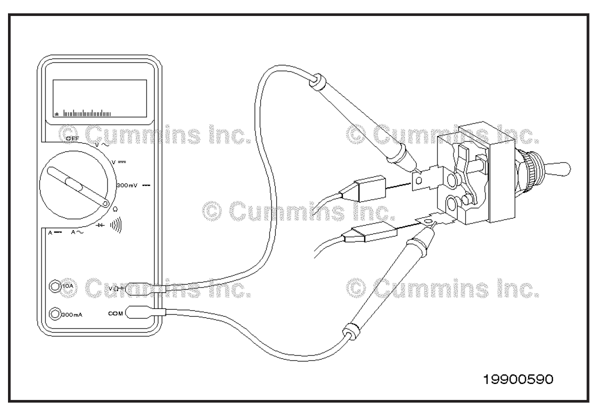
Engine Protection Override Switch (019-327)

General Information



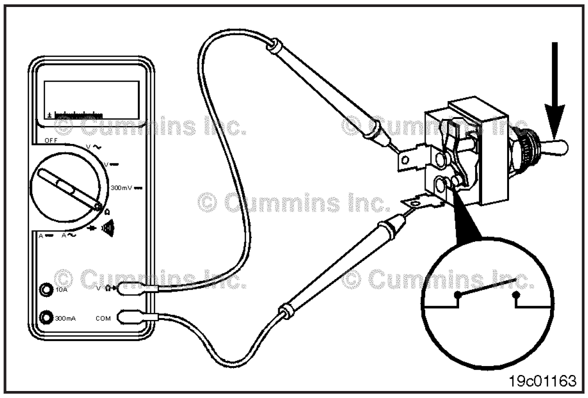
The engine protection override switch is an original equipment manufacturer (OEM) installed switch that allows a driver to abort a pending engine protection shutdown. The switch is **only** active when it is properly wired by the OEM and the engine protection shutdown override feature is enabled in the 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

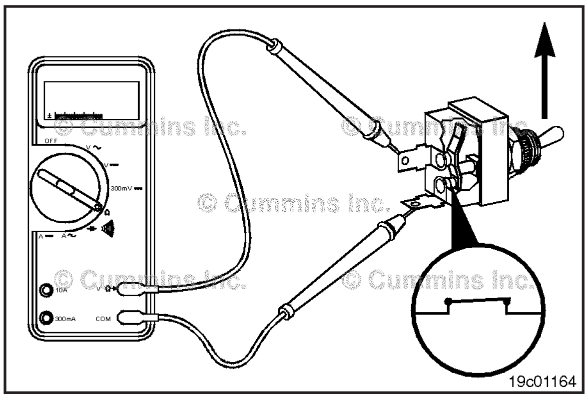


If INSITE™ electronic service tool is available, monitor the engine protection override switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

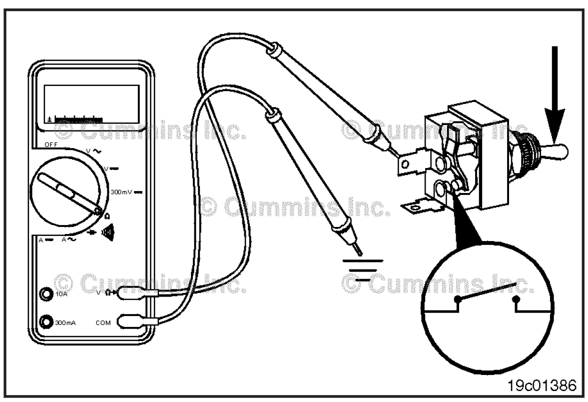
Locate the engine protection override switch. Label the wires with the location on the switch or the wire number. Remove the electrical connectors from the switch. Adjust the multimeter to measure resistance. Touch one multimeter probe to one of the terminals on the switch. Touch the other multimeter 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

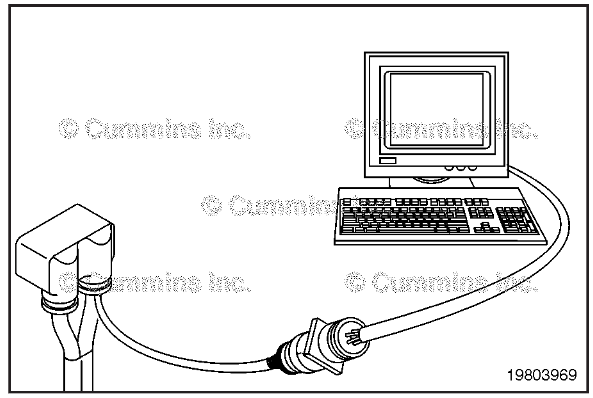
Touch one of the multimeter probes to one of the switch terminals. Touch the other probe to chassis ground. Move the switch to the non-override (released) position and measure the resistance. The multimeter **must** show an open circuit (100k ohms or more).

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

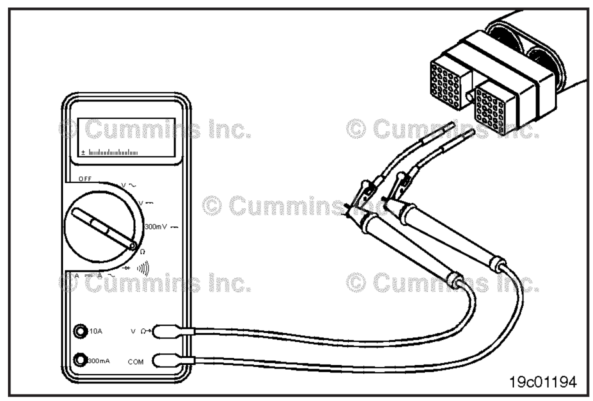


CAUTION

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.

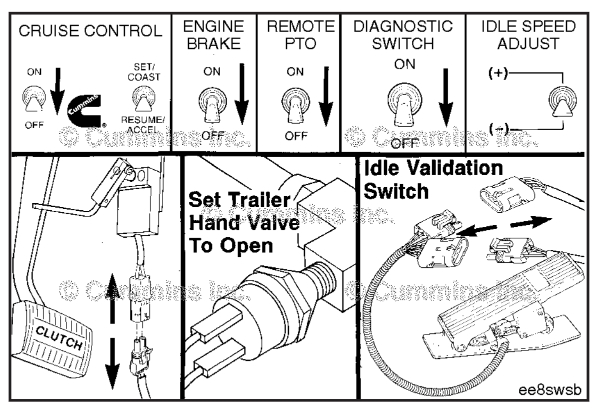
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). Insert one of the test leads into the switch return negative (-) pin of the OEM harness connector and connect the alligator clip to the multimeter probe. Insert the other lead into the engine protection override switch signal pin of the OEM harness connector and connect the alligator clip to the other multimeter probe.



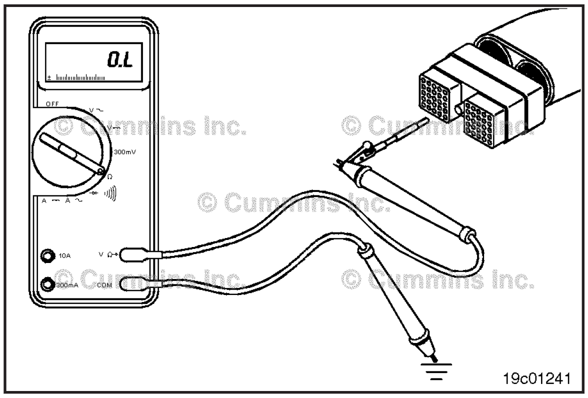
Move the engine protection override switch to the override (pressed) position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the switch return negative (-) wire and the engine protection override switch wire for an open circuit, provided that 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



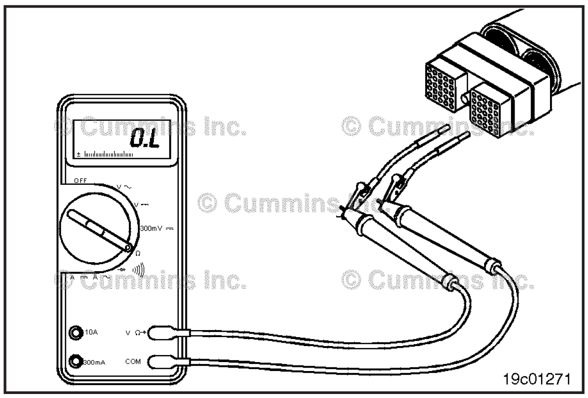
To isolate the engine protection override switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM connector and the OEM harness from the engine protection override switch. Disconnect the idle validation switch. Set all cab panel switches to the OFF or neutral position. Set the service brake using the trailer brake hand valve.



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.

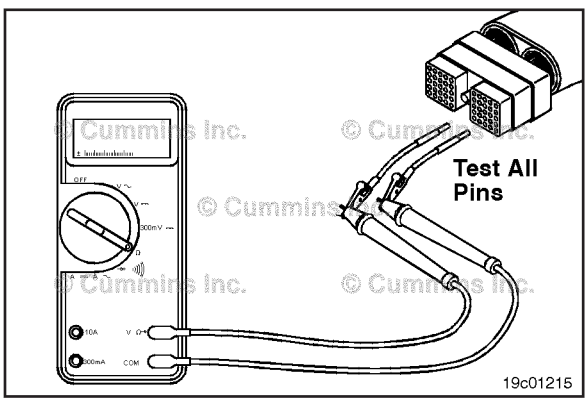
The multimeter **must** show an open circuit (100k ohms or more). If the circuit is **not** open, there is a short circuit to ground in the engine protection override switch circuit, provided that the switch has been previously checked.

Repair or replace the wire connected to cruise control input wire in the OEM harness according to the vehicle manufacturer's procedure.



Check for Short Circuit from Pin to Pin

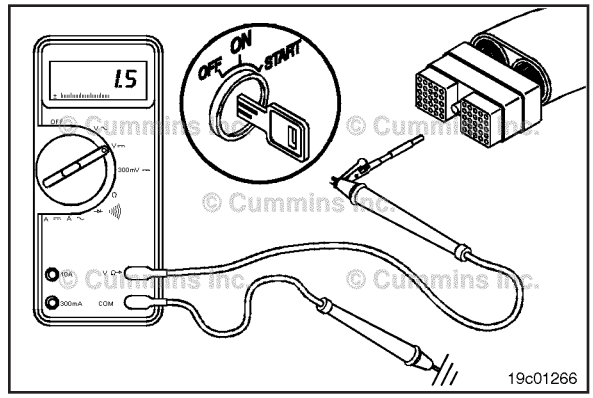
Check for a short circuit from pin-to-pin. Isolate the engine protection override circuit by setting the switches as in the previous section. Set the engine protection override switch to the override position. Insert the lead into the engine protection override switch pin. Connect the alligator clip 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).



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.

Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.

Check for Short Circuit to External Voltage Source



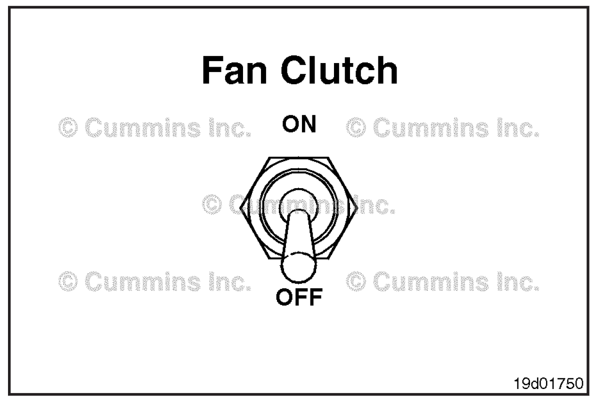
Turn the keyswitch to the ON position. Set the engine protection override switch to the override position. Adjust the multimeter to measure VDC. Insert a test lead into the engine protection override switch pin and attach it to a multimeter probe. Touch the other multimeter probe to the engine block 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.

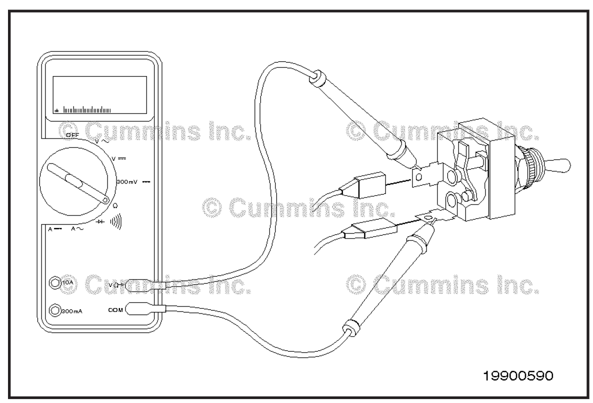
Fan Clutch Switch (019-329)

General Information



The fan clutch switch allows the driver to control the operation of the engine's fan.

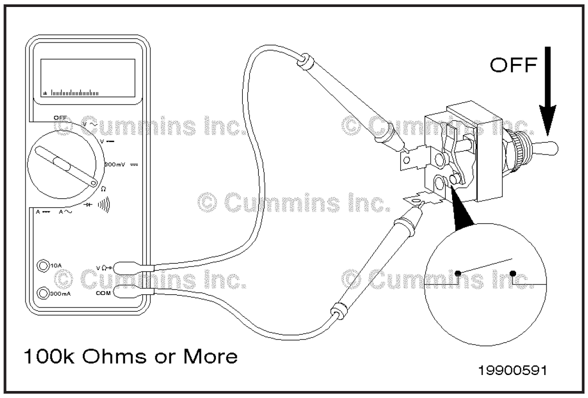
Resistance Check



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.

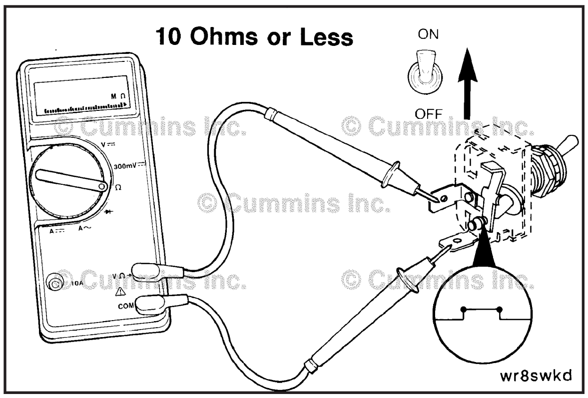


Move the switch to the OFF position, and measure the resistance.

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.

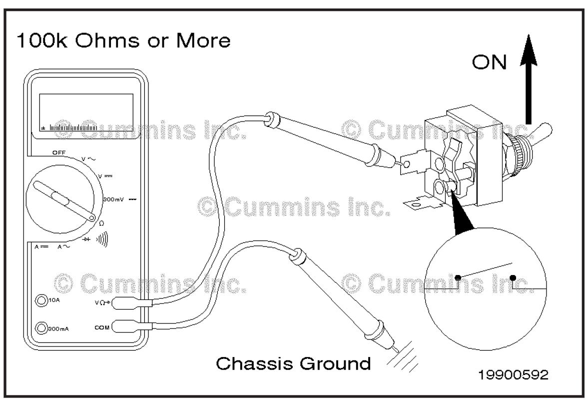


Move the switch to the ON position, and measure the resistance.

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.



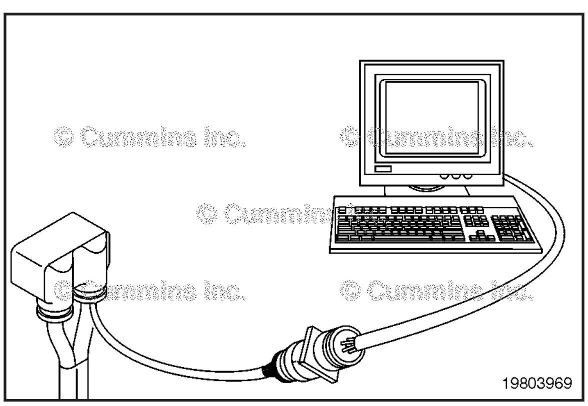
Check for Short Circuit to Ground

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.

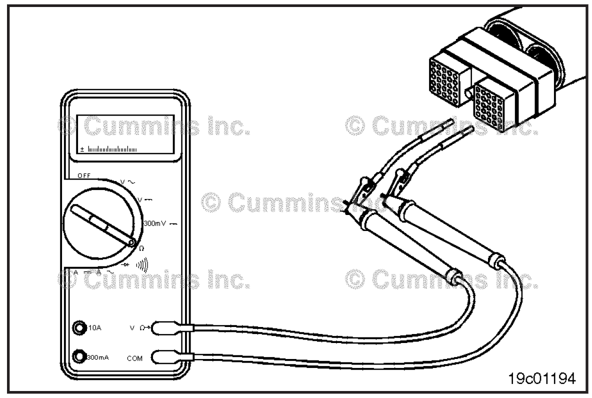
If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the following procedure.

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.

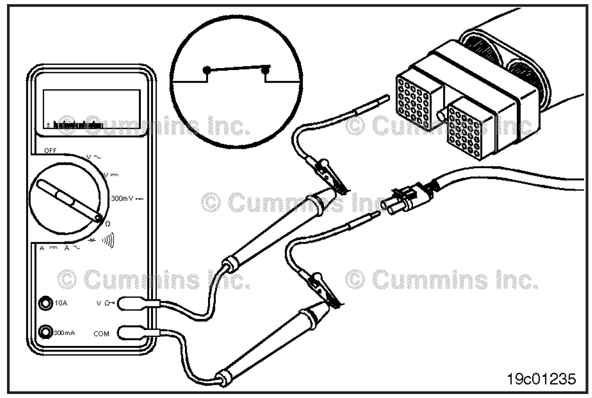


19c01194

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.



19c01235

Check for Short Circuit to Ground

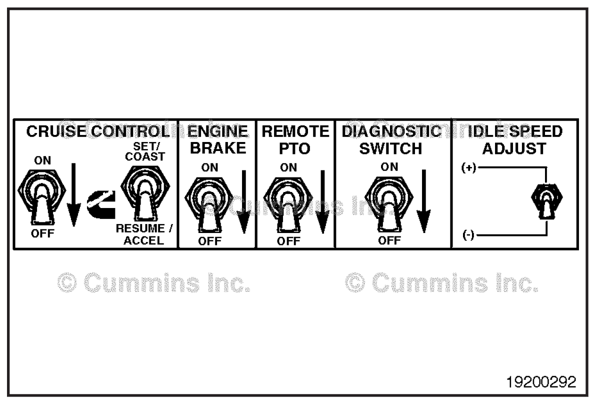
Disconnect the OEM harness connector from the ECM connector.

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.

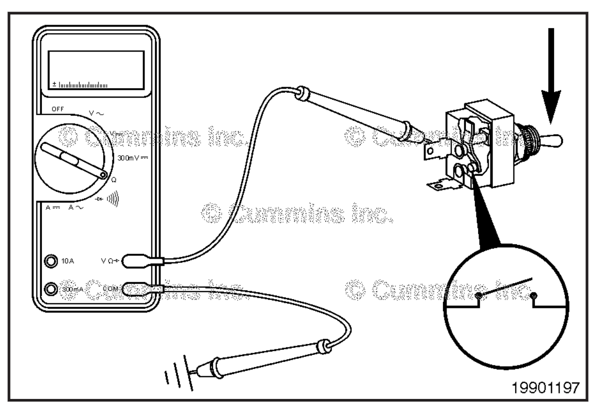
Set the service brake using the trailer brake hand valve. Set the multimeter to measure resistance.



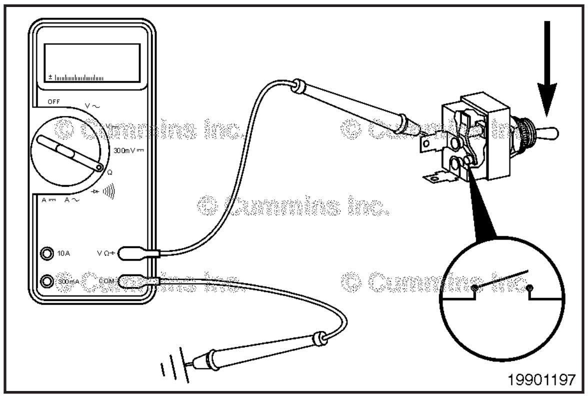
19200292

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.



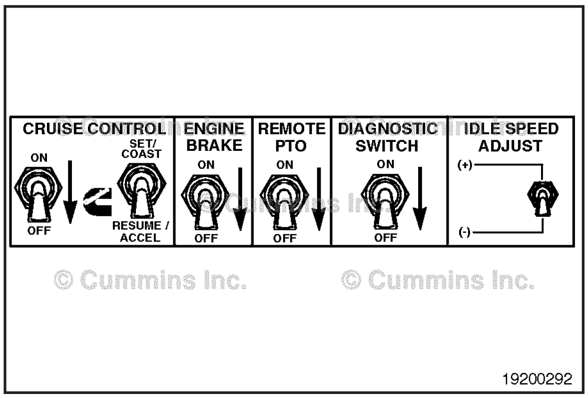
19901197



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

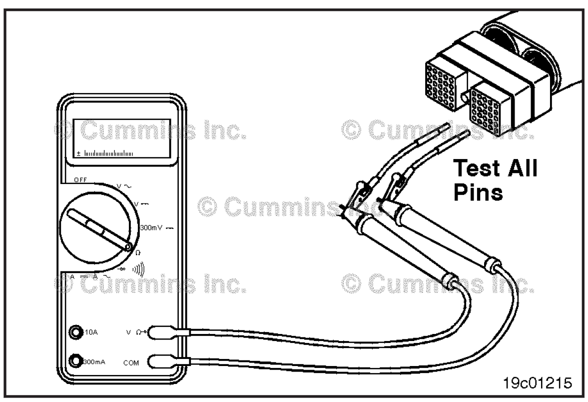
Disconnect the OEM harness connector from the ECM connector.

Disconnect the manual fan clutch switch from the OEM harness.

Disconnect the clutch switch and the idle validation switch.

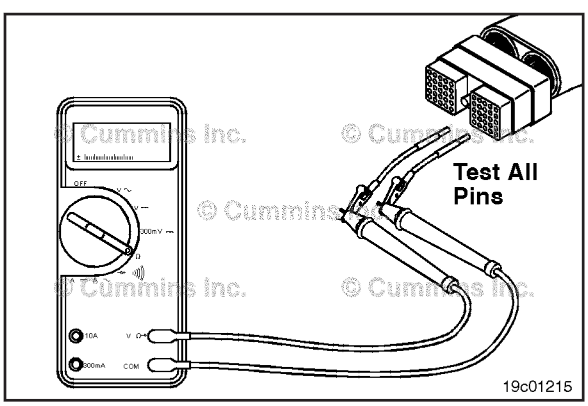
Set all cab switches to the OFF or neutral position.

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.

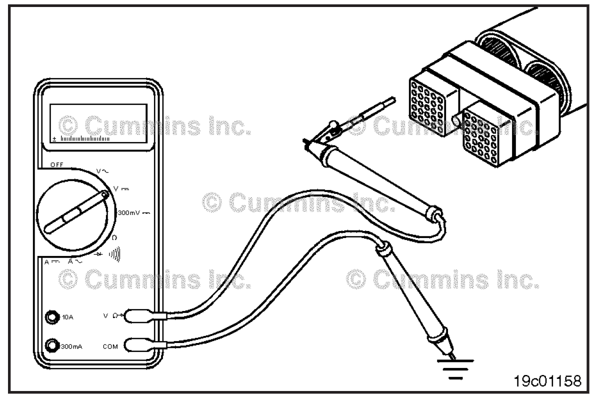
Check for Short Circuit to External Voltage Source

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.

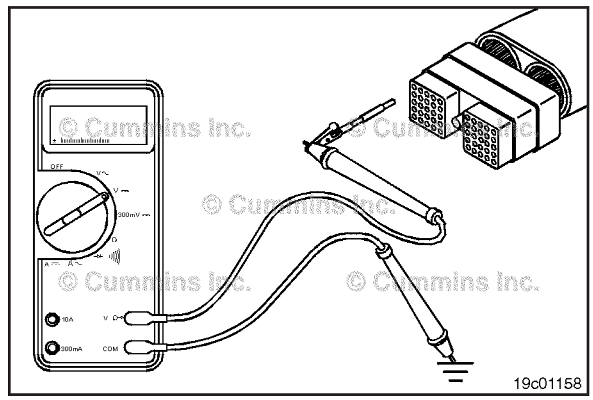
Touch the other multimeter probe to engine block ground and measure the voltage.



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.

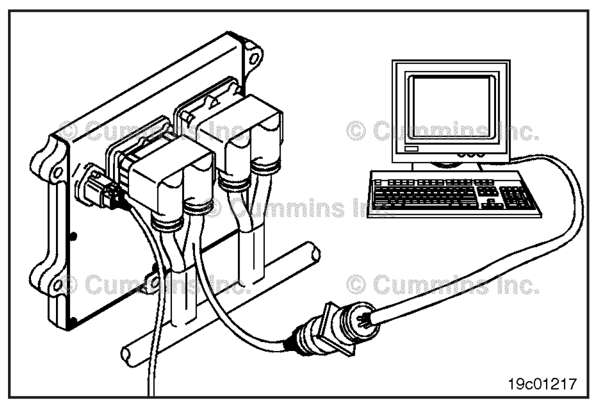
Remove the external voltage source.

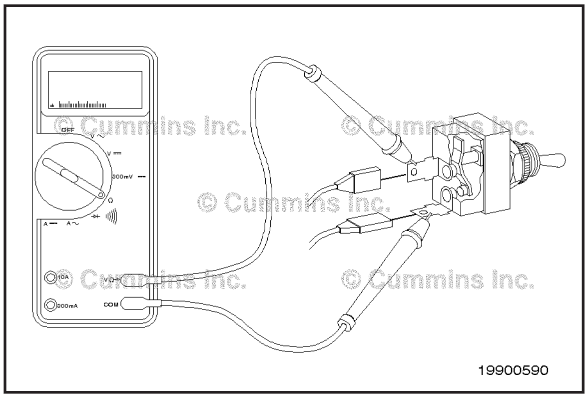


Remote Accelerator Switch (019-333)

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.

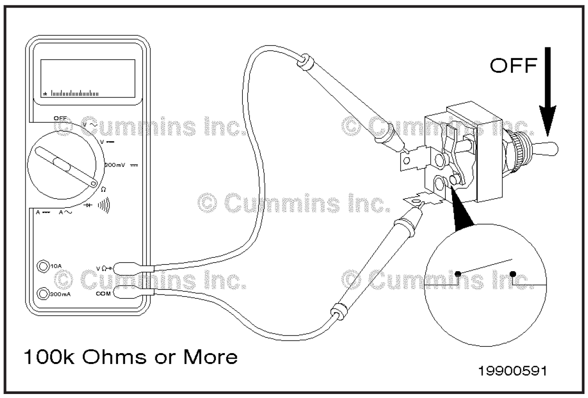




Resistance Check

If INSITE™ is available, monitor the switch for proper operation. If INSITE™ is **not** available, follow the troubleshooting procedures in this section.

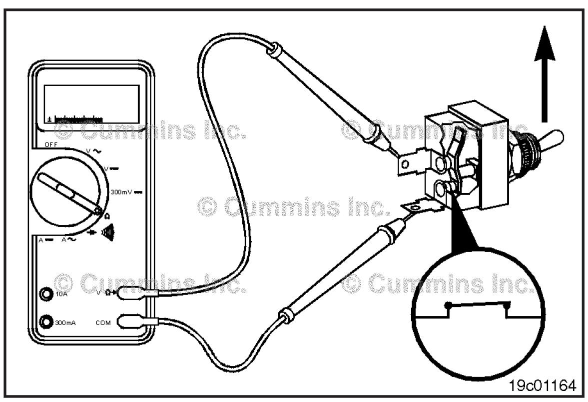
Locate the remote accelerator switch. Remove and tag the two connectors from the terminals on the switch.



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).

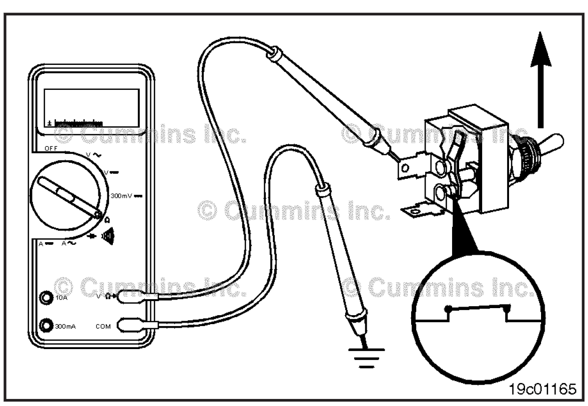
If the circuit is **not** open, the switch has failed. Refer to the OEM troubleshooting and repair manual for the replacement procedures.



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.



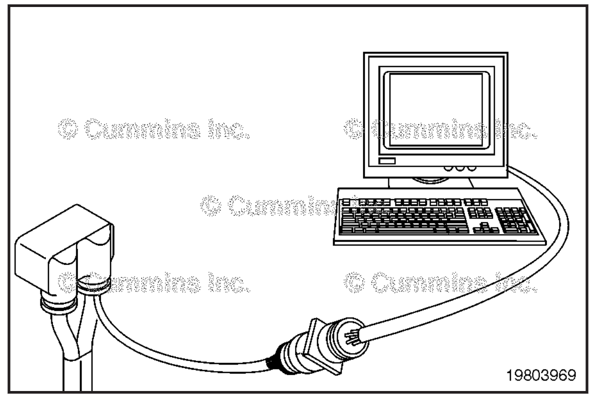
Check for Short Circuit to Ground

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)

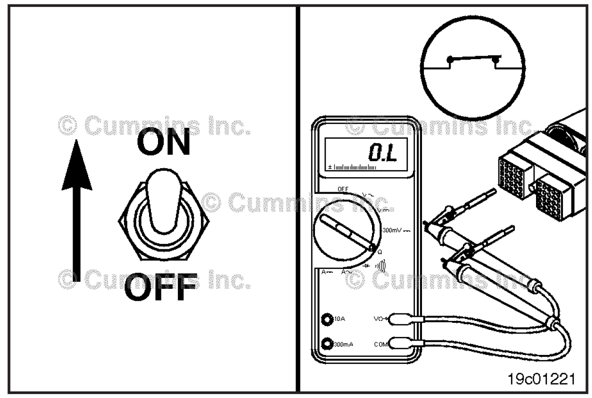
Resistance Check



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.



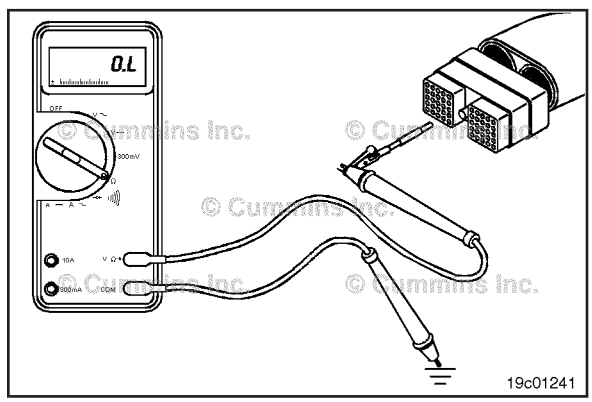
Disconnect the original equipment manufacturer (OEM) harness from the electronic control module (ECM).

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

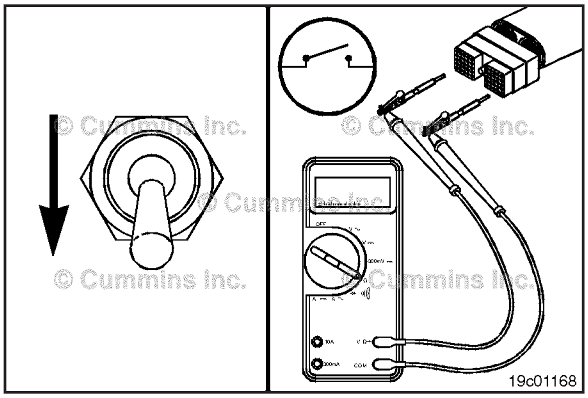


To isolate the remote accelerator switch circuit when checking for a short circuit, disconnect the OEM harness connector from the ECM and the OEM harness from the remote accelerator switch.

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.

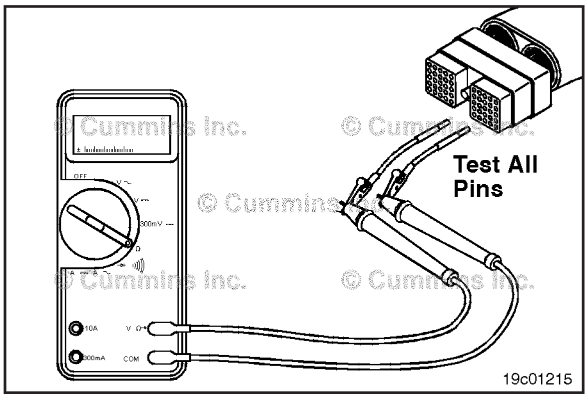


Check for Short Circuit from Pin to Pin

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.

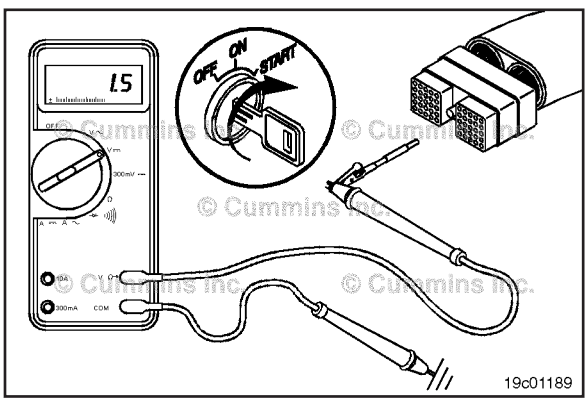
The multimeter **must** show an open circuit (100K ohms or more).



Remove the test lead from the remote accelerator switch signal wire and check all other pins. The multimeter **must** show an open circuit (100K ohms or more).

If the circuit is **not** open, there is a short circuit between the remote accelerator switch signal pin and any other pin that shows a closed circuit, provided the switch has previously been checked.

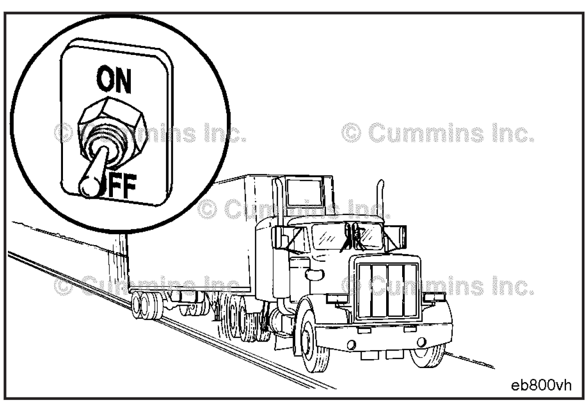
Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to External Voltage Source

Turn the vehicle keyswitch to the ON position. Set the remote accelerator switch to the ON position. Set the multimeter to measure VDC. Insert a test lead into the remote accelerator switch signal wire and attach it to a multimeter probe. Touch the other multimeter probe to engine block ground. Measure the voltage, the voltage **must** be 1.5 volts or less.

If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the remote accelerator switch circuit and a wire carrying power in the OEM harness. Repair or replace the OEM harness. Refer to Procedure 019-071.



Engine Torque Limit Control Switch (019-335)

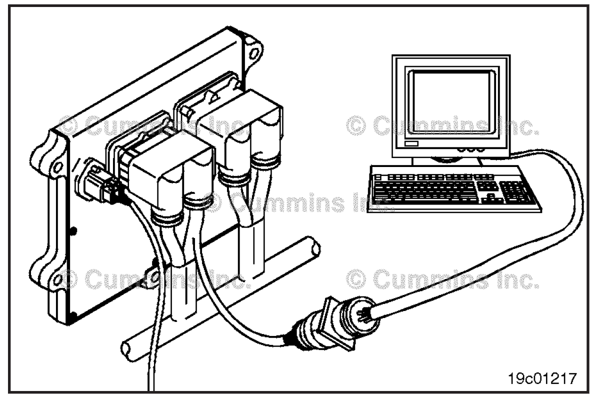
General Information

The engine torque limit switch allows the operator to switch to a different torque output limit by the engine. This is desirable in applications where auxiliary equipment can **not** handle full engine torque.

Activating this switch protects the equipment by limiting the maximum output torque of the engine. This maximum torque value can be entered through the electronic service tool under the powertrain protection feature.

Resistance Check

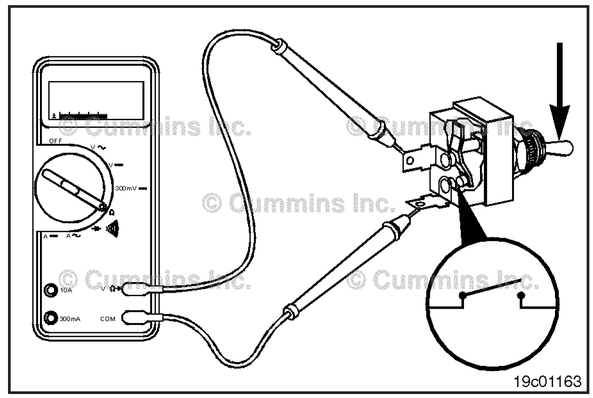
If INSITE™ is available, monitor the engine torque limit switch for proper operation. If **not**, follow the troubleshooting procedures in this section.



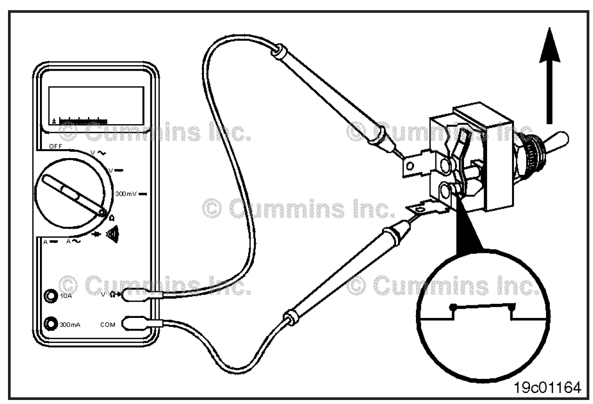
Locate the engine torque limit switch. Label the wires with the location of the switch or the wire number. Remove the electrical connectors from the switch. Adjust the multimeter to measure resistance. Touch one multimeter probe to one of the terminals on the switch. Touch the other multimeter probe to the other terminal of the switch.

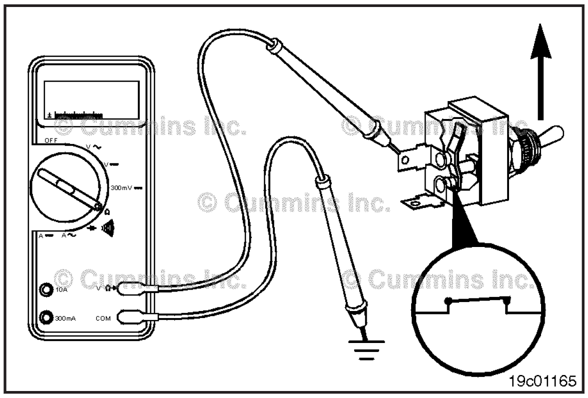
NOTE: The torque limit switch is programmable by the OEM. The open or closed position of the switch can represent “Normal” or “Torque Limit” depending on how the OEM programs the switch. Before continuing troubleshooting refer to the OEM literature to determine how the switch is programmed and apply the “switch failed” criteria accordingly when performing the troubleshooting.

Place the switch in the torque limit 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.



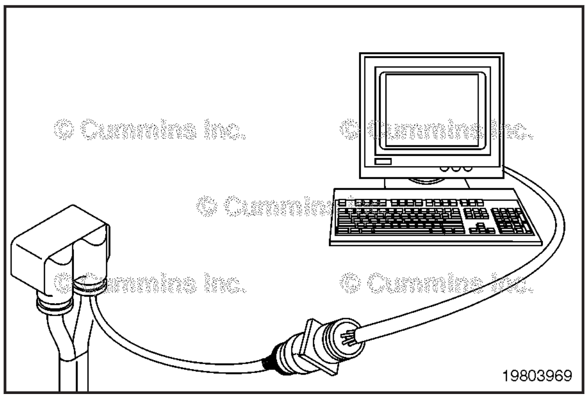
Place the switch in the normal position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the resistance value is correct, 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 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.



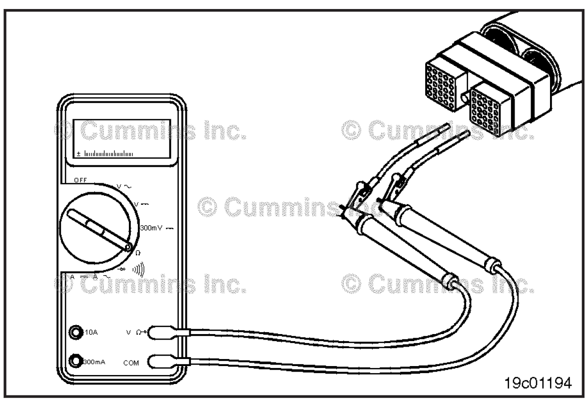
Engine Torque Limit Control Switch Circuit (019-336)

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 torque limit switch circuit for proper operation. If **not**, follow the troubleshooting procedures in this section.



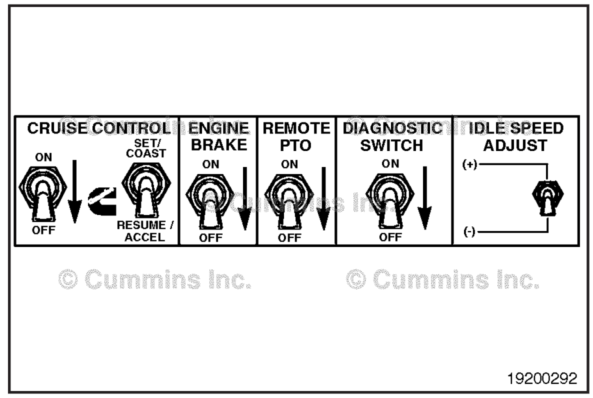
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). Insert one of the test leads into the switch return pin of the OEM harness connector and connect the alligator clip to the multimeter probe. Insert the other lead into the engine torque limit signal pin of the OEM harness connector and connect the alligator clip to the other multimeter probe.

NOTE: The torque limit switch is programmable by the OEM. The open or closed position of the switch can represent “Normal” or “Torque 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 torque limit 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 engine torque limit 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 engine torque limit 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

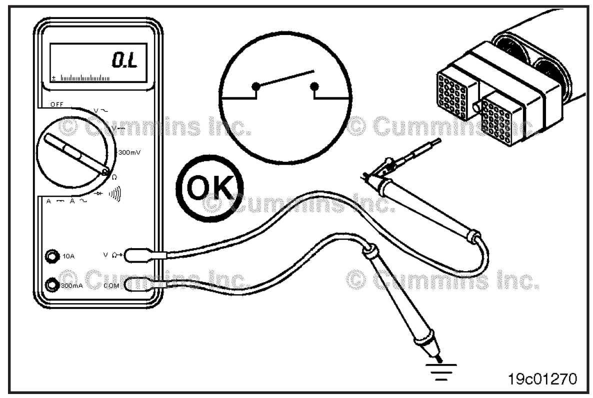
To isolate the engine torque limit switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM and the OEM harness from the engine torque limit switch. Disconnect the clutch pedal position switch/engine protection override switch and the accelerator pedal assembly. Set all cab panel switches to the OFF or neutral position. Set the service brake using the trailer brake hand valve.



Adjust the multimeter to measure resistance. Insert a test lead into the engine torque limit 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 torque limit switch circuit, provided that the switch has been previously checked.

Repair or replace the wire connected to the engine torque limit control switch signal wire in the OEM harness. Refer to the OEM troubleshooting and repair manual.

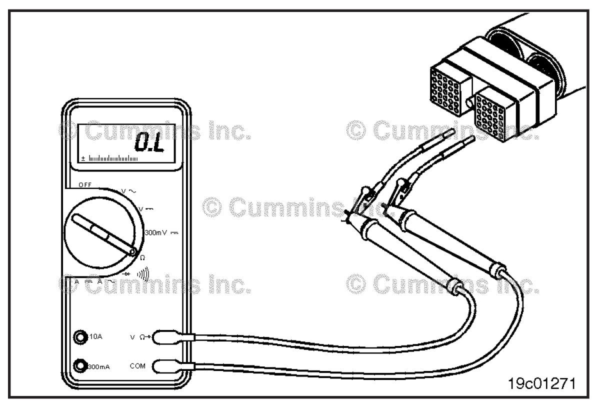


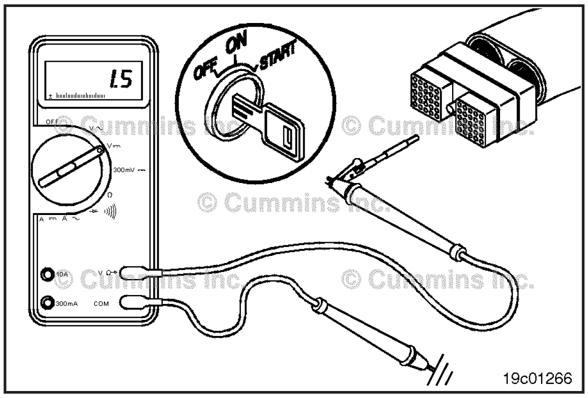
Check for Short Circuit from Pin to Pin

Isolate the engine torque limit switch circuit by setting the switches as in the previous section. Set the engine torque limit switch to the normal position. Insert the lead into the engine torque limit 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 engine torque limit 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 torque limit 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.





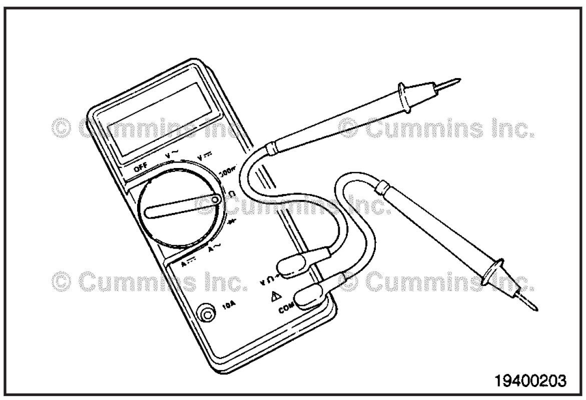
Check for Short Circuit to External Voltage Source

Turn the keyswitch to the ON position. Set the engine torque limit switch to the normal position. Adjust the multimeter to measure VDC. Insert a test lead into the engine torque limit 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 engine torque limit 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 engine torque limit switch circuit was approved in all of the previous tests, it is functioning correctly.



Multimeter Usage (019-359)

General Information

How to Use a Multimeter

On most meters, the negative (-), (black) meter probe **must** be plugged into the COM position and the positive (+), (red) meter probe **must** be plugged into one of the positions marked for amperage, resistance, or voltage. Refer to the manufacturer's procedures for more detail.

NOTE: When measuring to a block or chassis ground, use a clean, unpainted metal surface to make sure a good measurement exists.

Use of Special Test Leads

⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

Refer to the appropriate wiring repair kit for specific test leads used on this application.

How to Measure Amperage

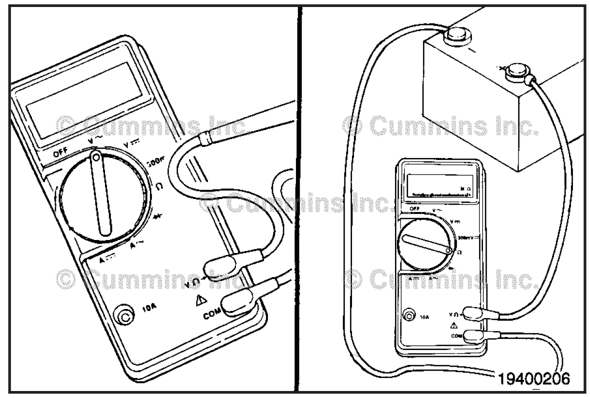
Make an open circuit at the place where the current is to be measured.

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.


19400206

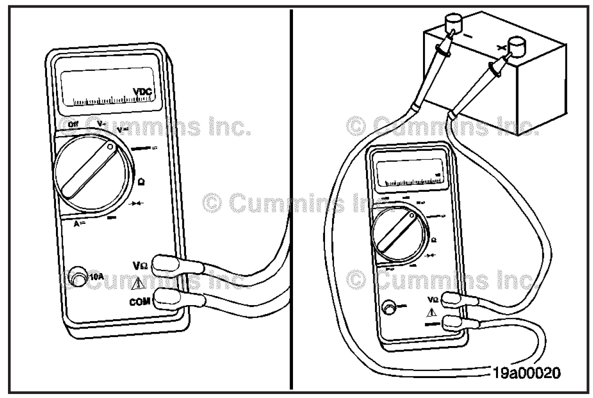
How to Measure Voltage

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.


19a00020

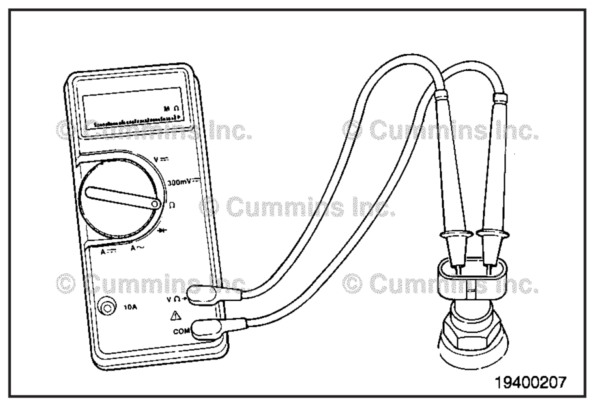
How to Measure Resistance

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.


19400207

How to Find the Internal Resistance of the Meter

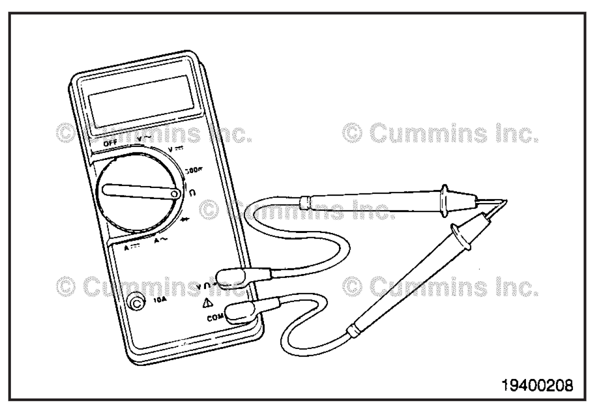
It is important to know the internal resistance of the meter when measuring small resistances. To measure small resistances accurately, the internal resistance of the meter **must** be subtracted from the measured resistance.

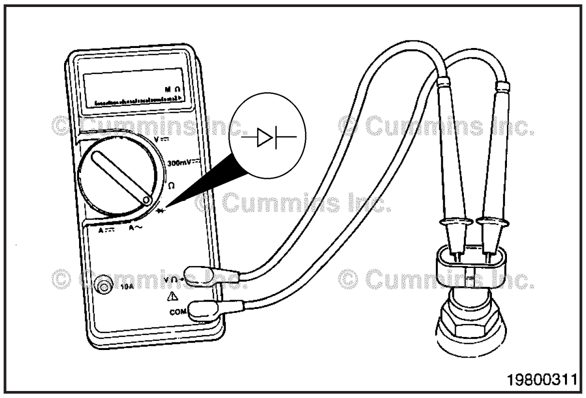
Turn the meter ON.

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


19800311

How to Test for Continuity

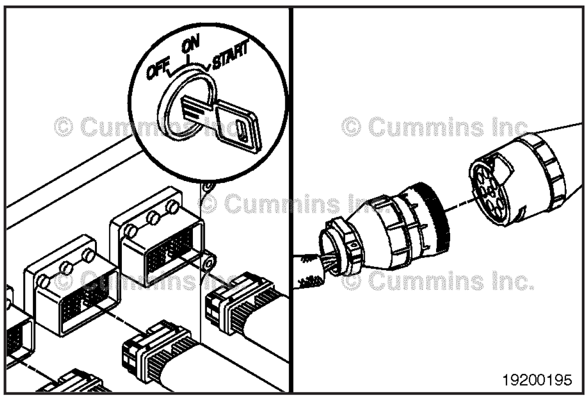
Select the continuity function on the meter (usually marked with a diode symbol).

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.



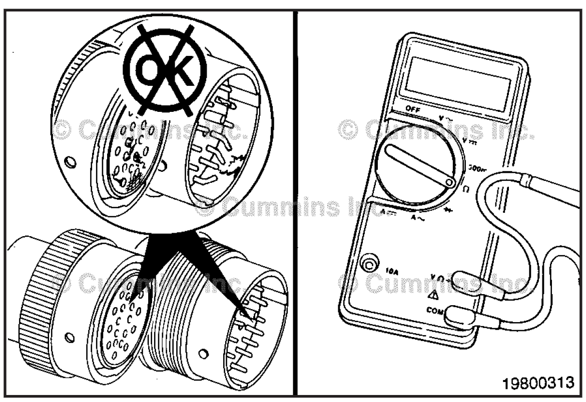
19200195

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.



19800313

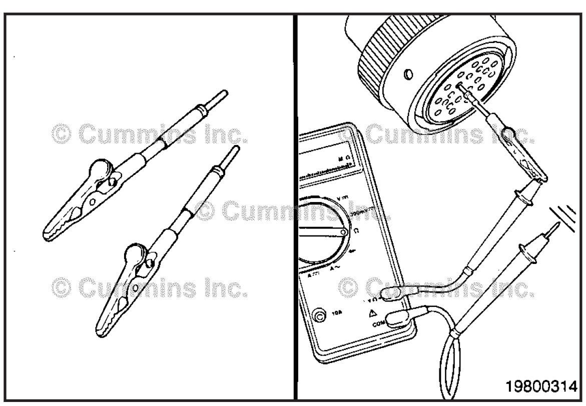
When testing a sensor, **only** the sensor connection is required to be disconnected.

When testing a harness, the harness connector at the electronic control unit and the connector at the sensor or multiple sensors should be disconnected.

Identify the pins that need to be tested.

Inspect the connector pins. 019-361.

Adjust the multimeter to measure resistance.


19800314

CAUTION

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

Touch one of the multimeter probes to the correct pin to be tested.

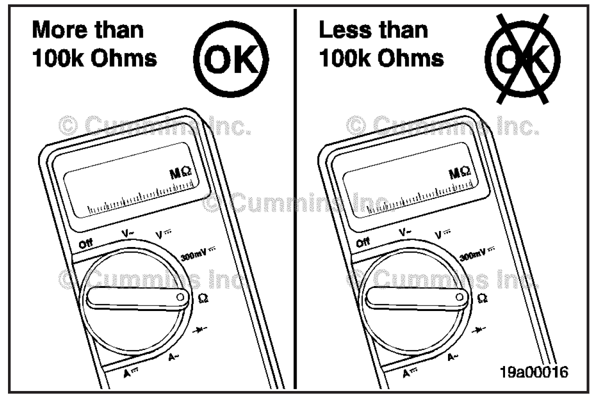
Touch the other probe of the multimeter to a clean, unpainted surface on the engine block or chassis ground.

Read the value on the multimeter display.

The multimeter **must** read greater than 100k ohms, which is an open circuit.

If the circuit is **not** open, the wire being checked has a short circuit to ground, engine block or chassis ground.

Repair or replace the component or wire.



Short Circuit from Pin to Pin - Check

Short circuit from pin to pin is a condition in which an electrical path exists between two pins where it is **not** intended to exist.

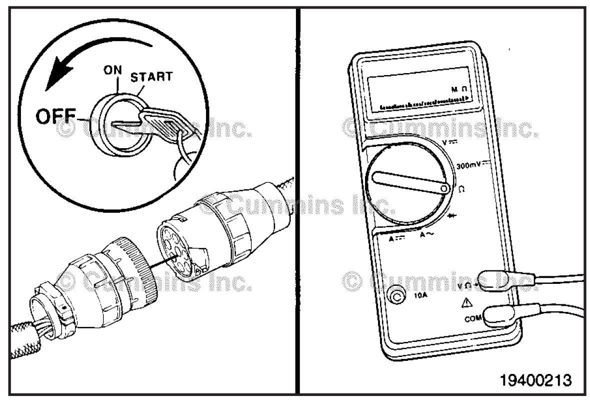
The procedure for checking short circuit from pin to pin is as follows:

1 Turn keyswitch OFF.

2 Disconnect the connector that is to be tested.

3 Identify the pins that are to be tested.

4 Adjust the multimeter to measure resistance.

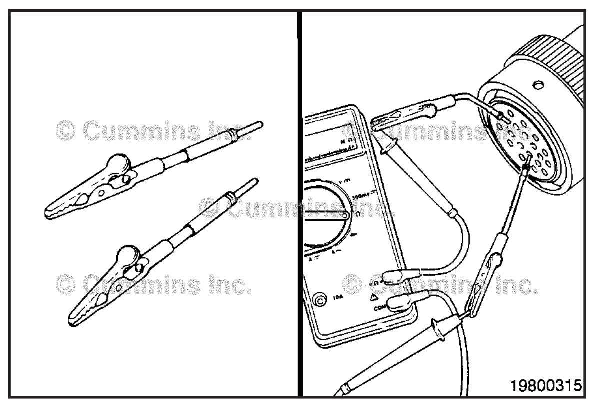


⚠CAUTION⚠

To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

1 Touch one of the multimeter probes to the correct pin to be tested on the harness side of the connector.

2 Touch the other probe of the multimeter to all other pins on the harness side of the connector.



1 Read the value on the multimeter display.

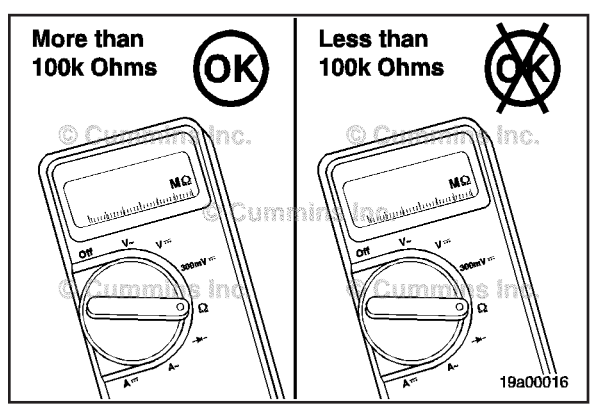
2 The multimeter **must** read greater than 100k ohms, which is an open circuit.

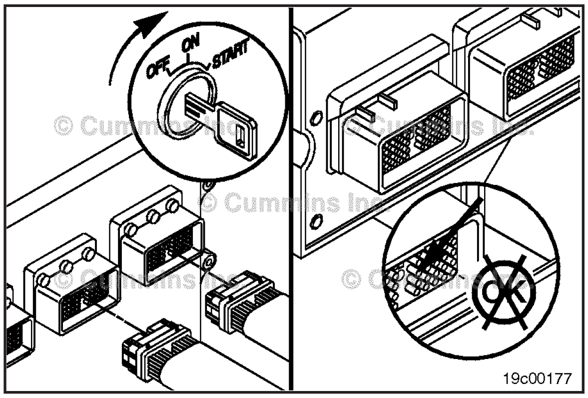
3 If the circuit is **not** open, the pins being checked are electrically connected.

NOTE: Refer to the wiring diagram to verify that the wires in question are **not** supposed to be connected.

1 Inspect the harness connectors for moisture that can be the cause of an inappropriate electrical connection.

2 Repair or replace the harness.





Voltage Checking

Voltage check is a procedure to measure the difference in voltage potential between two points.

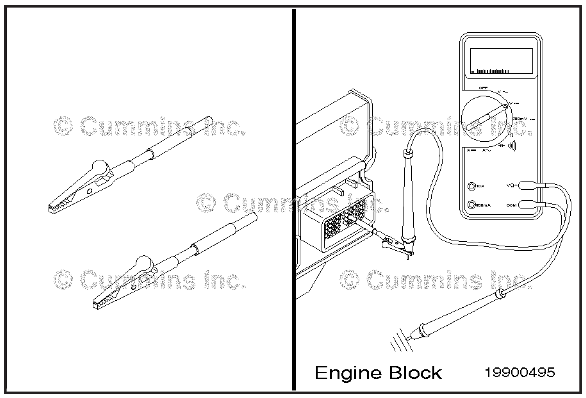
The procedure for checking voltage is as follows:

1 Disconnect the connectors that are to be tested.

2 Turn keyswitch ON.

3 Identify the pins that are to be tested.

4 Adjust the multimeter to AC voltage (V ˜) or DC voltage (V-).

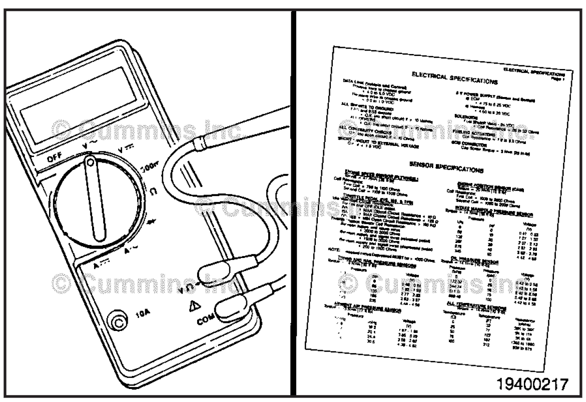


⚠CAUTION⚠

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.

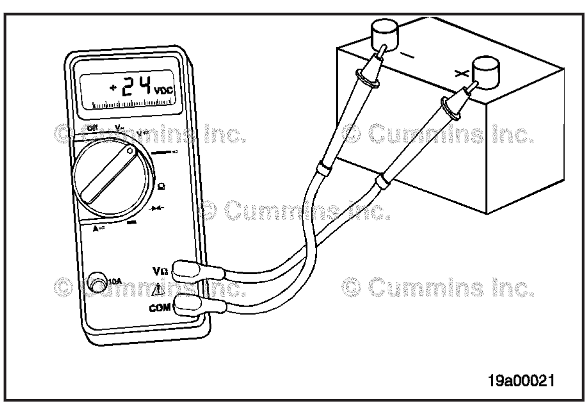
1 Touch one of the multimeter test probes to the correct lead to be tested.

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

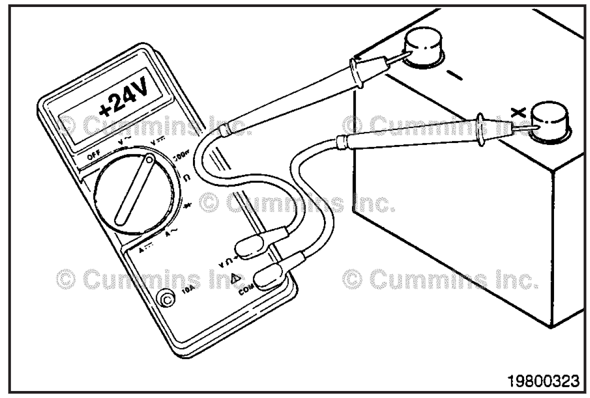
A battery will be used as an example to check polarity of a circuit.

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.

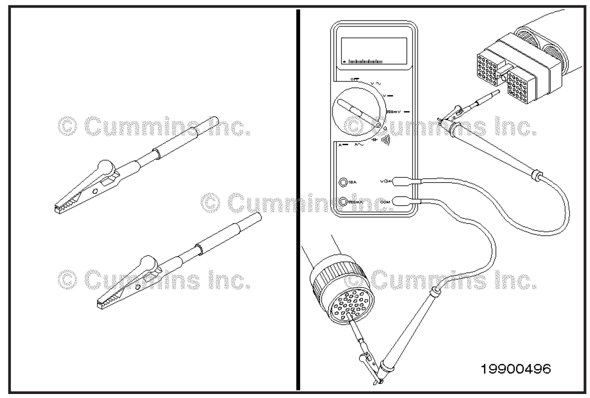


Continuity Check

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.

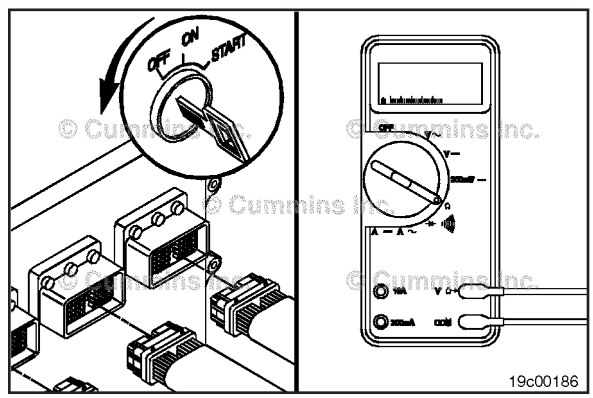


The procedure for checking continuity is as follows:

1 Turn keyswitch OFF.

2 Disconnect the harness connectors that are to be tested.

3 Adjust the multimeter to measure resistance.



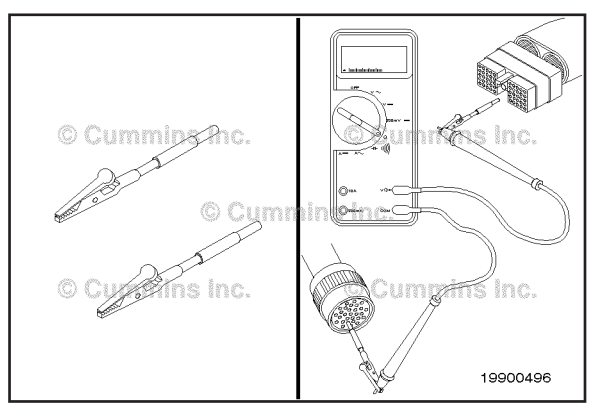
CAUTION

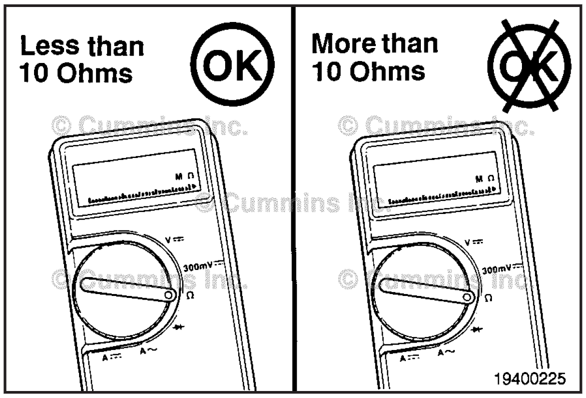
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit for this control system.

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.

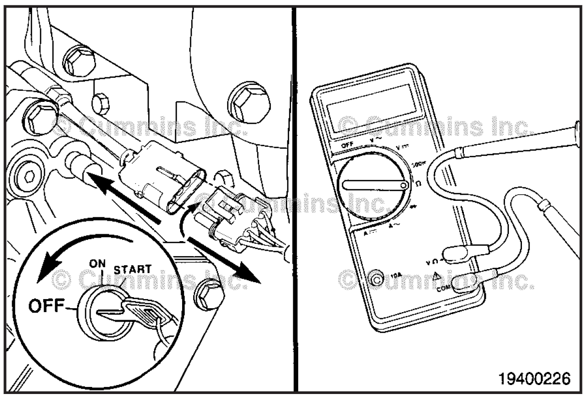
3 Read the value on the multimeter display.





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.

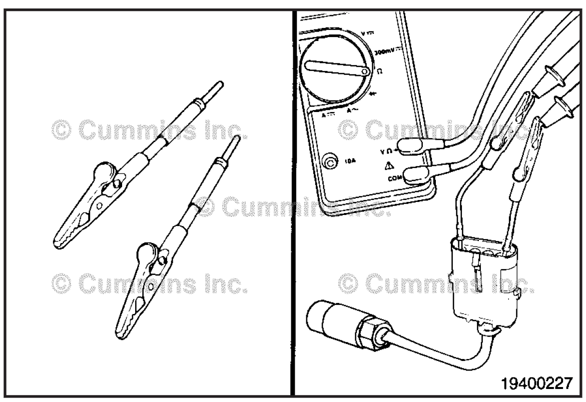


Resistance Check - Coil

Turn keyswitch OFF.

Disconnect the harness from the coil.

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.

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.

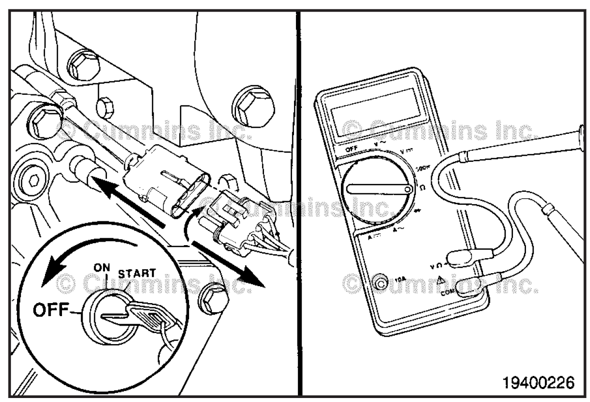
Resistance Check

Turn the key switch off.

Disconnect the appropriate connector from the component.

Adjust the multimeter to measure resistance.

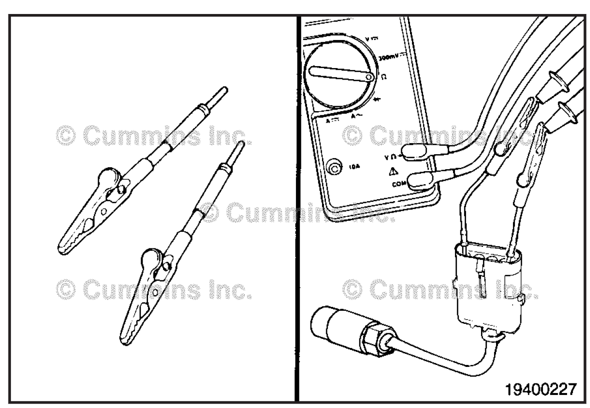
Use the wiring diagram to determine the pins that apply to the component you are measuring.

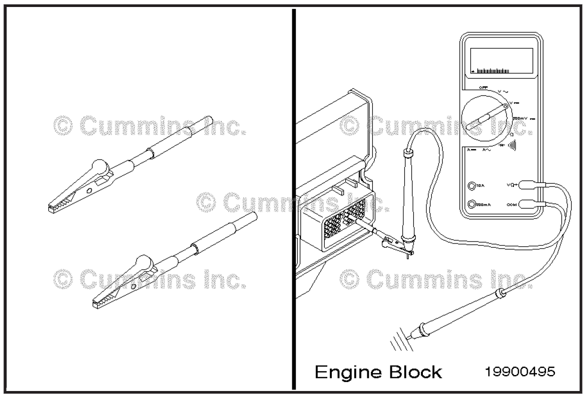


⚠CAUTION⚠
To reduce the possibility of pin and harness damage, use the appropriate test lead for the connector. Refer to the Service Tools listing or the appropriate wiring repair kit.

Connect the appropriate connector test leads to the connector pins and connect the alligator clips to the multimeter probe. Measure the resistance.

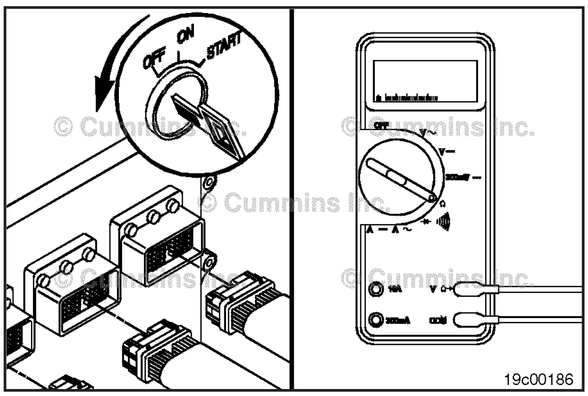
Compare this value to the applicable fault code specification or applicable Electrical or Sensor Specification on the wiring diagram. If the value is not correct, the component is malfunctioning. Refer to the applicable fault code procedure for instructions.





Continuity Check

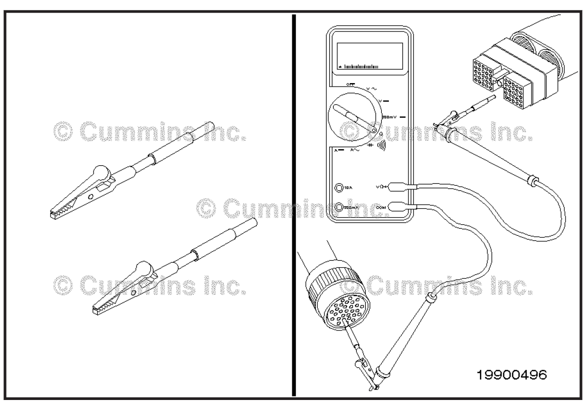
Continuity is an electrical connection between two pins that is less than a certain value. For harness wires, the specification is less than 10 ohms.



Turn the key switch to the OFF position.

Disconnect the harness connectors that are to be tested.

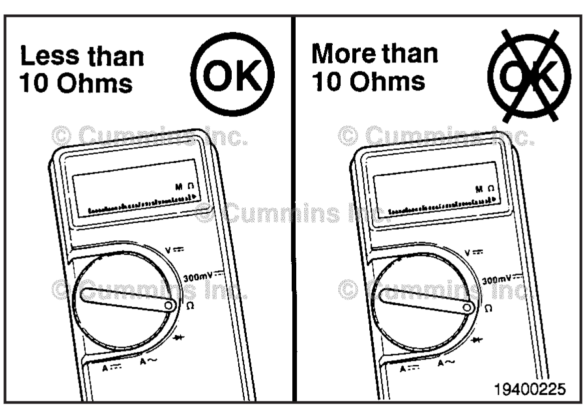
Adjust the multimeter to measure resistance.



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.

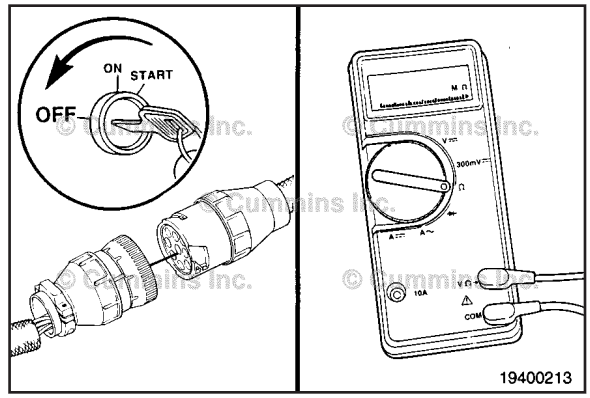
Check for Short Circuit from Pin to Pin

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.

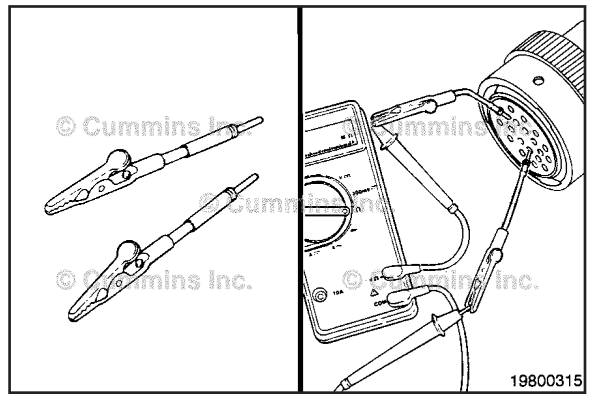
Adjust the multimeter to measure resistance.



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.

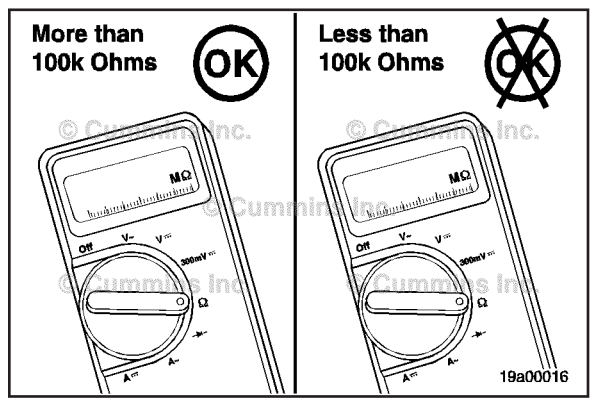
Connect the appropriate connector test leads to the connector pins and connect the alligator clips to the multimeter probes. Measure the resistance.



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.

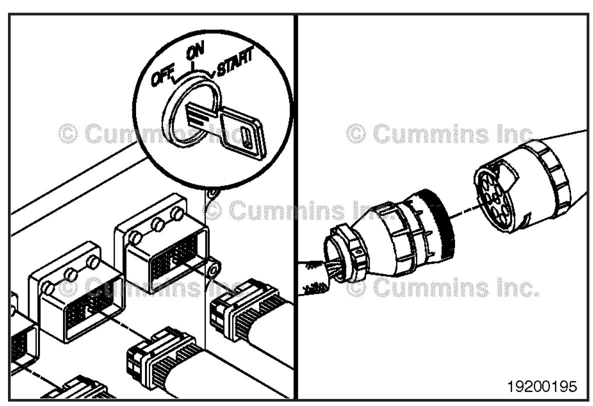


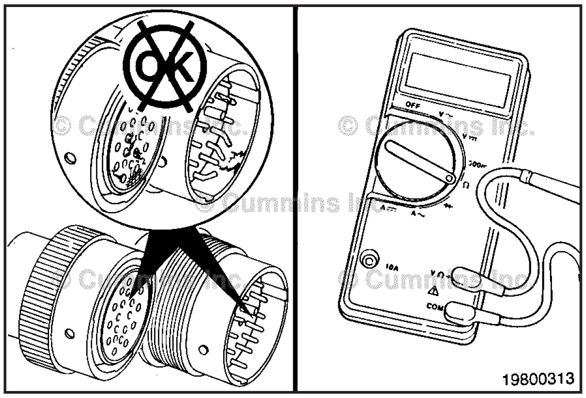
Check for Short Circuit to Ground

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.



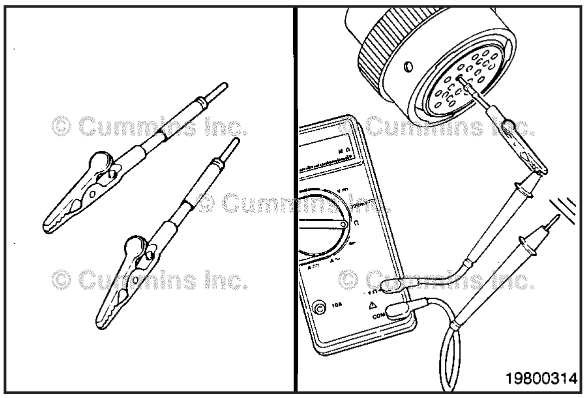


When testing a sensor, **only** the sensor connection is required to be disconnected.

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.

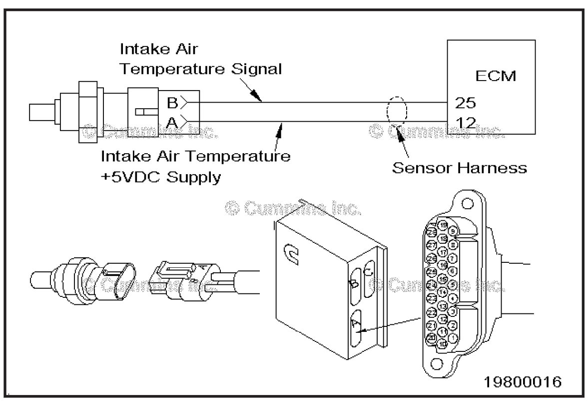


CAUTION

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)

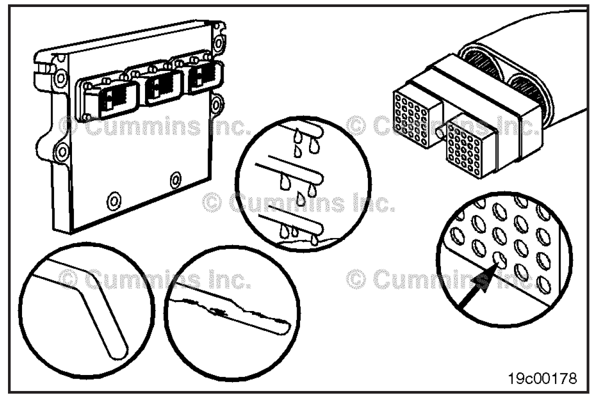
General Information

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.

Inactive or Intermittent Fault Code (019-362)

General Information

This procedure is designed to troubleshoot electrical circuit faults that are intermittent and are currently inactive. This procedure can also be used to troubleshoot high inactive counts of circuit related fault codes.

If multiple fault codes are present, use a wiring diagram to check for common sensor supplies and ground circuits that may be shared between sensors, actuators, and switches. Pressure sensors may share a common 5 volt supply and ground circuit. Temperature sensors and actuators may share a common ground circuit. If either a sensor supply or a ground circuit has an intermittent connection, fault codes related to all the sensors may be active or have high counts of inactive fault codes.

If the conditions for a fault code to trigger exist and then the conditions are no longer present, an inactive fault code is created. When conditions are intermittent, there may be multiple inactive counts for a given fault code. If there are more than 10 inactive counts, the fault code should be troubleshot as an active fault code. Troubleshooting priority should be given to fault codes that are associated engine performance components such as the turbocharger, EGR valve, or any system related fault code.

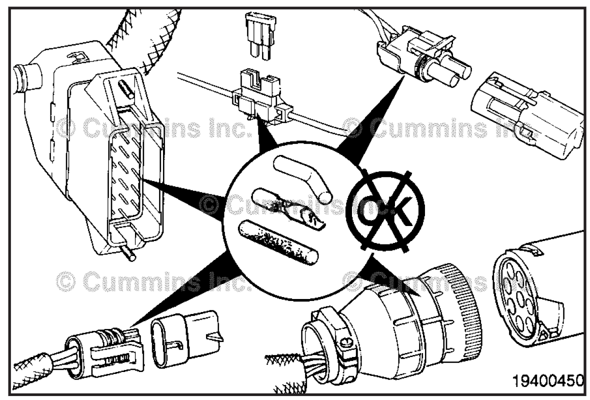
Initial Check

Interview the operator and determine the engine operating conditions when the fault occurs and what symptoms occur when the fault is active.

Determine if there have been any recent service repairs or maintenance performed that may be related to the intermittent condition.

Review the “Shop Talk” section of the fault code troubleshooting tree. Shop Talk will give additional troubleshooting information and will list possible causes for the fault code.

Verify the electronic control module (ECM) calibration is correct. Check the calibration revision history found on QuickServe® Online for applicable fixes to the calibration stored in the ECM. If necessary, recalibrate the ECM. 019-032 (ECM Calibration Code) in Section 19 in the corresponding Troubleshooting and Repair Manual for the engine being serviced.



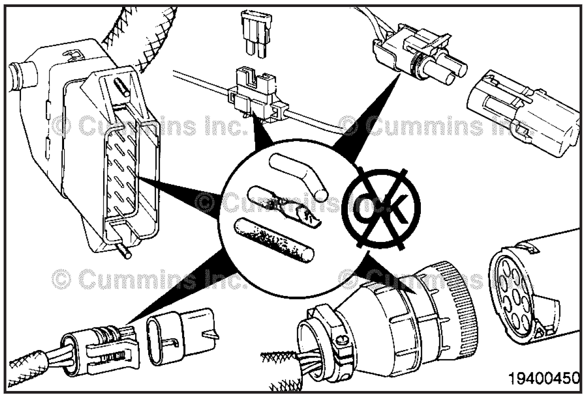
Disconnect the sensor or actuator related to the intermittent condition.

Inspect the wiring harness and connector for the following:

- Loose connector (gently pull the wires at the back of the connectors)
- Corroded pins
- Bent or broken pins
- Pushed back or expanded pins
- Moisture in or on the connectors
- Dirt or debris in, or on, the connector pins
- Missing or damaged connector seals
- Wire insulation damage
- Connector shell broken
- Damaged locking tab connector
- Pin wear (close visual inspection)
- Rusty, painted, corroded, or loose grounds.

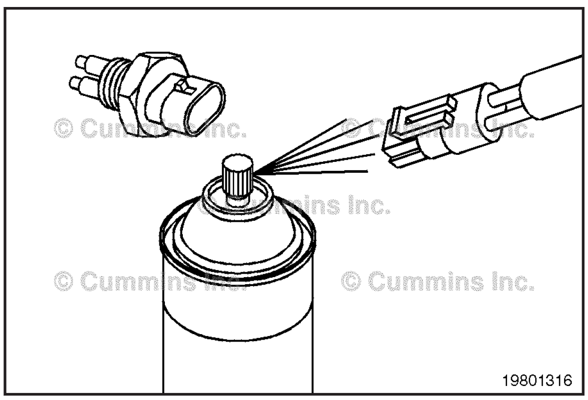
Thoroughly inspect the wiring harness between the suspected component and ECM connection. Check for the proper strain relief on the wiring harness.

A dark powder found inside the connector may be a sign of pin fretting. Clean the pin contacts and reconnect the connector.

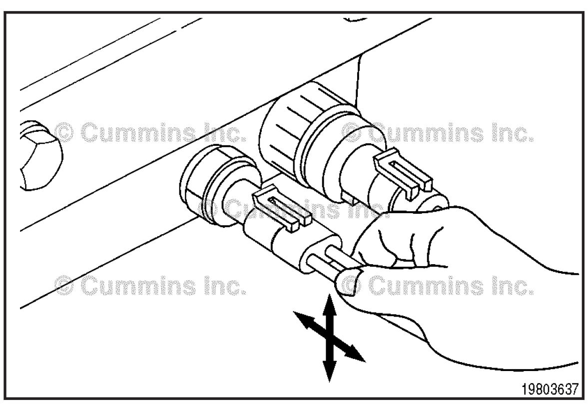


Disconnect the wiring harness connector from the ECM. Inspect the ECM connector for the following:

- Loose connector (gently pull the wires at the back of the connectors)
- Corroded pins
- Bent or broken pins
- Pushed back or expanded pins
- Moisture in or on the connectors
- Dirt or debris in, or on, the connector pins
- Missing or damaged connector seals
- Wire insulation damage
- Connector shell broken
- Damaged locking tab connector
- Pin wear (close visual inspection)
- Rusty, painted, corroded, or loose grounds.



Clean connector(s) of suspect components and clear the fault code.



Harness Shake Test

Connect INSITE™ and open the Data Monitor/Logger feature. Monitor the sensor signal voltage for the appropriate sensor. Also monitor the actual value of the sensor or component.

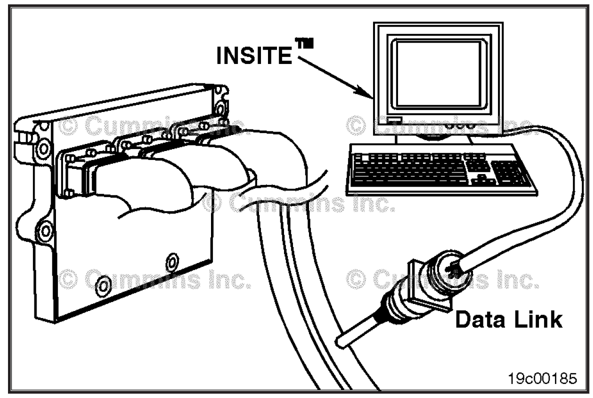
Beginning at the component in question and working back through the harness to the ECM, gently twist, bend and pull at each connection and in between connections in the harness.

While performing the Harness Shake Test, the sensor signal voltage that INSITE™ displays should remain between steady. A typical reading should be between 0.5 and 5.12 volts.

NOTE: This procedure can also be used to check for loose or damaged wires for switches. Switch status can be monitored with INSITE™. Look for switch changes when performing the Harness Shake Test.

If the fault code goes active, if inactive counts increase, the sensor signal voltage fluctuates, or the switch status changes, there is a loose connection or damaged wire at that specific location. Refer to Procedure 019-361, Component Connector and Pin Inspection, and inspect the pins at the connectors in question. Repair or replace as necessary.

NOTE: The ECM will **not** change the status of switches and faults instantaneously. Approximately 10 to 15 seconds should be used to gently twist the harness and see a reading change from the ECM. Trying to monitor too many parameters at one time with INSITE™ will slow down the update rate on the screen. Keep the number of parameters monitored with INSITE™ to minimum to increase the update rate.



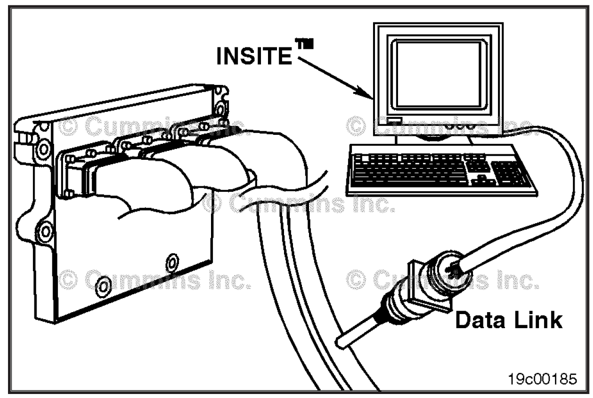
Start the engine.

With the engine running, connect to INSITE™ and open up the Data Monitor/Logger feature. Monitor the sensor signal voltage for the appropriate sensor. Also monitor the actual value of the sensor or component.

While performing the Harness Shake Test, the sensor signal voltage that INSITE™ displays should remain between steady. A typical reading should be between 0.5 and 5.12 volts.

Now gently bend, twist, and pull the connections and in between connections in the harness while monitoring the sensor signal voltage.

If the sensor signal voltage fluctuates during the test, then there is a loose connection or damaged wire at that specific location. Inspect the pins at the connectors in question.

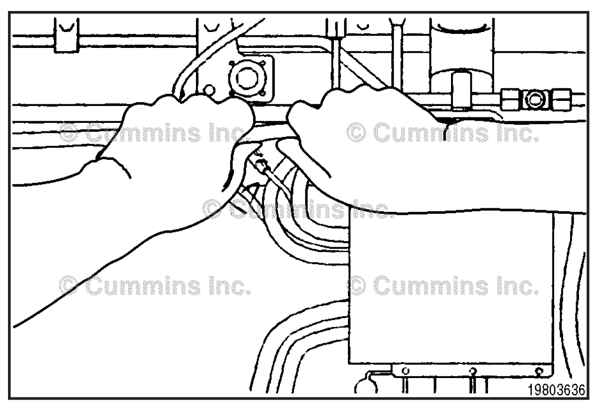


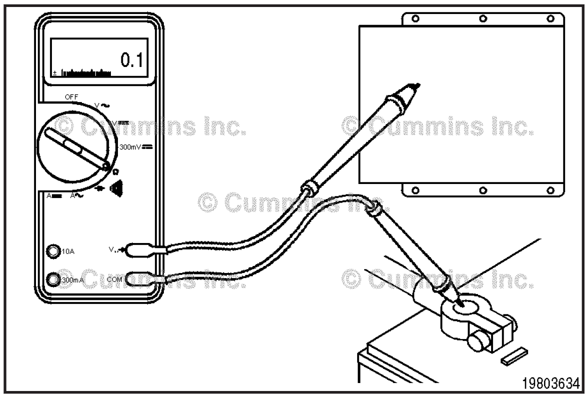
Ground Circuit Check

Check for poor battery and chassis grounds. Firmly pull on ground wires or cables checking for loose connections. Check the following grounds making sure they are secure, clean, and on a non-painted surface:

- engine block grounds
- chassis (or frame rail) grounds
- ECM grounds
- alternator and starter negative posts

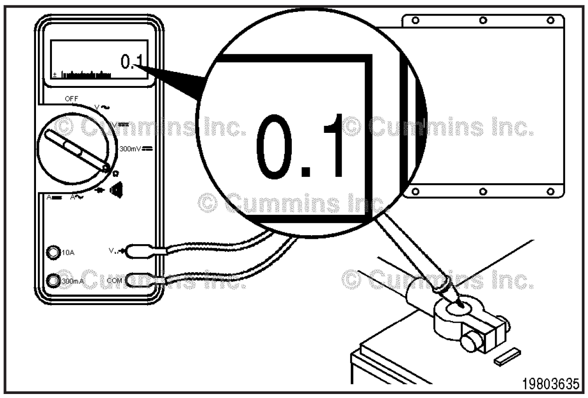
While performing this step, check to see if the fault code goes active, or if inactive counts increase. If this happens, there is a loose connection or damaged wire at that location. Disconnect, clean grounding cables and grounding surfaces, then reconnect. Repair or replace grounding cables or wires if necessary.





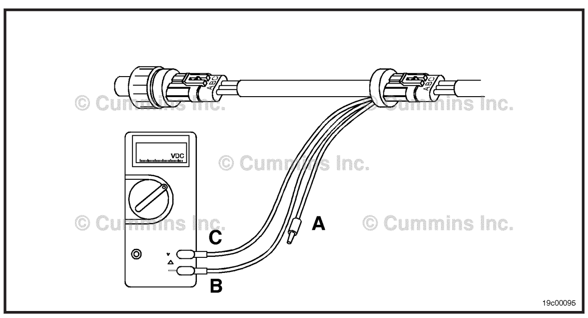
Measure resistance from the battery negative (-) post to:

- ECM casing (clean, non-painted surface)
- Engine Block (clean, non-painted surface)
- Starter (-) post
- Alternator (-) post
- Firewall grounding post
- Cab ground (dash switches, common ground)
- Vehicle frame rail.



All resistance values should measure less than 1 ohm. If resistance values exceed 1 ohm, clean grounding cables and grounding surfaces, then reconnect. Repair or replace grounding cables or wires if necessary.

NOTE: Refer to Procedure 019-359, “General Multimeter Usage”, for the correct use of a multimeter.



Voltage Check

This test **must** be performed with the actuator connected to the wiring harness.

With the sensor or actuator disconnected from the wiring harness, measure the voltage at the engine harness connector of the component.

Connect the sensor or actuator to the wiring harness and measure the voltage with all the components connected. Use a breakout cable or back-probe the connector with the multimeter leads when performing this check.

The voltage to the component should be within 0.5 volts of the original voltage measured. If the voltage drops more than 0.5 volts, check for intermittent connections, cut wires, or corroded relay connections between the actuator and the ECM.

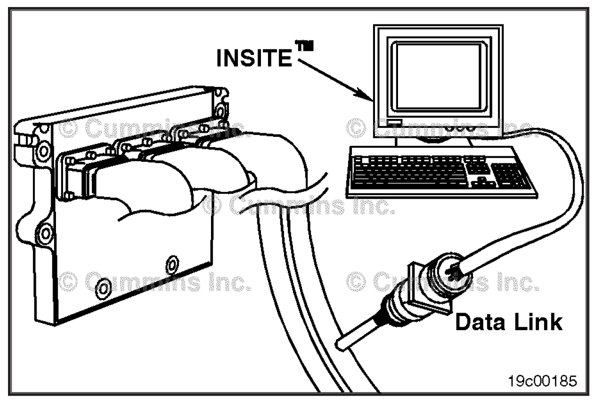
Sensor Accuracy Check

When a sensor circuit is shorted high or shorted low, the sensor value will be locked to a default value when the fault code is active. The default value will usually be set to a value that is within the standard operating range of the sensor. When monitoring the sensor values with a service tool it will appear as if the sensor is reading a correct value even when the fault code is active. Some typical global default sensor values are as follows:

- Engine Coolant Temperature = 104.4°C [219.9°F]
- Intake Manifold Temperature = 21.3°C [70.3°F]
- Intake Manifold Pressure = 2.4 kpa [0.7 inHg]
- EGR Temperature = 37.8°C [100°F]
- Engine Oil Pressure = 73.1 kPa [10.6 psi]

Be aware when troubleshooting intermittent circuit fault codes that the value displayed with a service tool could be a default sensor reading. Always use the sensor signal voltage measurement when troubleshooting intermittent circuit fault codes.

If further investigation is necessary, use the Data Monitor/ Logger feature in INSITE™ to monitor the inputs and outputs of a running engine and to capture data to a log file. The Logger feature in INSITE™ will allow for information to be captured during the intermittent event and can reviewed at a later time.



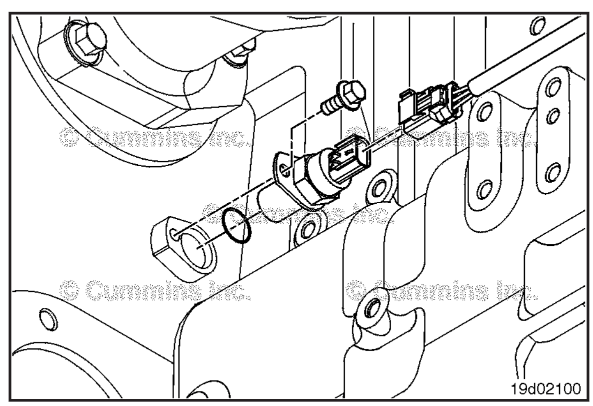
Camshaft Position Sensor (019-363)

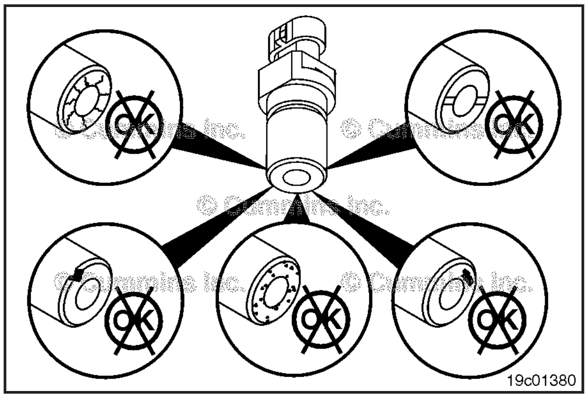
Remove

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 from the sensor.

Remove the capscrew that secures the sensor to the cylinder block.

Remove the sensor from the mounting location.



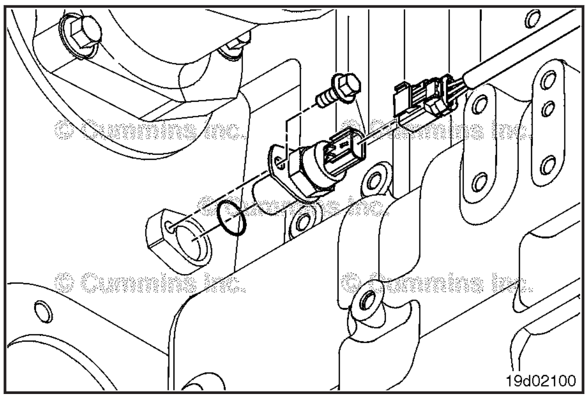


Inspect for Reuse

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 damaged, replace the sensor with a new one.



Install

Install a new o-ring onto the sensor.

Apply clean engine oil to the o-ring.

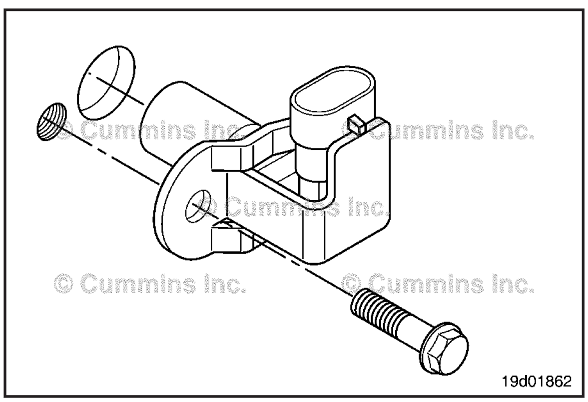
Install the new sensor into the mounting hole.

Install and tighten the capscrew.

Torque Value: 10 N•m [89 in-lb]

Connect the sensor to the engine harness.

Slide the lock tab sideways to lock the connector to the sensor.



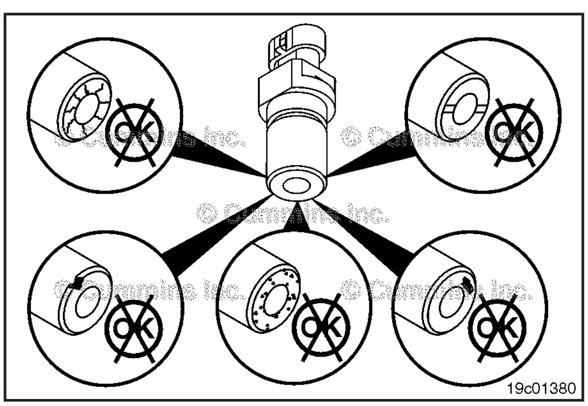
Crankshaft Position Sensor (019-365)

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 from the sensor.

Remove the capscrew that secures the sensor to the cylinder block.

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 or damaged, replace the sensor with a new one.

Install

Install a new o-ring onto the sensor.

Apply clean engine oil to the o-ring.

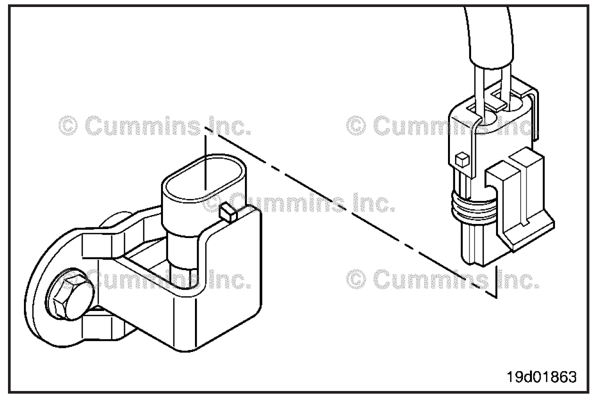
Install the new sensor into the mounting hole.

Install and tighten the capscrew.

Torque Value: 25 N•m [221 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

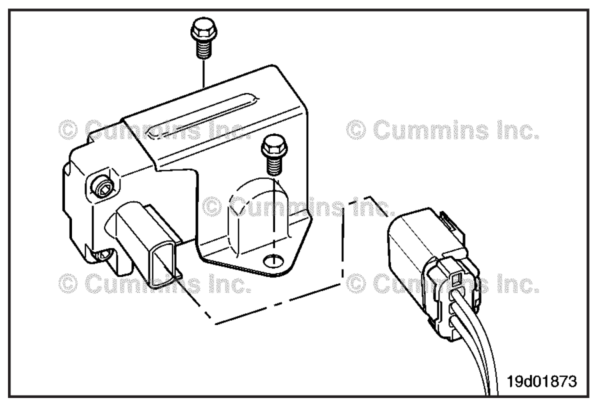
The EGR valve differential pressure sensor has two ports that sense a pressure drop across the EGR gas entrance to the intake connection. The ECM uses this pressure drop to calculate the amount of EGR gas entering the intake. This calculation helps to determine the commanded position of the EGR valve (and VG turbocharger) that will control the amount of EGR gas flow into the engine.

The EGR valve differential pressure sensor is mounted on the side of the intake air horn.

Remove

Slide the locking tab sideways. Push down on the button toward the rear of the connector and disconnect from the sensor.

Remove the two 10-mm capscrews from the base of the sensor and remove the sensor from the engine.

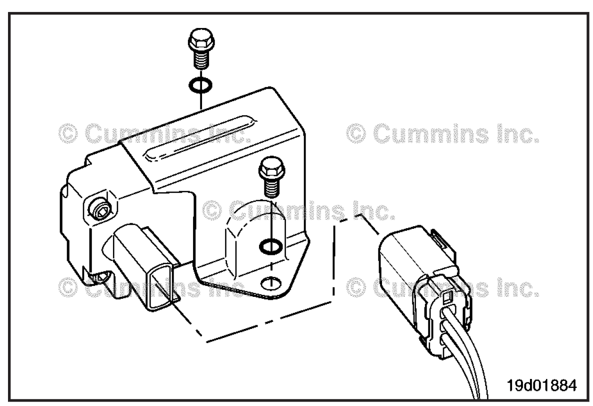


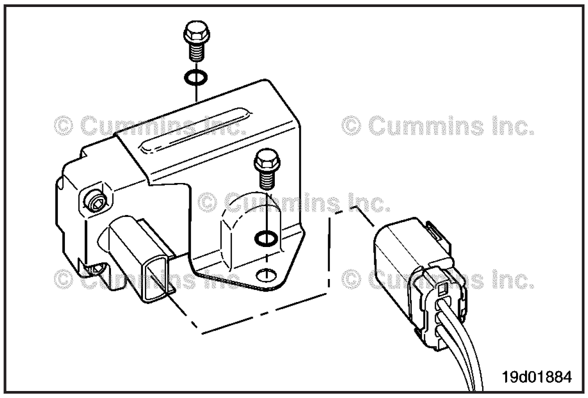
Install

Make sure the new sensor has two o-rings in the two grooves at the base of the sensor.

Install a new sensor into the engine. Tighten the sensor.

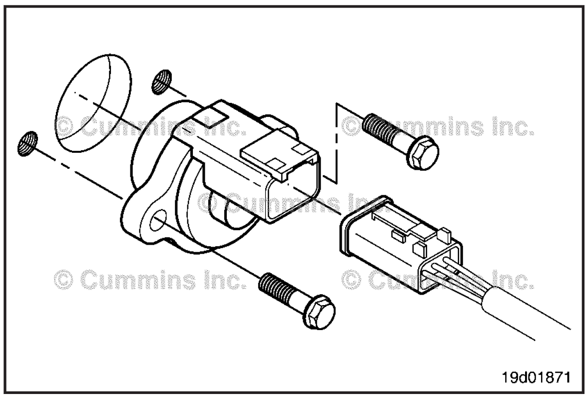
Torque Value: 24 N•m [212 in-lb]





Push the connectors together until they lock.

Slide the locking tab to the lock position.



EGR Valve Position Sensor (019-372)

General Information

CAUTION

The position sensor pins can be bent if the engine harness connector is mated to the sensor connector at an angle. Therefore, the engine harness connector must be inserted straight into the position sensor connector to reduce the possibility of damaging the pins. Bent pins will result in poor engine performance and intermittent fault codes.

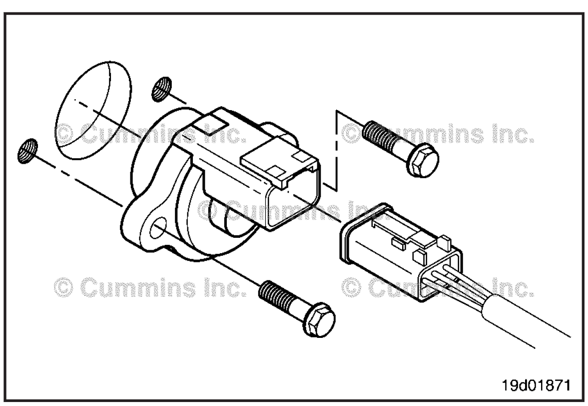
CAUTION

Do not use connector grease on the EGR valve position sensor connector. Use of connector grease can cause damage to the EGR valve and low engine performance.

The EGR valve position sensor outputs a voltage signal to the ECM. The ECM converts this signal into a percentage, 0 to 100 percent, indicating valve position. A fully open valve is equivalent to 100 percent. The engine harness is connected to the EGR valve by an EGR valve extension harness.

The EGR valve position sensor is located on the EGR valve assembly.

There are two types of position sensors. The original position sensor has the connector molded into the sensor (shown in the diagram). The new hull effect position sensor has a pigtail harness connected to the sensor.



Remove

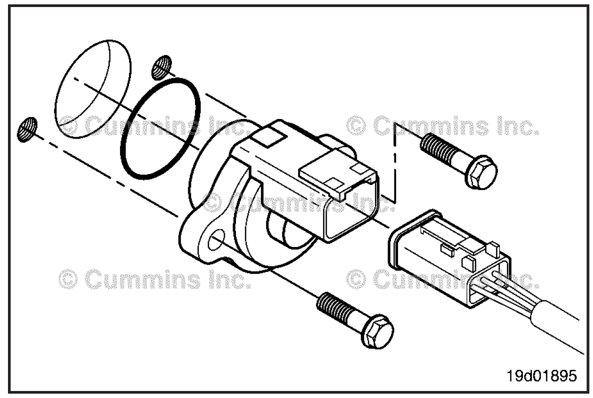
Push down on the connector tab and disconnect the connector from the sensor.

Remove the two capscrews securing the sensor to the EGR valve assembly.

Remove the sensor.

Inspect for Reuse

Inspect the position sensor for a damaged or missing o-ring and damaged or broken connector pins.

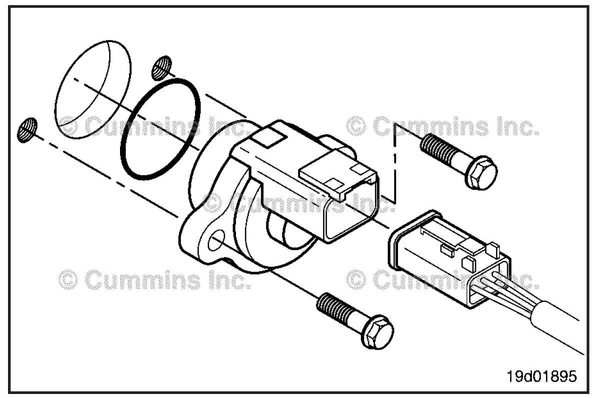


Install

⚠CAUTION⚠

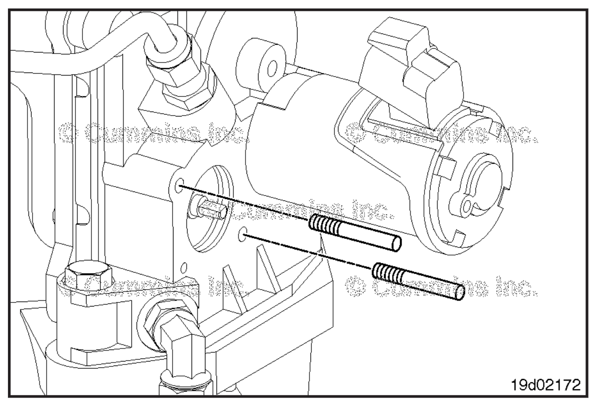
The position sensor pins can be bent if the engine harness connector is mated to the sensor connector at an angle. Therefore, the engine harness connector must be inserted straight into the position sensor connector to reduce the possibility of damaging the pins. Bent pins will result in poor engine performance and intermittent fault codes.

Rotate the internal hub of the sensor so it will align with the flat spot on the shaft.



Guide pins, Part Number 3165138, are necessary for proper alignment between the position sensor and the housing. Improper alignment will result in damage to the sensor.

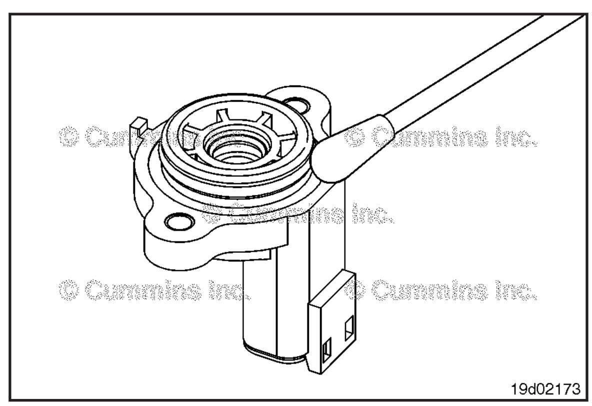
Insert alignment pins into the capscrew holes in the housing.

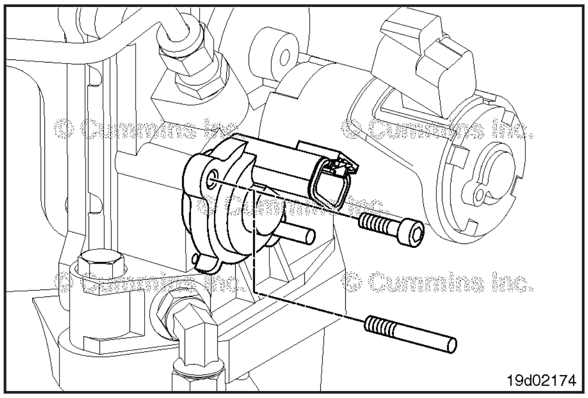


⚠CAUTION⚠

Do not allow any of the solution to get inside the sensor. Damage to electrical components can occur.

Use a cotton swab to lubricate the sensor o-ring with a mild soap and water solution.





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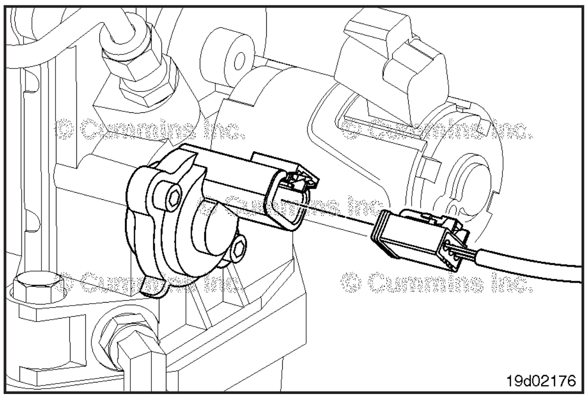
Install the position sensor over the guide pins.

Press the sensor into the bore until the o-ring is fully engaged.

The external locating tab on the sensor should align with the hole in the housing.

When the position sensor is fully seated against the housing, remove the alignment pins and install the two M4 capscrews.

Torque Value: 3.1 N•m [27 in-lb]



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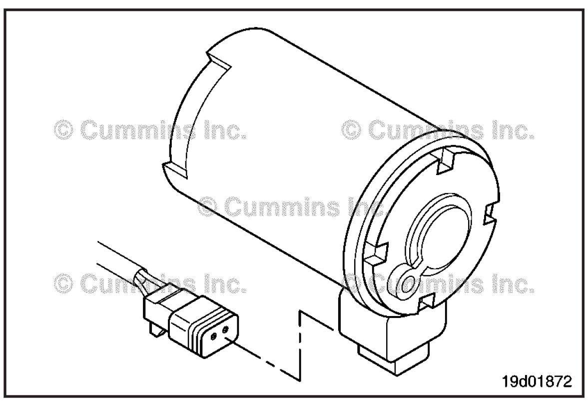
CAUTION

Do not use connector grease on the EGR valve position sensor connector. Use of connector grease can cause damage to the EGR valve and low engine performance.

Connect the engine harness connector to the sensor. Push the connectors together until they lock.

Inspect the wiring harness and connector for excessive tension.

If excessive tension is present, determine the source and relieve the tension on the circuit.



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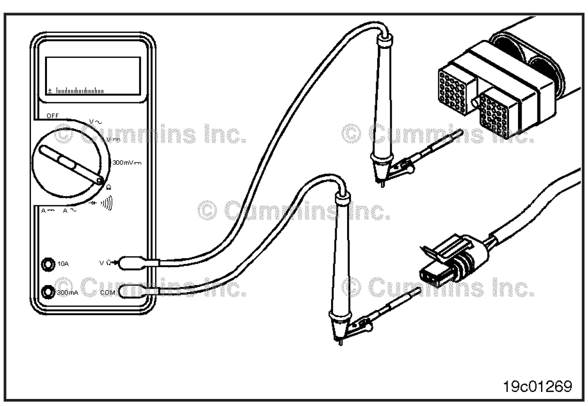
EGR Valve Assembly Circuit (019-375)

Initial Check

Disconnect the EGR valve motor connector from the engine harness. Disconnect the 60-pin engine harness connector from the ECM.

Check the EGR valve motor connector and engine harness connectors for broken, bare, or melted wires; loose, dirty, damaged, or missing pins; and other visible signs of damage.



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Resistance Check

CAUTION

To reduce the possibility of pin and connector damage, use test leads, Part Numbers 3822758 and 3823993, when taking a measurement.

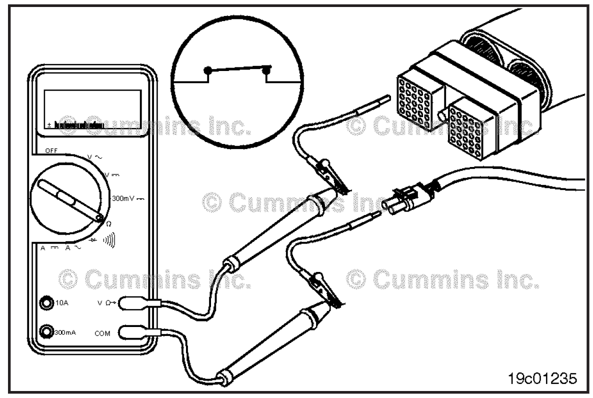
Disconnect the 60-pin engine harness connector from the ECM. Disconnect the EGR valve motor from the engine harness. Set the multimeter to measure resistance.

Insert a test lead into the EGR valve motor signal pin of the 60-pin engine harness connector. Connect the alligator clip to a multimeter probe. Insert the second test lead to the signal pin of the EGR valve motor 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 engine harness. Refer to Procedure 019-043.

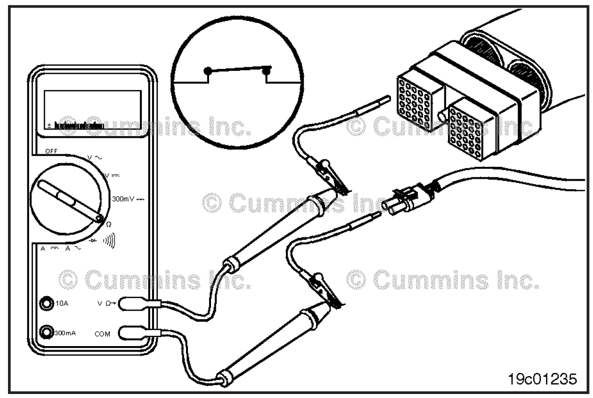


Repeat the resistance check for the return wire. Measure the resistance from the EGR valve motor return pin of the 60-pin engine harness connector to the EGR valve motor return pin of the harness connector.

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 engine harness. Refer to Procedure 019-043.

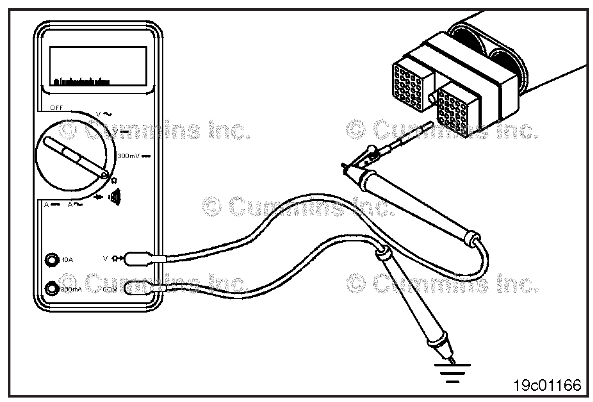


Check for Short Circuit to Ground

⚠CAUTION⚠
To reduce the possibility of pin and connector damage, use test lead, Part Number 3822758, when taking a measurement.

Disconnect the 60-pin engine harness connector from the ECM. Disconnect the EGR valve motor from the engine harness. Set the multimeter to measure resistance.

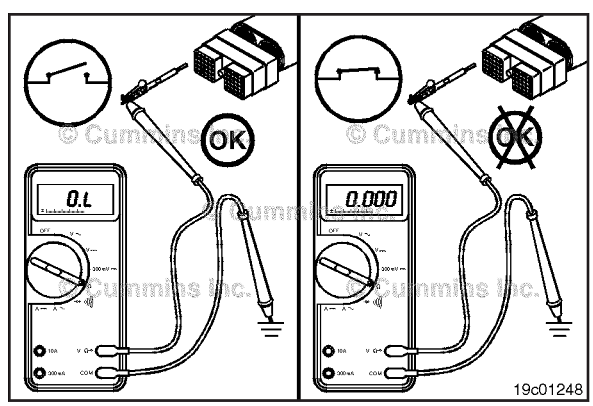
Insert the test lead into the EGR valve motor signal pin of the 60-pin engine harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.

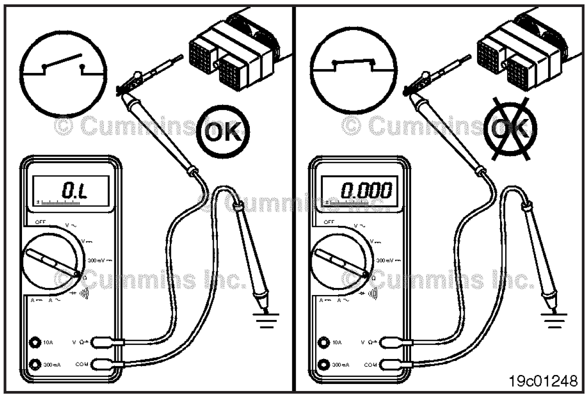


The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the signal wire.

Repair or replace the engine harness. Refer to Procedure 019-043.





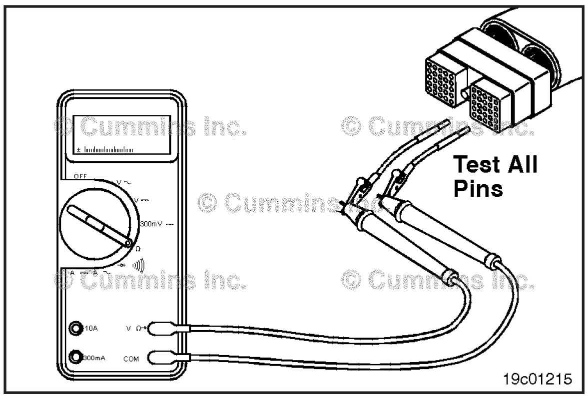
19c01248

Repeat the short-to-ground check for the return wire. Measure the resistance from the EGR valve motor return pin of the 60-pin engine 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 engine harness. Refer to Procedure 019-043.

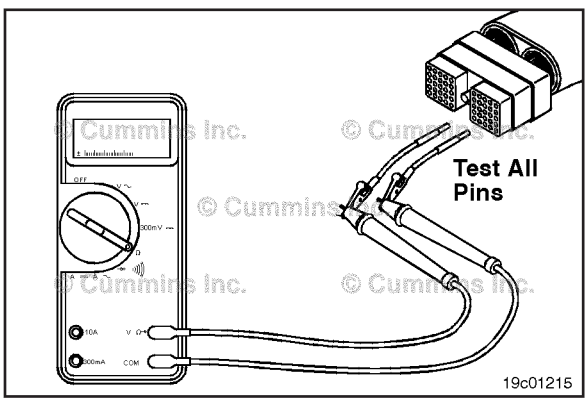


19c01215

Check for Short Circuit from Pin to Pin

Disconnect the 60-pin engine harness connector from the ECM. Disconnect the EGR valve motor from the engine harness. Set the multimeter to measure resistance.

Measure the resistance from the EGR valve motor signal pin in the 60-pin engine harness connector to all other pins in the connector.

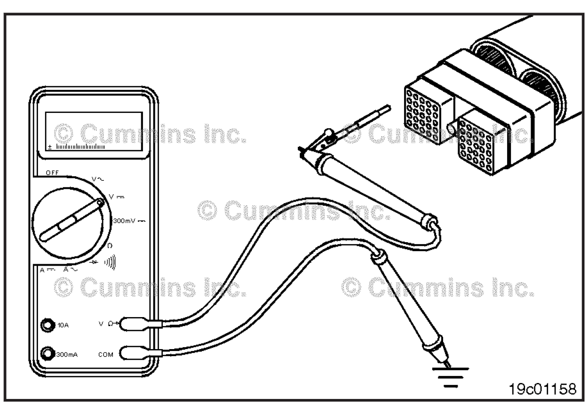


19c01215

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 engine harness. Refer to Procedure 019-043.



19c01158

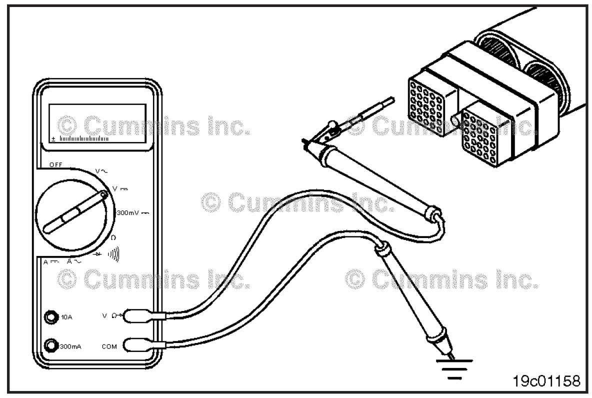
Check for Short Circuit to External Voltage Source

Disconnect the 60-pin engine harness connector from the ECM. Disconnect the EGR valve motor from the engine harness. Set the multimeter to measure VDC. Turn the vehicle keyswitch to the ON position.

Insert the test lead connected to the positive (+) multimeter probe into the EGR valve motor signal pin of the 60-pin engine 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.

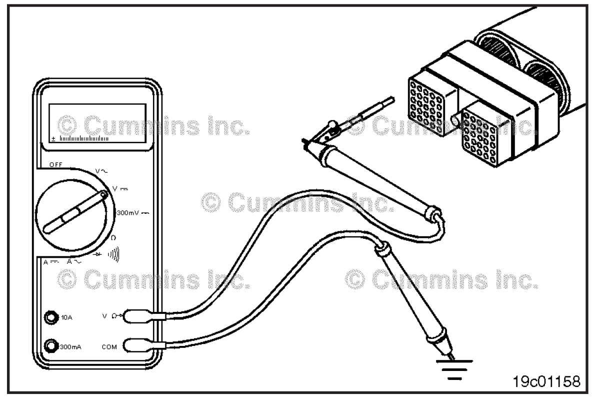
Remove the external voltage source.



Repeat the short-to-external-voltage-source check for the return wire. Measure the voltage from the EGR valve motor return pin of the 60-pin engine harness connector to engine block ground.

If voltage is present, there is a short circuit from the return wire to an external voltage source.

Remove the external voltage source.



Exhaust Gas Pressure Sensor (019-376)

General Information

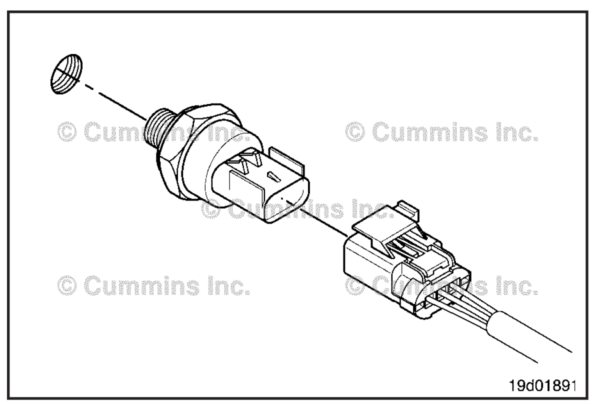
The exhaust gas pressure sensor monitors the pressure from the exhaust and passes that information on to the ECM through the engine harness. If the exhaust gas pressure sensor becomes too low, it will cause a derate condition.

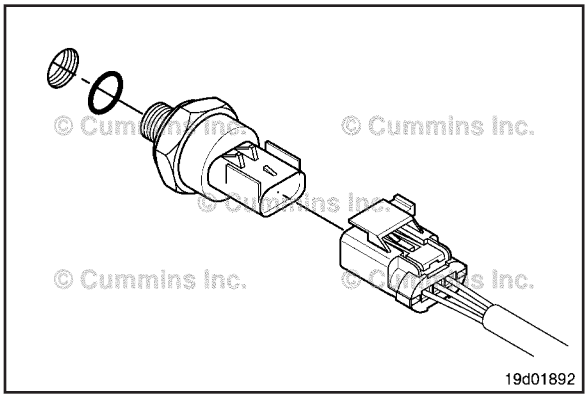
The exhaust gas pressure sensor is located on the EGR cooler on the exhaust side of the engine.

Remove

Slide the locking tab on the connector sideways. Push down on the button toward the rear of the connector and disconnect from the sensor.

Remove the sensor from the engine.





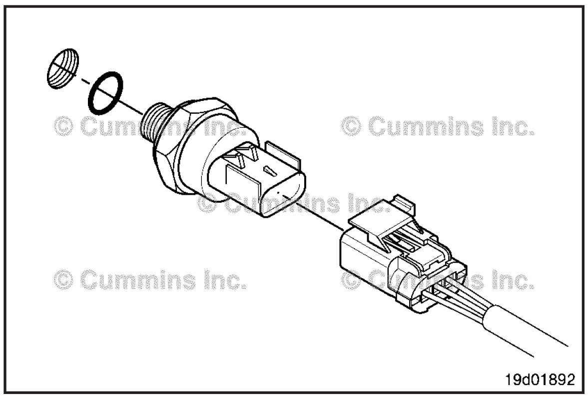
Install

Make sure the new sensor has an o-ring.

Lubricate the o-ring with clean engine oil.

Install a new sensor into the engine. Tighten the sensor.

Torque Value: 18 N•m [159 in-lb]



Push the connectors together until they lock.

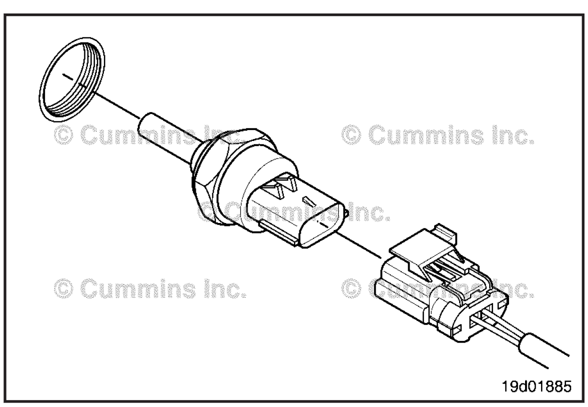
Slide the locking tab to the lock position.

EGR Temperature Sensor (019-378)

General Information

The exhaust gas recirculation (EGR) cooler outlet temperature sensor is used to measure the temperature of the exhaust gas that exits the EGR cooler. The ECM uses this temperature to control the emission levels of the engine.

The EGR cooler outlet temperature sensor is located at the intake air horn at the front of the engine.

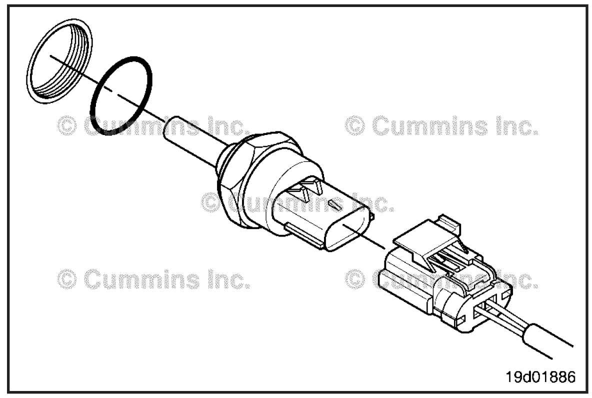


Remove

Lift the tab and detach the connector from the sensor.

Remove the sensor from the air intake connection.

Install


19d01886

Check to make sure the new sensor has an o-ring.

Lubricate the o-ring with clean engine oil.

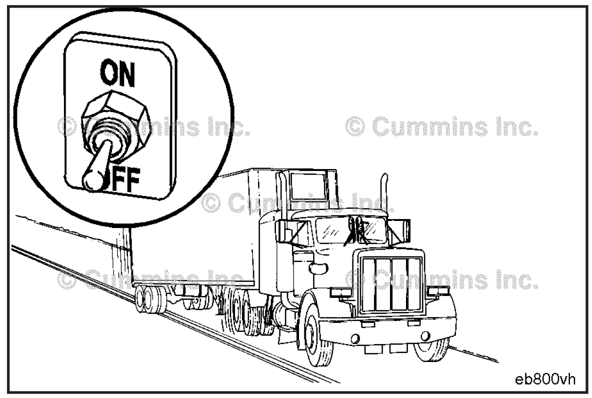
Install the new sensor into the engine. Tighten the sensor.

Torque Value: 15 N•m [133 in-lb]

Connect the engine harness connector to the new sensor.

Fan Control Switch (019-380)

General Information

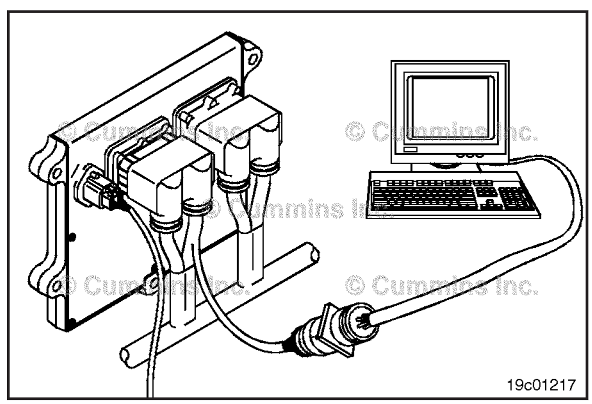


eb800vh

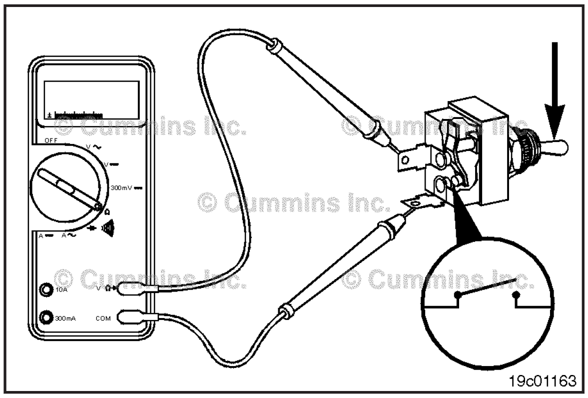
The fan control switch circuit signals the system that the operator is requesting the engine fan to be engaged. The fan on and off circuit consists of the fan control switch signal, the switch return, and the OEM cab-mounted toggle switch. This circuit is considered “fail safe”, meaning when the circuit is open, the engine fan will be engaged by the ECM.

NOTE: This procedure is **only** valid if the fan control switch is wired through the ECM and the feature manual fan switch is enabled in the ECM. If the fan control switch is wired in series with the fan control relay, the ECM could log fan circuit errors during normal operation. Please verify the circuit is wired properly before performing this procedure.

Resistance Check

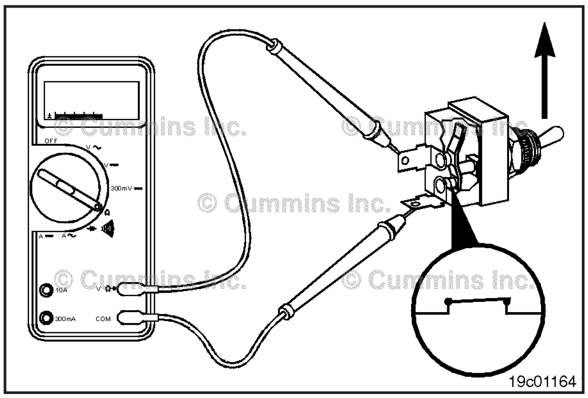

19c01217

If INSITE™ is available, monitor the fan control switch for proper operation. If **not** operating properly, follow the troubleshooting procedures in this section.

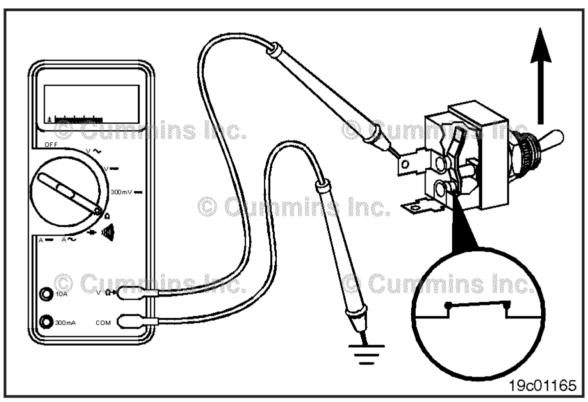


Locate the fan control switch. Label the wires with the location of the switch or the wire number. Remove the electrical connectors from the switch. Adjust the multimeter to measure resistance. Touch one multimeter probe to one of the terminals on the switch. Touch the other multimeter probe to the other 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.

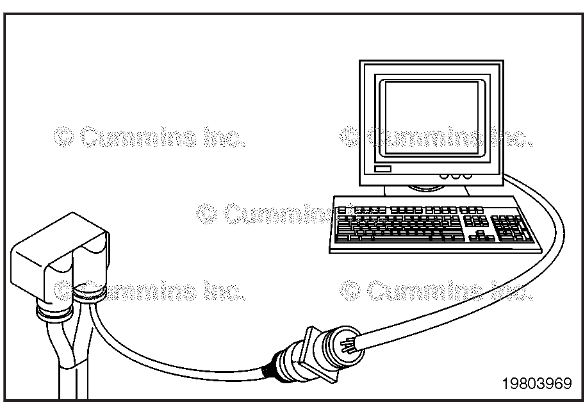


Place the switch in the OFF position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the resistance value is correct, 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

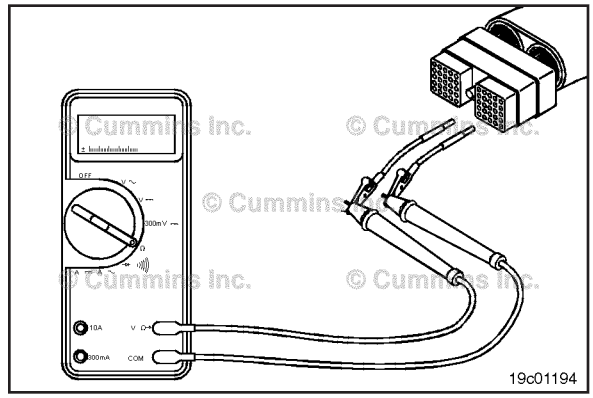
CAUTION

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.

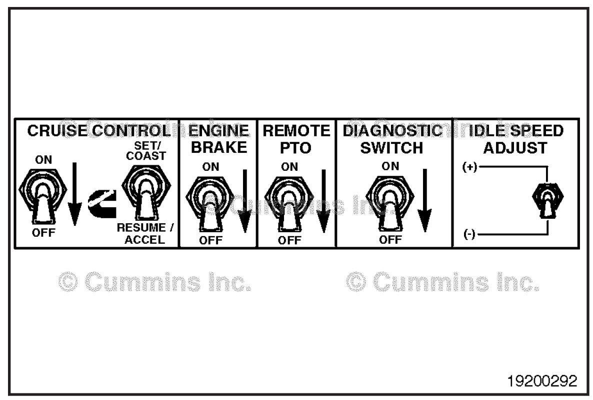
Disconnect the original equipment manufacturer (OEM) harness connector from the electronic control module (ECM). Insert one of the test leads into the switch return pin of the OEM harness connector and connect the alligator clip to the multimeter probe. Insert the other lead into the fan control switch signal pin of the OEM harness connector and connect the alligator clip to the other multimeter probe.

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.



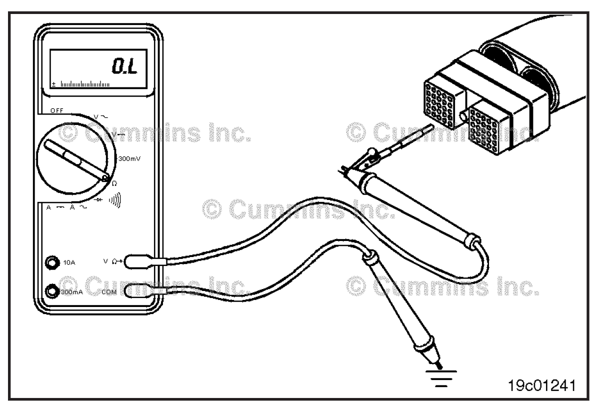
Check for Short Circuit to Ground

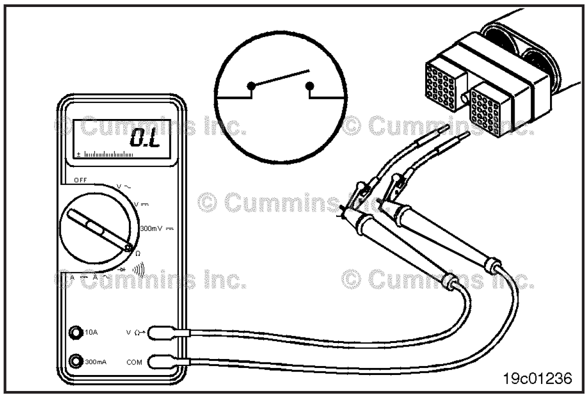
To isolate the fan control switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM and fan control switch. Disconnect the clutch position switch/engine protection override switch and the accelerator pedal assembly. Set all cab panel switches to the OFF or neutral position. Set the service brake using the trailer brake hand valve.



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.

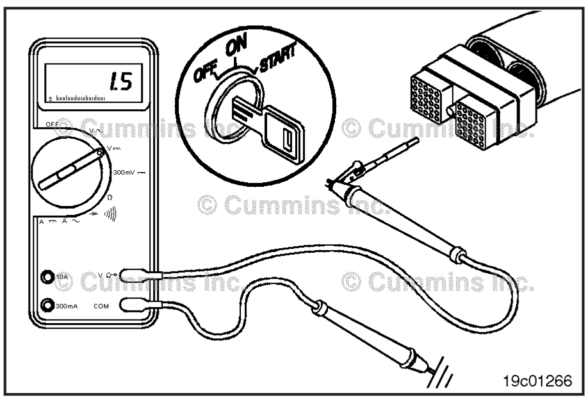




Check for Short Circuit from Pin to Pin

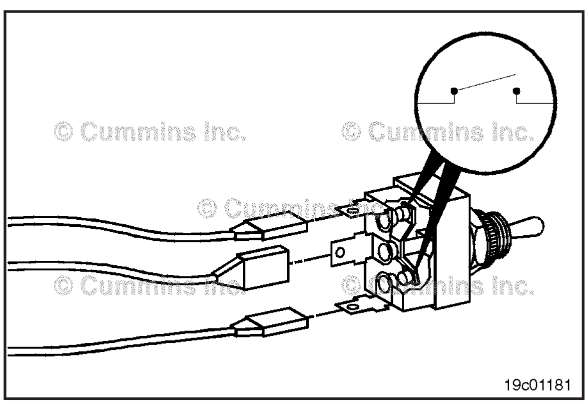
Isolate the fan control switch circuit by setting the switches as in the previous section. Set the fan control switch to the ON position. Insert the lead into the fan control switch signal pin. Connect the alligator clip to the multimeter. With the other lead inserted into the switch return pin, measure 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.



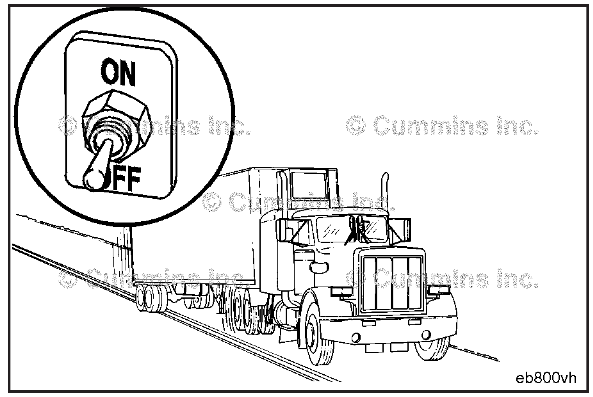
If the voltage is **not** correct, there is an external voltage source connected to the circuit, or there is a short circuit between the fan control switch circuit and a wire carrying power in the OEM harness. Remove the voltage source or repair the wiring in the OEM harness according to the vehicle 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.

Maximum Engine Speed Switch (019-382)

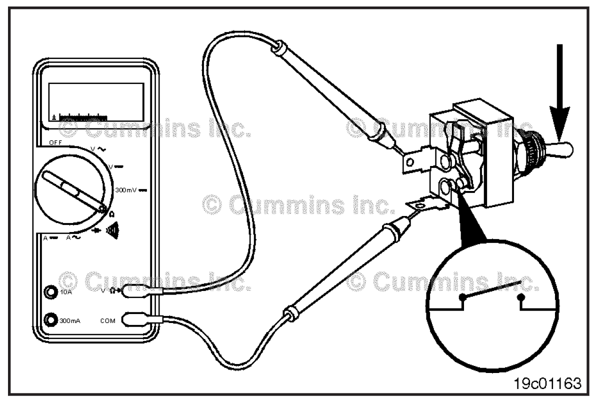
General Information



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.

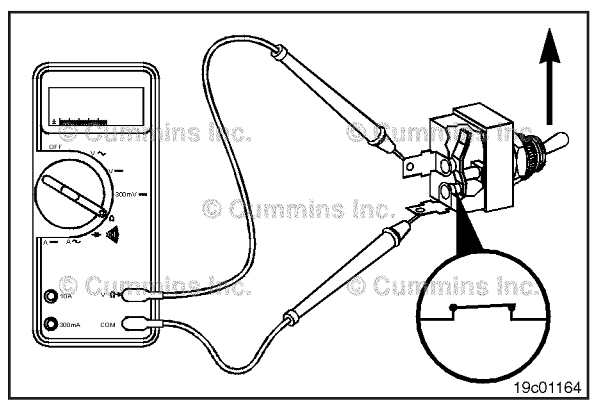
Resistance Check



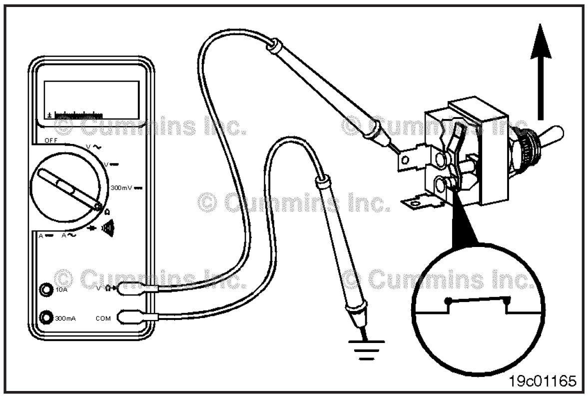
If INSITE™ is available, monitor the maximum engine speed switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

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.

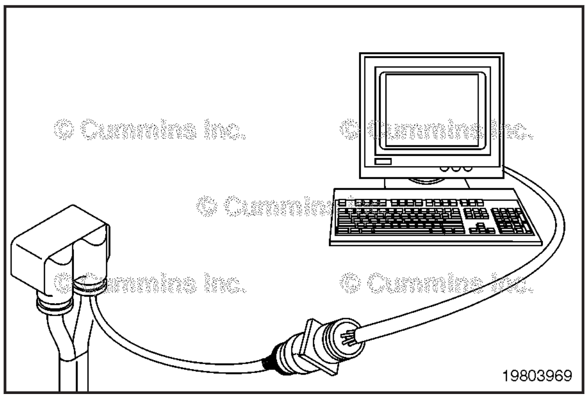


Place the switch in the closed position and measure the resistance. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, the switch has failed. Refer to the OEM troubleshooting and repair manual for replacement procedures. If the resistance value is correct, 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.



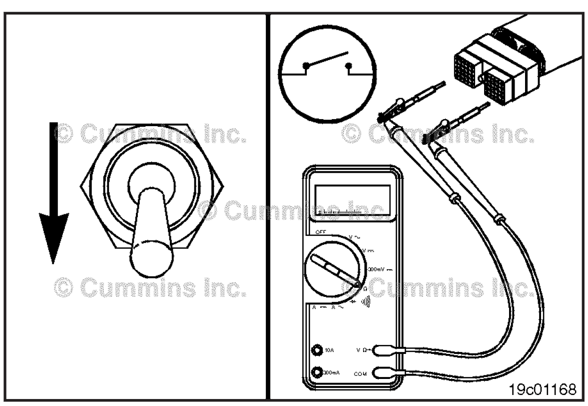
Maximum Engine Speed Switch Circuit (019-383)

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.

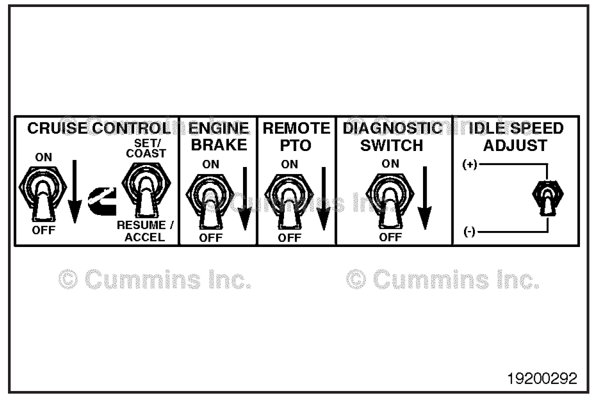


NOTE: The maximum engine speed switch is programmed by the OEM. The open or closed position of the switch can represent “Normal” or “Speed Limit” depending on how the OEM programs the switch. Before continuing to troubleshoot refer to the OEM troubleshooting and repair manual to determine how the switch 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

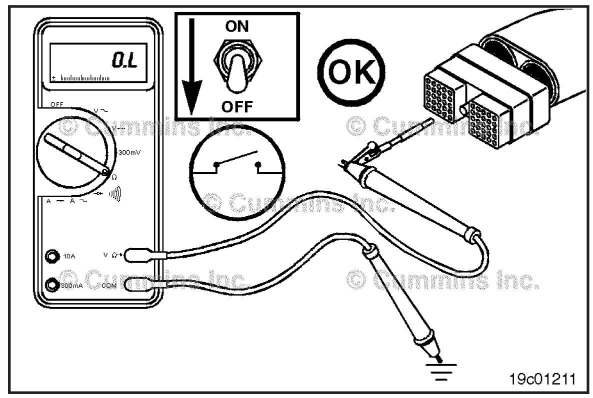
To isolate the maximum engine speed switch circuit when checking for an electrical short, disconnect the OEM harness from the ECM and the OEM harness from the maximum engine speed switch. Disconnect the clutch pedal position switch/engine protection override switch and the accelerator pedal assembly 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.

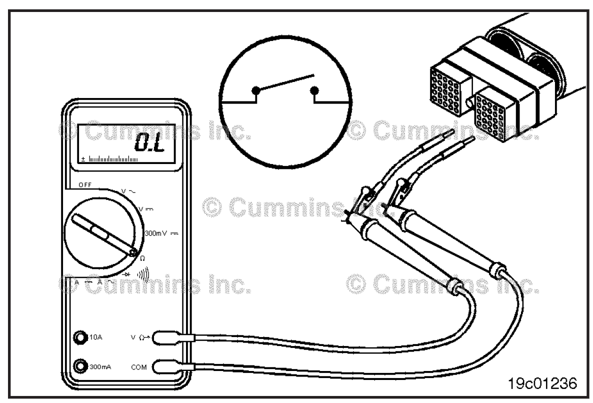


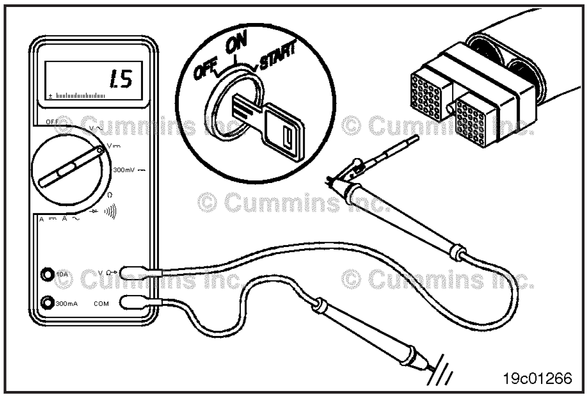
Check for Short Circuit from Pin to Pin

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.

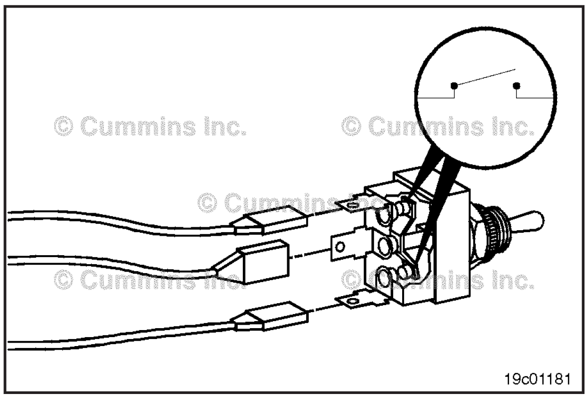
Repair or replace the wires in the OEM harness. Refer to Procedure 019-071.





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.

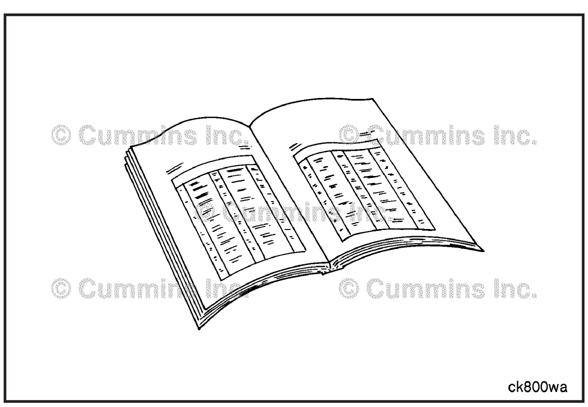
Turbocharger Control Valve (019-388)

General Information

ISL Engines

A small amount of air can possibly be heard escaping from the turbocharger control valve during the turbocharger actuator test. This is a normal condition for the valve to achieve output regulation pressure. Do **not** replace the turbocharger control valve for this condition.

The valve **must not** leak air with the key ON and the engine OFF. If the valve leaks air with the key ON and the engine OFF, the valve is damaged.



Preparatory Steps

ISB

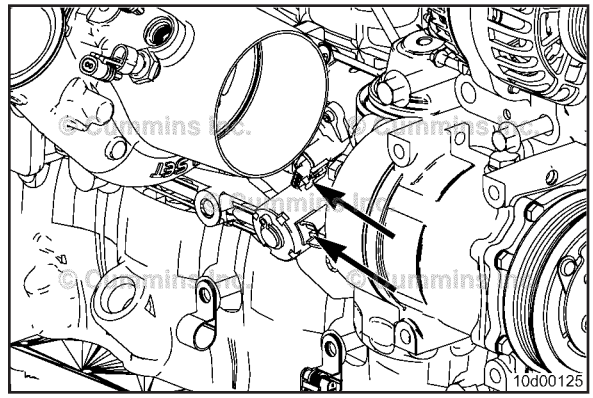
NOTE: Removal of the variable geometry turbocharger may be necessary to access and service the actuator. Use the following procedure in Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System), Bulletin 4021271. Refer to Procedure 010-033 in Section 10.

- Drain the coolant. Use the following procedure in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System), Bulletin 4021271. Refer to Procedure 008-018 in Section 8.
- Remove the actuator coolant lines. Use the following procedure in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System), Bulletin 4021271. Refer to Procedure 011-030 in Section 11

Remove

ISB

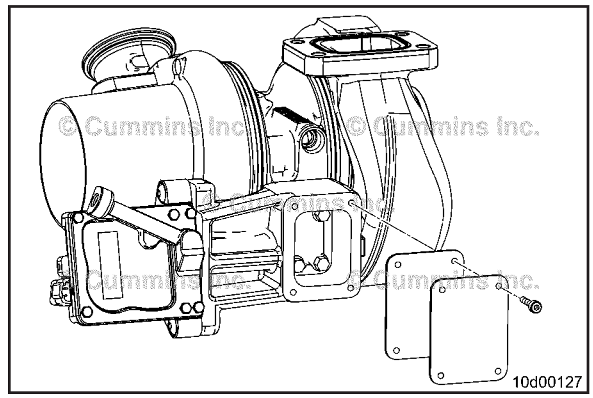
Disconnect the electrical connections from the actuator.



Remove the four capscrews from the dust cover plate.

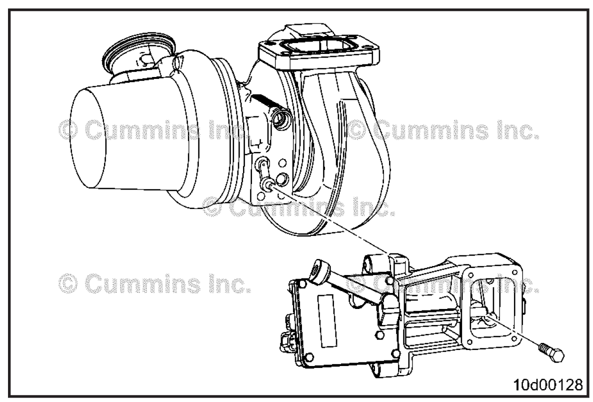
Remove the cover and gasket.

Discard the gasket.



Remove the three capscrews that attach the actuator housing to the turbocharger.

Remove the actuator assembly and pivot wear block.



ISL Engines

Make sure the keyswitch is in the OFF position.

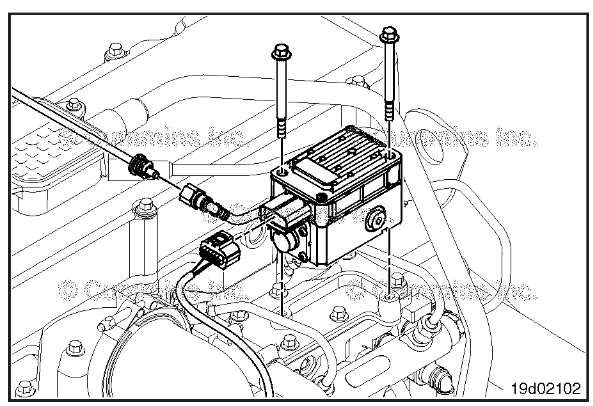
Bleed the air from the turbocharger control valve supply line.

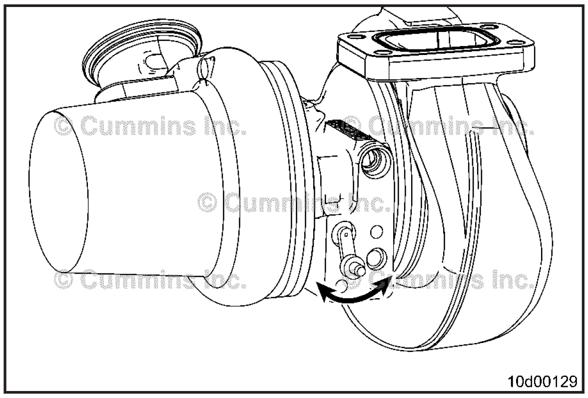
Remove the air lines to the turbocharger actuator and the OEM air supply.

Disconnect the electrical harness from the turbocharger valve.

Remove the two mounting capscrews.

Discard the sealing washers.



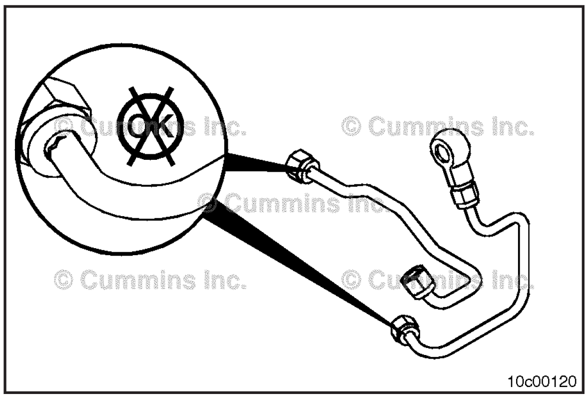


Inspect for Reuse

ISB

Check the actuator lever on the turbocharger for freedom of movement by moving the lever back and forth by hand. The movement **must** be smooth, with the lever operating properly.

If the lever is stuck or **not** moving freely, the variable geometry turbocharger **must** be replaced.



ISL Engines

WARNING

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

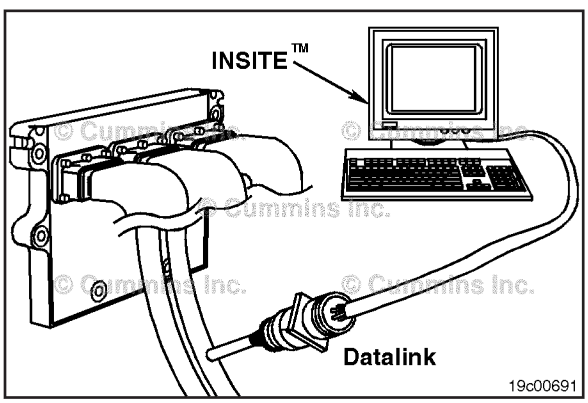
It is normal for a small amount of air to be heard escaping from the turbocharger control valve. Do **not** replace the turbocharger control valve for this condition.

The valve **must not** leak air with the keyswitch ON and the engine OFF. If the valve leaks air with the keyswitch ON and the engine OFF, the valve is damaged.

Check the air lines for cracks. Replace the air lines if cracks are found.

Check the air lines for contamination or water.

Use compressed air to clean the air lines.



Measure

ISB

With the actuator removed from the turbocharger, connect the actuator harness electrical connections.

Use INSITE™ electronic service tool to command the variable geometry actuator open and closed.

Observe the movement of the actuator push rod.

Movement **must** be free and smooth with no binding. If the actuator does **not** move freely or binds, it **must** be replaced.

Follow any related turbocharger fault codes.

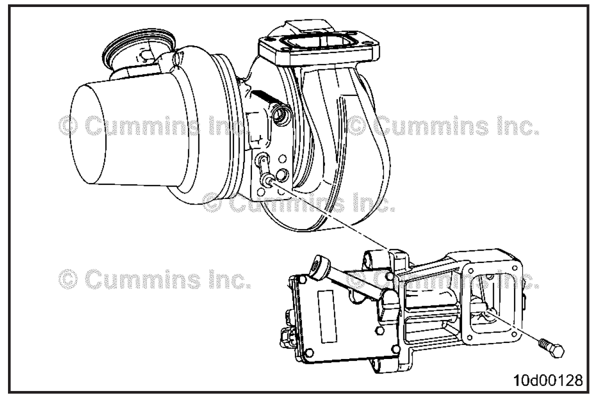
Install

ISB

Install a new pivot wear block and position the actuator on the turbocharger.

Install the two mounting capscrews.

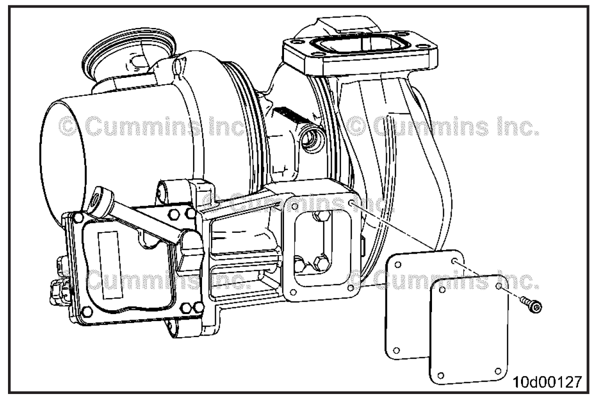
Torque Value: 17 N•m [150 in-lb]



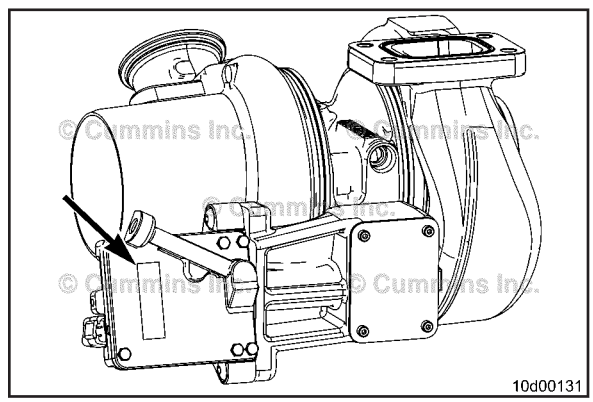
Install four new capscrews, the dust cover plate, and a new gasket.

Tighten the capscrews.

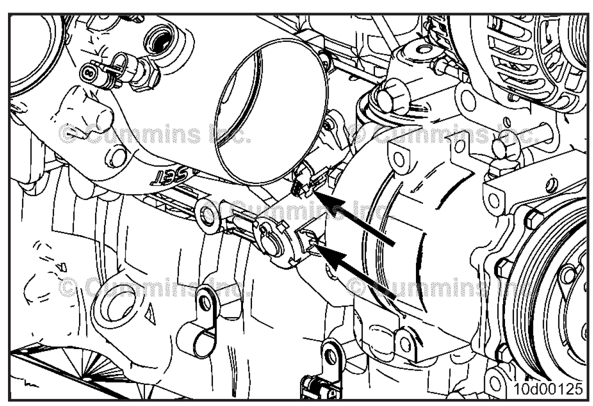
Torque Value: 6 N•m [53 in-lb]

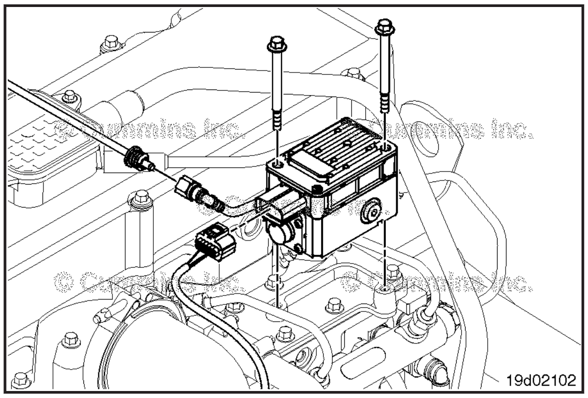


NOTE: If the actuator is replaced, transfer the turbocharger dataplate information onto the new data tag and adhere the tag to the new actuator.



Connect the electrical connections to the actuator.





ISL Engines

⚠CAUTION⚠

Do not use any type of thread sealant or thread tape on air lines. The sealant can cause contamination or malfunction of the turbocharger control valve.

Install the two mounting capscrews.

Torque Value: 15 N•m [133 in-lb]

Install the turbocharger control valve outlet fitting into the valve body Port 2.

Polymer body outlet fitting	9 n.m	[80 in-lb]
Aluminum body outlet fitting	15 n.m	[133 in-lb]
Polymer body with metal inserts	20 N•m	[177 in-lb]

Install the turbocharger control valve inlet fitting into the valve body Port 1.

Polymer body outlet fitting	9 n.m	[80 in-lb]
Aluminum body outlet fitting	15 n.m	[133 in-lb]
Polymer body with metal inserts	20 N•m	[177 in-lb]

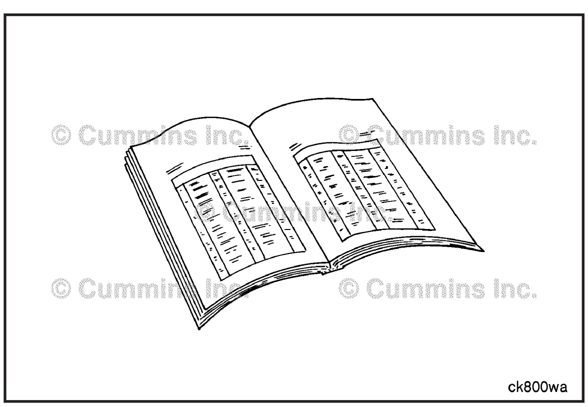
Connect the electrical harness to the turbocharger control valve.

Install the air line from the turbocharger actuator to the turbocharger control valve.

Torque Value: 16 N•m [142 in-lb]

Install the air supply line to the turbocharger control valve.

Torque Value: 16 N•m [142 in-lb]



Finishing Steps

ISB

- Install the turbocharger, if removed.
- Install the coolant lines. Use the following procedure in the Service Manual, ISBe, ISB, and QSB , Bulletin 4021271. Refer to Procedure 011-030 in Section 11.
- Fill the cooling system. Use the following procedure in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel System), Bulletin 4021271. Refer to Procedure 008-018 in Section 8.
- Clear any fault codes.
- Operate the engine and check for leaks.

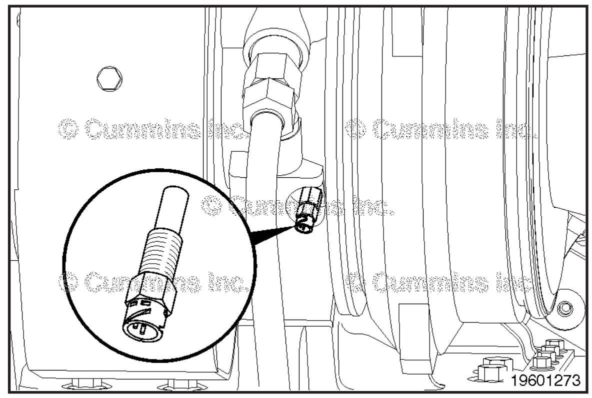
ISL Engines

- Start and operate the engine. Verify proper operation.
- Check for air leaks.

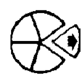
Turbocharger Speed Sensor (019-390)

General Information

The turbocharger speed sensor is located on the bottom of the turbocharger between the compressor and the turbine housings toward the rear (flywheel) side of the turbocharger. INSITE™ electronic service tool can be used to monitor the sensor for proper operation.



Remove

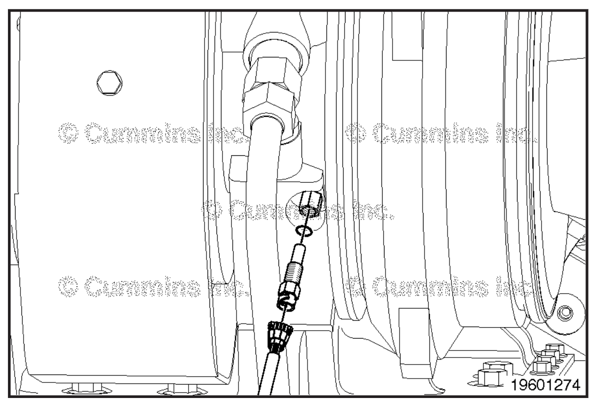


CAUTION

When removing the turbocharger speed sensor, use a twisting motion while pulling upward. Prying on the sensor body with a screwdriver can lead to broken sensors and could result in unwarranted turbocharger replacement.

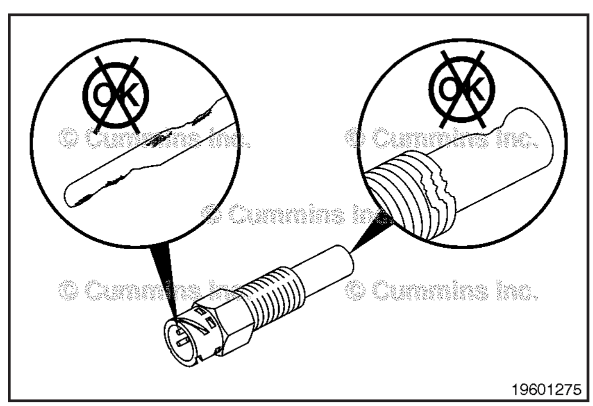
Disconnect the Cannon™ connector from the turbocharger speed sensor.

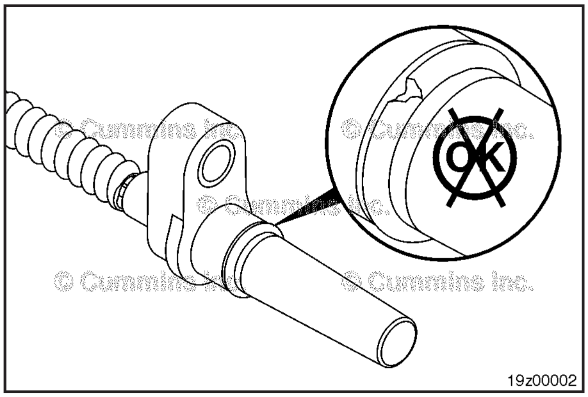
Unscrew the speed sensor from the turbocharger housing and remove.



Inspect for Reuse

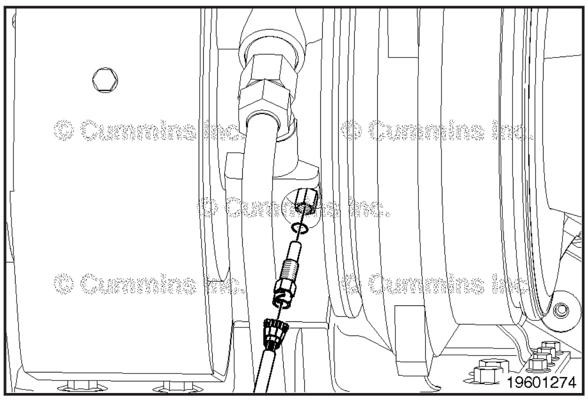
Inspect the turbocharger speed sensor body for signs of melting or damage. If signs of melting or damage are found on the sensor, inspect the turbocharger coolant supply for restriction.





If the turbocharger speed sensor is being removed due to an oil leak, inspect the turbocharger speed sensor o-ring for signs of damage. If the o-ring is cut or damaged, the o-ring **must** be replaced.

If there are no cuts or damage evident to the o-ring, it is possible to reseal and prevent oil leaks. To do this, apply Loctite™ 5699, or equivalent, to the o-ring and the area where the o-ring sits on the speed sensor, prior to assembly.



Install

CAUTION

The turbocharger speed sensor harness must be tied up and away from any heat sources and hard or sharp surfaces. Failure to do so will cause damage to the harness.

Make sure the new turbocharger speed sensor has a new o-ring installed.

If the turbocharger speed sensor was removed due to an oil leak, it is possible to reuse the turbocharger speed sensor and either replace or inspect the o-ring for reuse (as described in the Inspection section above).

Apply Loctite™ 5699, or equivalent, to the o-ring. This helps seal and prevent oil leaks.

Install the turbocharger speed sensor into the engine.

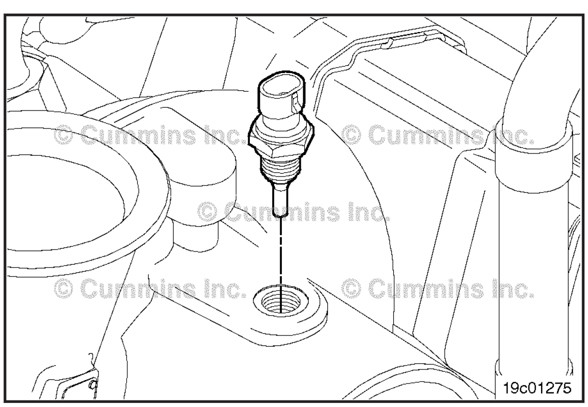
Torque Value: 15 N•m [133 in-lb]

Push the Cannon™ connector together and twist until it locks in place.

The connector **must** be fully mated.

Use cable ties to attach the harness to the turbocharger coolant feed line.

Start the engine and verify with INSITE™ electronic service tool that the turbocharger speed sensor is working properly.



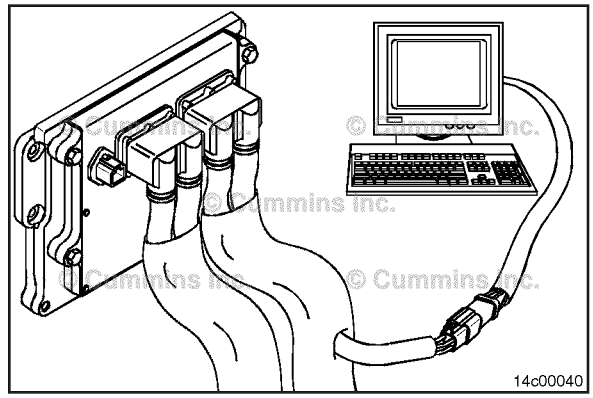
Turbocharger Compressor Inlet Air Temperature Sensor (019-395)

General Information

The turbocharger compressor inlet air temperature sensor is located on the air inlet of the turbocharger.

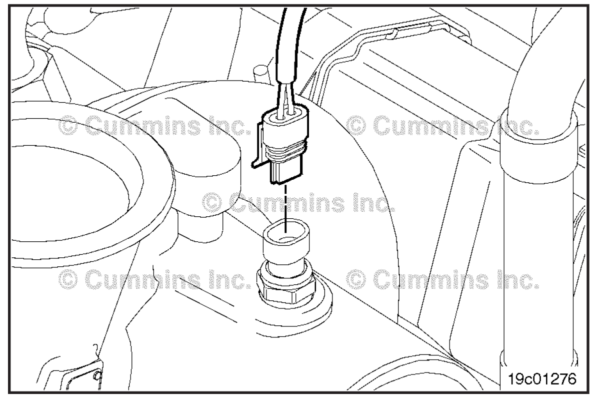
Initial Check

Use the electronic service tool to monitor the turbocharger compressor air inlet temperature sensor.

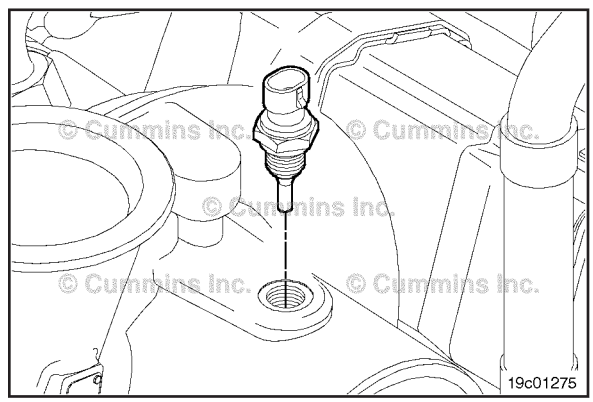


Remove

Lift up on the locking tab and pull the electrical connectors apart.



Remove the sensor.



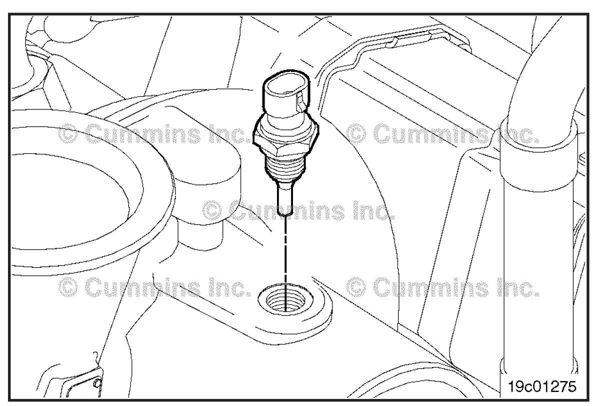
Install

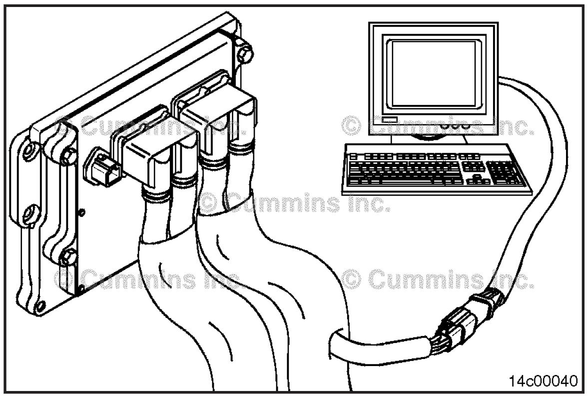
Make sure the new sensor has an o-ring installed.

Lubricate the o-ring with clean engine oil.

Install the new sensor into the engine. Tighten the sensor.

Torque Value: 23 N•m [17 ft-lb]





Push the connectors together until they lock.

Start the engine and verify with the electronic service tool that the sensor is working properly.

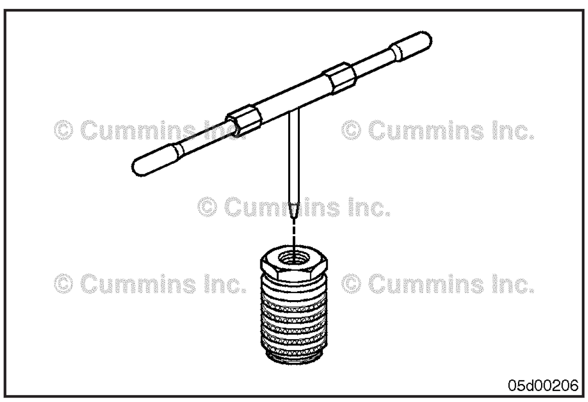
Fuel Lift Pump (019-396)

Initial Check

With EGR

NOTE: This test **only** applies to engines equipped with EGR. Engines **not** equipped with EGR do **not** have a lift pump.

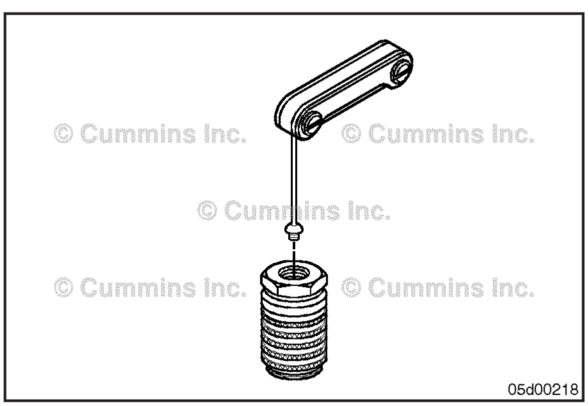
NOTE: High fuel inlet restriction can result in lift pump damage. Before replacing the lift pump, measure the fuel inlet restriction. Refer to Procedure 006-020, in the Troubleshooting and Repair Manual, ISB^{e}, ISB and QSB5.9 (Common Rail Fuel System) Series Engines, Bulletin 4021271.



If service tool, Part Number 316461, lift pump performance test orifice, is **not** available, the following instructions can be followed to assemble the tool.

Tap a female quick connect, Part Number 3376859.

Tap size: 8-36 national fine (U.S.)



WARNING

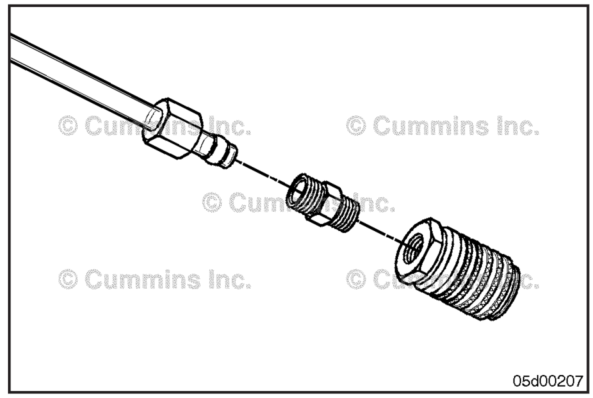
Wear appropriate eye and face protection when using compressed air. Flying debris and dirt can cause personal injury.

Clean the female quick connect, Part Number 3376859, with compressed air to remove debris.

Assemble a 1.09-mm [0.043-in] injector orifice, Part Number 3045018, with washer, to the female quick connect, Part Number 3376859.

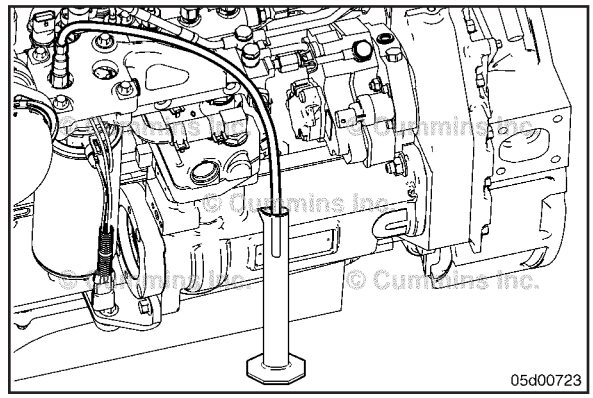
NOTE: To obtain correct flow, use a 1.09-mm [0.043-in] injector orifice, Part Number 3045018.

Attach to an appropriate length (it **must** reach from the lift pump to the measurement device) of 1/4-inch, or larger, tubing.



Install an M10 male Compuchek™ fitting, Part Number 3824842, on the diagnostic port on the inlet side of the fuel filter. Connect the service tool containing a 1.09-mm [0.043-inch] orifice, Part Number 3164621, to the diagnostic port.

Allow the other end of the hose to drain into a 500-ml graduated beaker, Part Number 3823705.

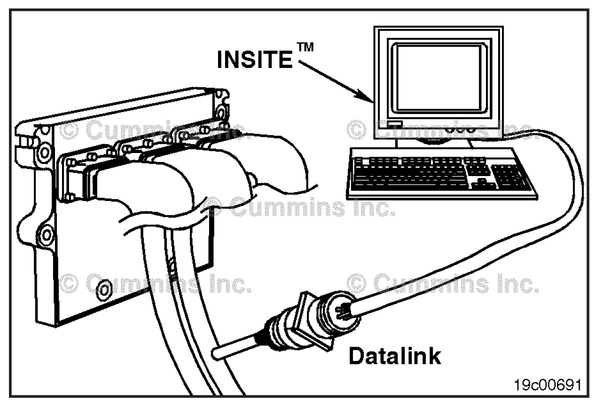


NOTE: This test is performed with the engine **not** running.

Start the lift pump by using the INSITE™ electronic service tool, lift pump override test. Refer to INSITE™ electronic service tool. Alternatively, the lift pump can be temporarily activated by "bumping" the starter **without** starting the engine or by turning the keyswitch on.

Measure the amount of fuel flowed by the lift pump in a 60-second interval:

- Fuel flow rate for lift pump (engine **not** running) - greater than 600 ml in 60 seconds or filling a 12-ounce can in 36 seconds or less.

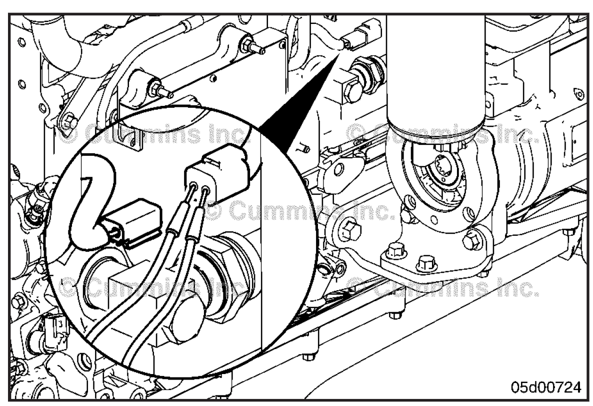


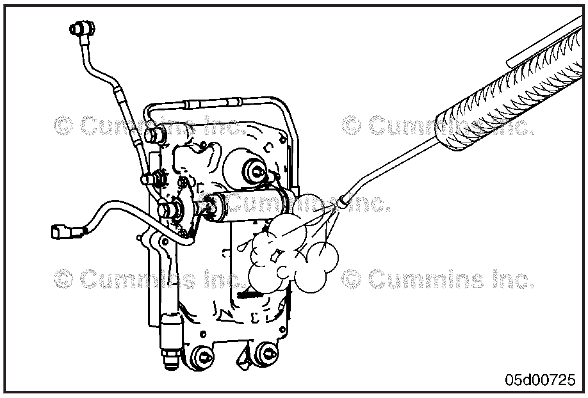
NOTE: Voltage will **only** be present when the lift pump is commanded ON. This can be accomplished by either using the INSITE™ electronic service tool lift pump override test or by "bumping" the starter.

If the lift pump is **not** functioning properly, check the voltage and resistance at the lift pump.

If the voltage does **not** meet the specifications, check the power supply.

System	Voltage	Resistance
12 VDC	9 VDC (minimum)	5 ohms (maximum)
24 VDC	21 VDC (minimum)	5 ohms (maximum)

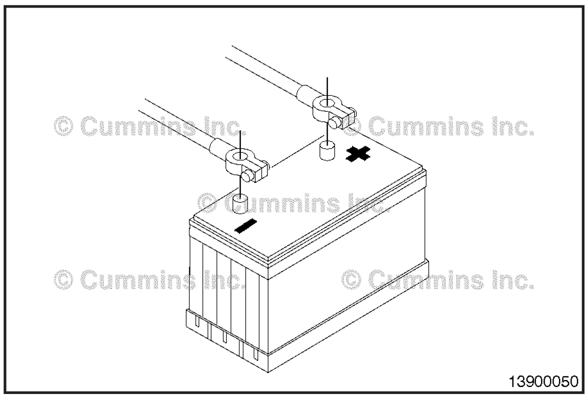




Clean

With EGR

Thoroughly clean the fittings and components before removal. Make sure that debris, water, steam, or cleaning solution does **not** reach inside the fuel system.



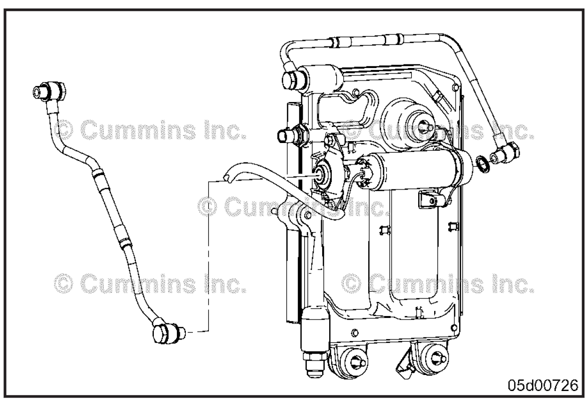
Remove

With EGR

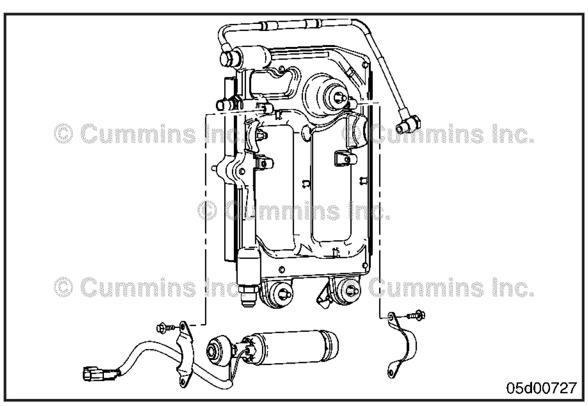
WARNING

Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the 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.



Remove the fuel lift pump inlet and outlet fuel lines.



Remove the fastener holding the lift pump to the back of the ECM cooler plate.

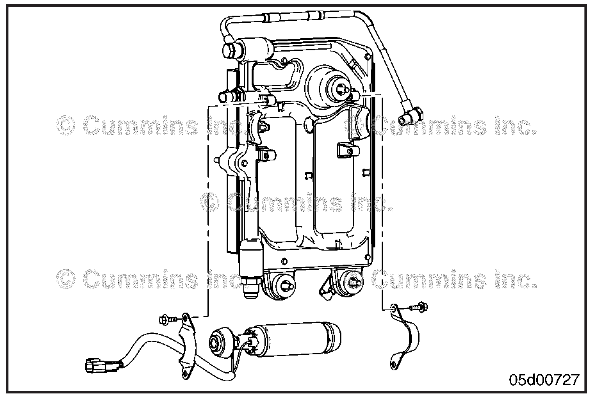
Install

With EGR

NOTE: Make sure the inlet and outlet are properly oriented. Check the lift pump for labeling of inlet and outlet ports. Verify that the correct pump (12 VDC or 24 VDC) is installed.

Install the lift pump on the mounting bracket behind the ECM cooling plate.

Torque Value: 7 N•m [62 in-lb]



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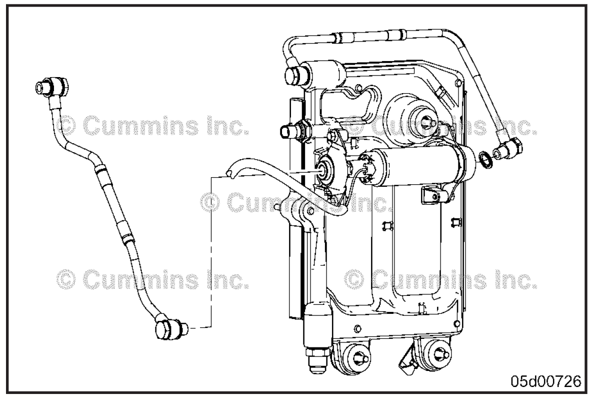
Install the fuel lift pump inlet and outlet fuel lines.

Torque Value: 24 N•m [212 in-lb]



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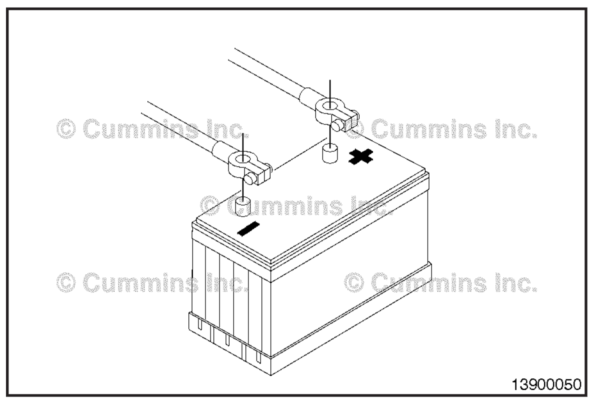
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

Connect the battery.



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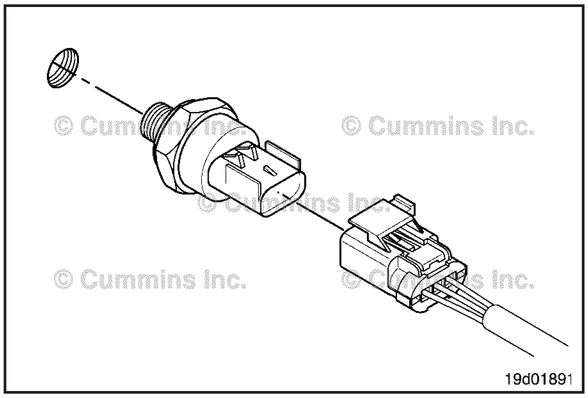
Prime

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

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

For engines with EGR, allow the lift pump to run by turning the keyswitch ON and waiting 30 seconds before starting.



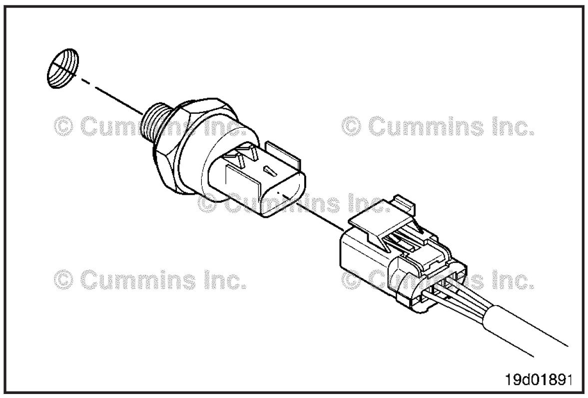
OEM Pressure Sensor (019-400)

General Information

Some original equipment manufacturers (OEMs) can choose to install an additional pressure sensor.

The OEM pressure sensor monitors an OEM-defined pressure and passes that information on to the electronic control module (ECM) through the OEM harness. The ECM uses this information to determine the state of an OEM switched output device.

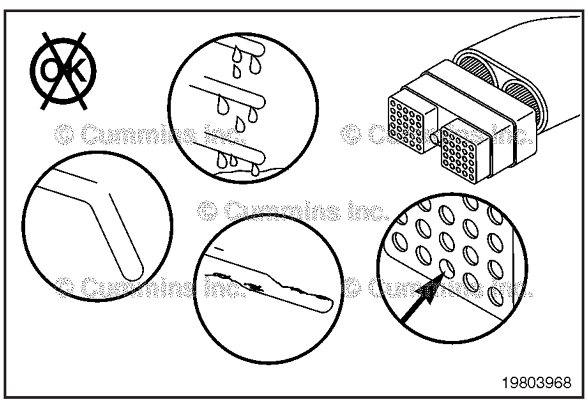
Refer to the OEM troubleshooting and repair manual for the location of the OEM pressure sensor.



Inspect for Reuse

Inspect the OEM pressure sensor for damaged or broken connector pins.

Refer to the OEM troubleshooting and repair manual for removal and installation instructions.



OEM Pressure Sensor Circuit (019-401)

Initial Check

Disconnect the original equipment manufacturer (OEM) pressure sensor connector from the OEM harness. Disconnect the OEM harness connector from the electronic control module (ECM).

Check the OEM pressure sensor connector and OEM harness connectors for broken, bare, or melted wires; loose, dirty, damaged, or missing pins; and other visible signs of damage.

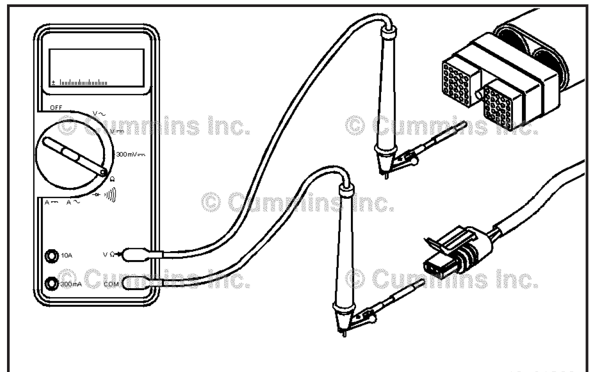
Resistance Check

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. Disconnect the OEM pressure sensor from the OEM harness. Set the multimeter to measure resistance.

Insert a test lead into the OEM pressure sensor signal pin of the OEM harness connector. Connect the alligator clip to a multimeter probe. Insert the second test lead to the signal pin of the OEM pressure sensor harness connector and connect the clip to the other multimeter probe. Measure the resistance.



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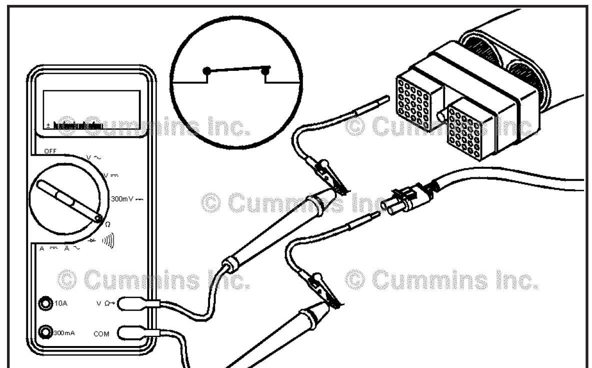
The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the signal wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.



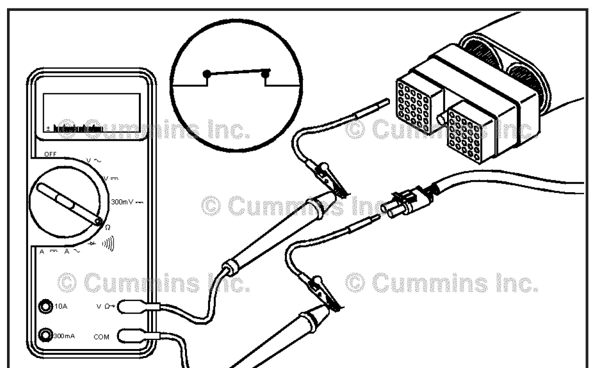
19c01235

Repeat the resistance check for the return wire. Measure the resistance from the OEM pressure sensor return pin of the OEM harness connector to the OEM pressure sensor return pin of the harness connector.

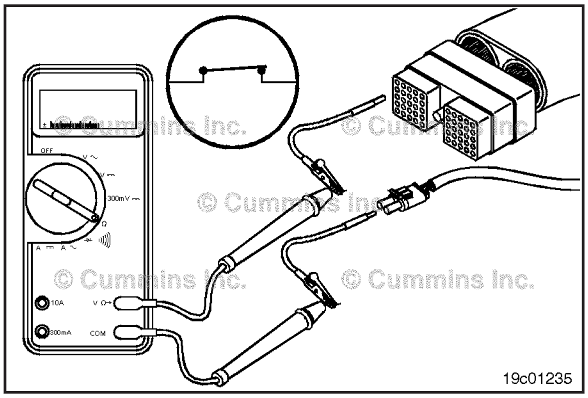
The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the return wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.



19c01235

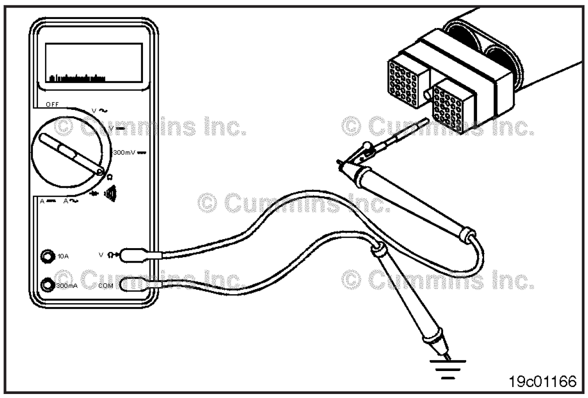


Repeat the resistance check for the 5 volt supply wire. Measure the resistance from the OEM pressure sensor 5 volt supply pin of the OEM harness connector to the OEM pressure sensor 5 volt supply pin of the harness connector.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the 5 volt supply wire.

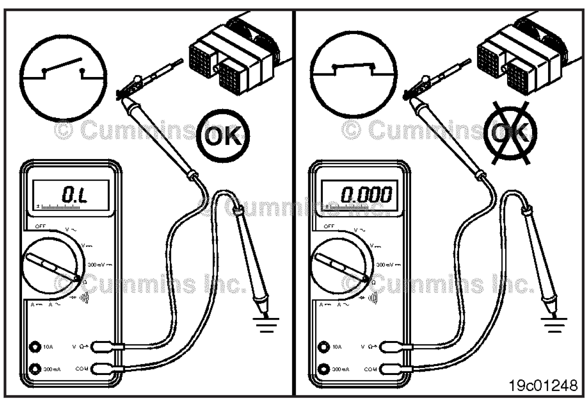
Repair or replace the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to Ground

Disconnect the OEM harness connector from the ECM. Disconnect the OEM pressure sensor from the OEM harness. Set the multimeter to measure resistance.

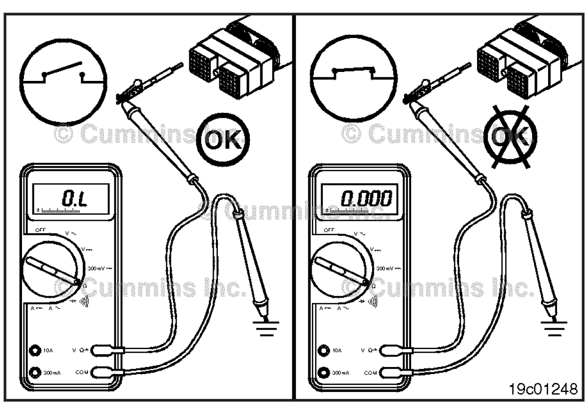
Insert the test lead into the OEM pressure sensor signal pin of the OEM harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.



The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the signal wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.



Repeat the short-to-ground check for the return wire. Measure the resistance from the OEM pressure sensor return pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the return wire.

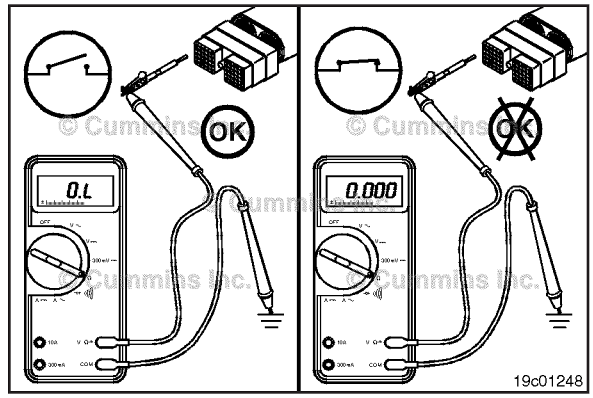
Repair or replace the OEM harness. Refer to Procedure 019-071.

Repeat the short-to-ground check for the 5 volt supply wire. Measure the resistance from the OEM pressure sensor 5 volt supply pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the 5 volt supply wire.

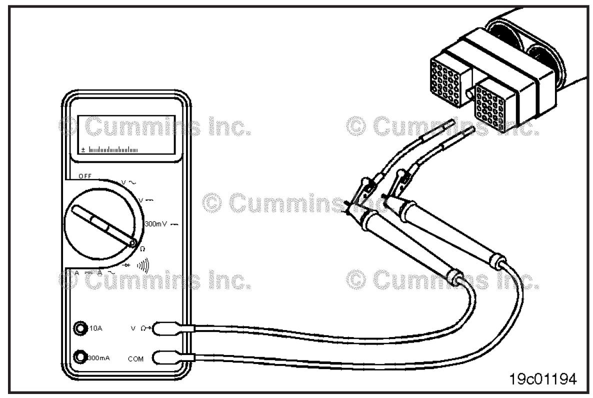
Repair or replace the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit from Pin to Pin

Disconnect the OEM harness connector from the ECM. Disconnect the OEM pressure sensor from the OEM harness. Set the multimeter to measure resistance.

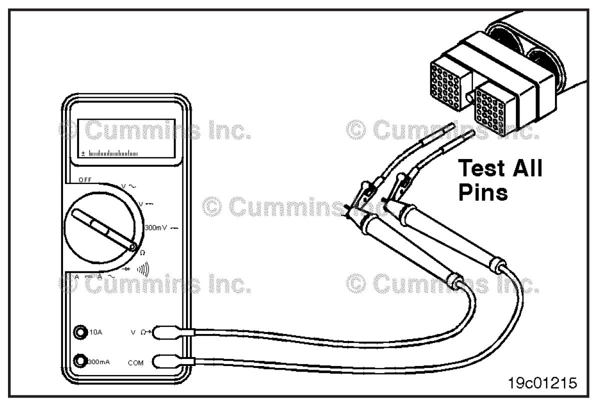
Measure the resistance from the OEM pressure sensor signal pin in the OEM harness connector to all other pins in the connector.



The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit between the signal wire and any other pin that measured a closed circuit.

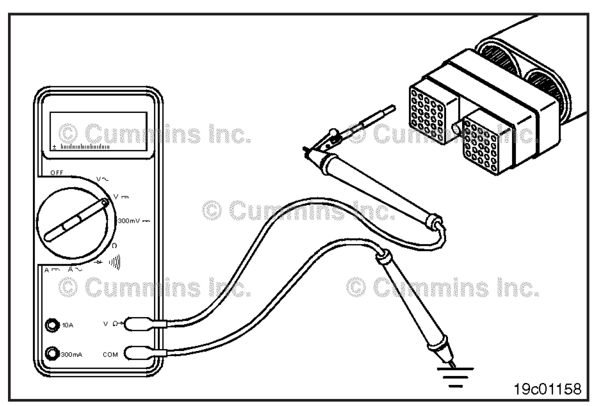
Repair or replace the OEM harness. Refer to Procedure 019-071.

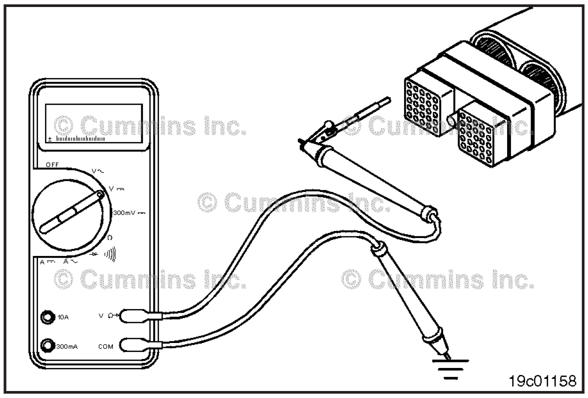


Check for Short Circuit to External Voltage Source

Disconnect the OEM harness connector from the ECM. Disconnect the OEM pressure sensor from the OEM harness. Set the multimeter to measure VDC. Turn the vehicle keyswitch to the ON position.

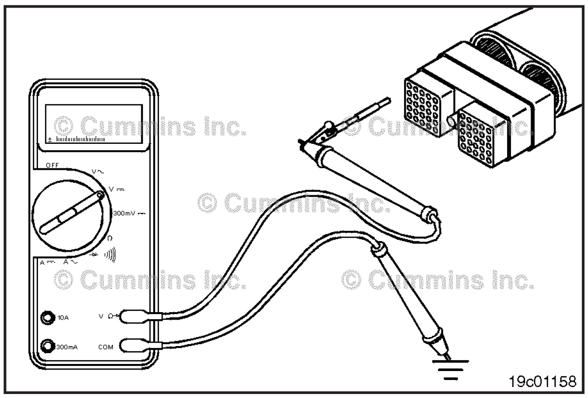
Insert the test lead connected to the positive (+) multimeter probe into the OEM pressure sensor signal pin of the OEM harness connector. Touch the negative (-) multimeter probe to engine block ground and measure the voltage.





If there is voltage present, there is a short circuit from the signal wire to an external voltage source.

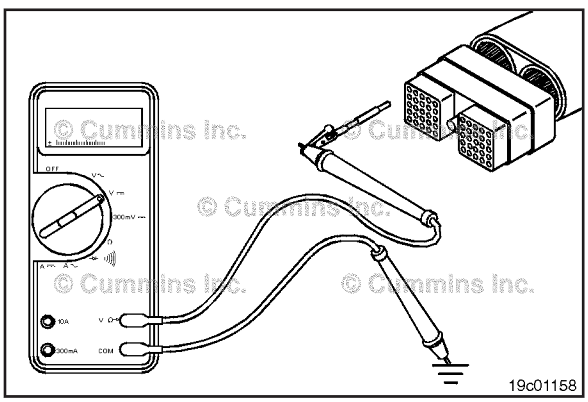
Repair or replace the OEM harness. Refer to Procedure 019-071.



Repeat the short to external voltage source check for the return wire. Measure the voltage from the OEM pressure sensor return pin of the OEM harness connector to engine block ground.

If there is voltage present, there is a short circuit from the return wire to an external voltage source.

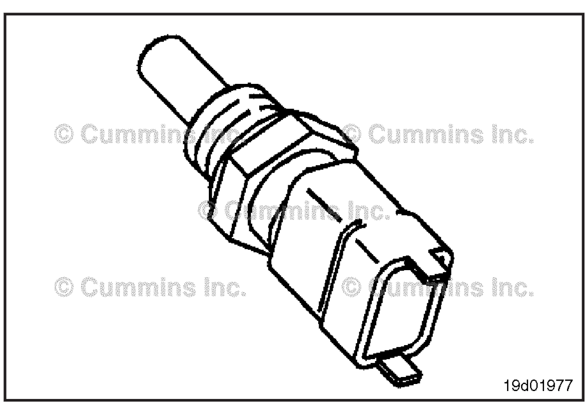
Repair or replace the OEM harness. Refer to Procedure 019-071.



Repeat the short to external voltage source check for the 5 volt supply wire. Measure the voltage from the OEM pressure sensor 5 volt supply pin of the OEM harness connector to engine block ground.

The multimeter **must** show a voltage of less than 5.5 VDC. If the voltage is greater than 5.5 VDC, there is a short circuit from the 5 volt supply wire to an external voltage source.

Repair or replace the OEM harness. Refer to Procedure 019-071.



OEM Temperature Sensor (019-402)

General Information

Some original equipment manufacturers (OEMs) can choose to install an additional temperature sensor.

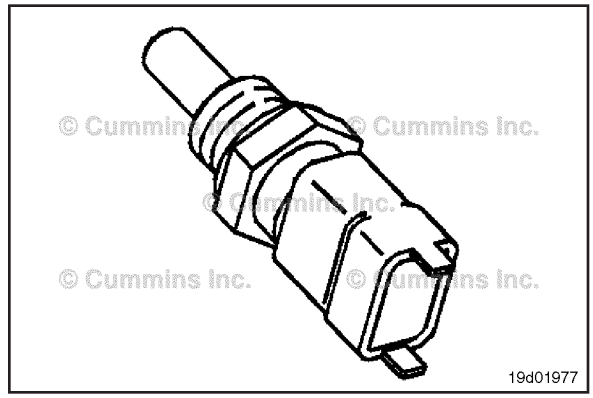
The OEM temperature sensor monitors an OEM-defined temperature and passes that information on to the electronic control module (ECM) through the OEM harness. The ECM uses this information to determine the state of an OEM switched output device.

Refer to the OEM troubleshooting and repair manual for the location of the OEM temperature sensor.

Inspect for Reuse

Inspect the OEM temperature sensor for damaged or broken connector pins.

Refer to the OEM troubleshooting and repair manual for removal and installation instructions.

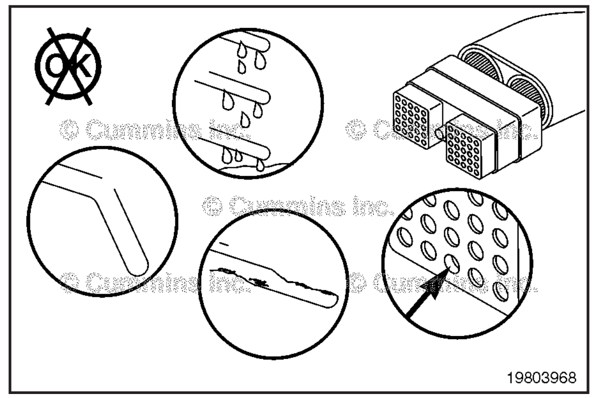


OEM Temperature Sensor Circuit (019-403)

Initial Check

Disconnect the original equipment manufacturer (OEM) temperature sensor connector from the OEM harness. Disconnect the OEM harness connector from the electronic control module (ECM).

Check the OEM temperature sensor connector and OEM harness connectors for broken, bare, or melted wires; loose, dirty, damaged, or missing pins; and other visible signs of damage.



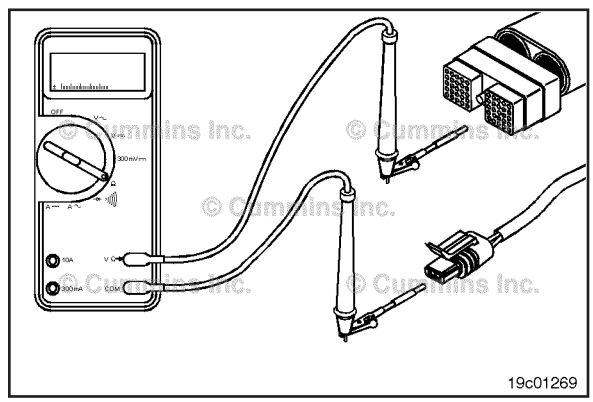
Resistance Check

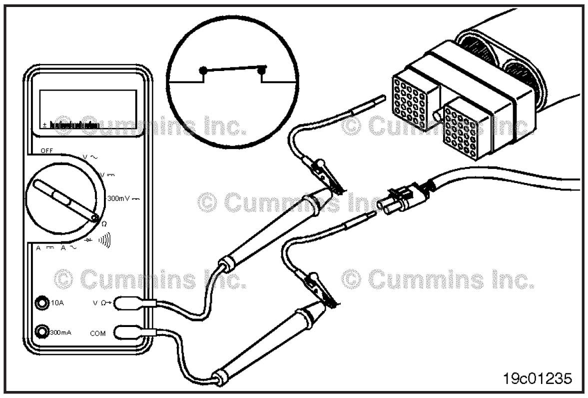
⚠CAUTION⚠

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. Disconnect the OEM temperature sensor from the OEM harness. Set the multimeter to measure resistance.

Insert a test lead into the OEM temperature sensor signal pin of the OEM harness connector. Connect the alligator clip to a multimeter probe. Insert the second test lead to the signal pin of the OEM temperature sensor harness connector and connect the clip to the other multimeter probe. Measure the resistance.

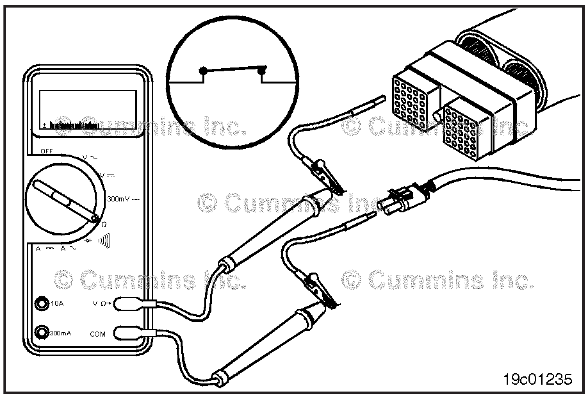




The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the signal wire.

Repair or replace the OEM harness. Refer to Procedure 019-071.

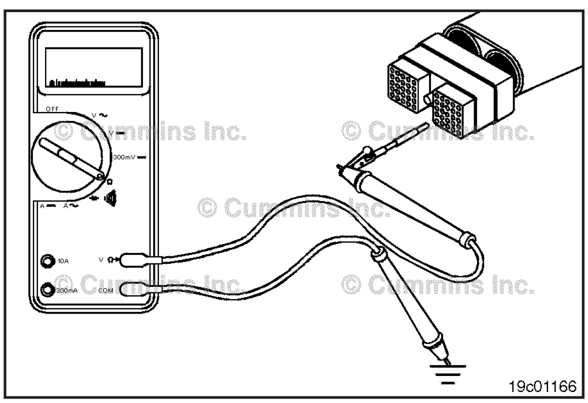


Repeat the resistance check for the return wire. Measure the resistance from the OEM temperature sensor return pin of the OEM harness connector to the OEM temperature sensor return pin of the harness connector.

The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

If the measured value is more than 10 ohms, there is an open circuit in the return wire.

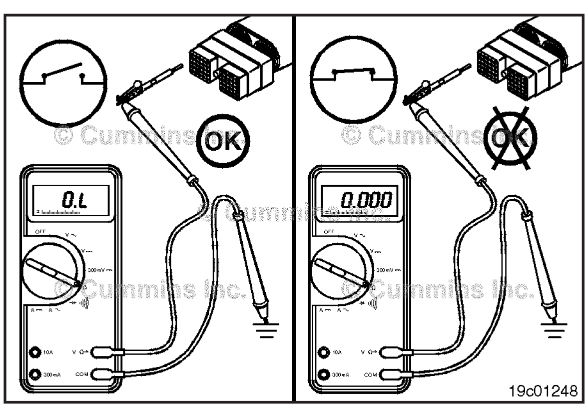
Repair or replace the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit to Ground

Disconnect the OEM harness connector from the ECM. Disconnect the OEM temperature sensor from the OEM harness. Set the multimeter to measure resistance.

Insert the test lead into the OEM temperature sensor signal pin of the OEM harness connector. Touch the other multimeter probe to engine block ground. Measure the resistance.



The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the signal wire.

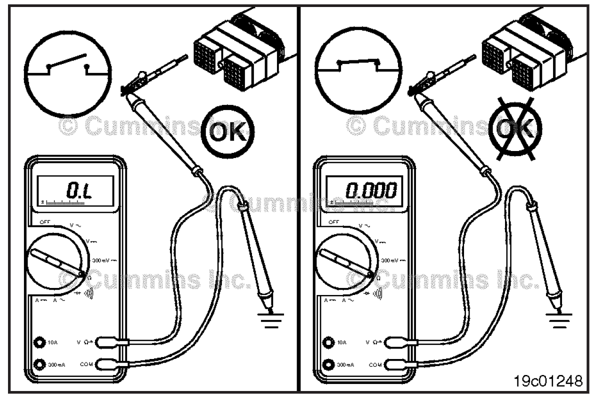
Repair or replace the OEM harness. Refer to Procedure 019-071.

Repeat the short-to-ground check for the return wire. Measure the resistance from the OEM temperature sensor return pin of the OEM harness connector to engine block ground.

The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit to ground in the return wire.

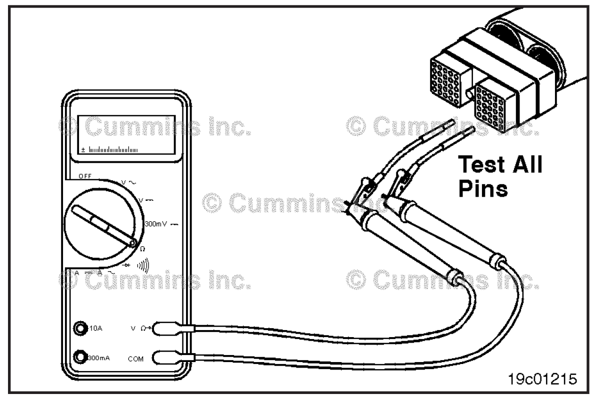
Repair or replace the OEM harness. Refer to Procedure 019-071.



Check for Short Circuit from Pin to Pin

Disconnect the OEM harness connector from the ECM. Disconnect the OEM temperature sensor from the OEM harness. Set the multimeter to measure resistance.

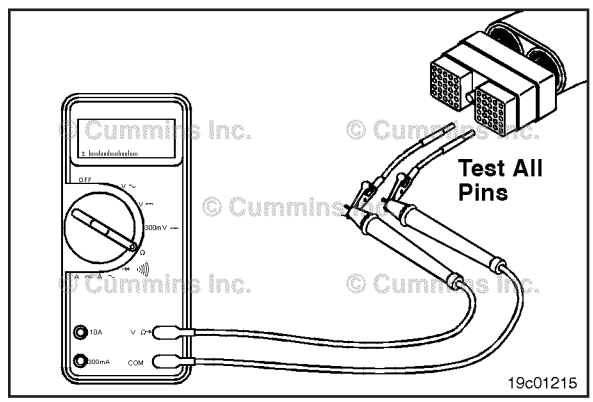
Measure the resistance from the OEM temperature sensor signal pin in the OEM harness connector to all other pins in the connector.



The multimeter **must** show a measurement of 100k ohms or more (open circuit).

If the measured value is less than 100k ohms, there is a short circuit between the signal wire and any other pin that measured a closed circuit.

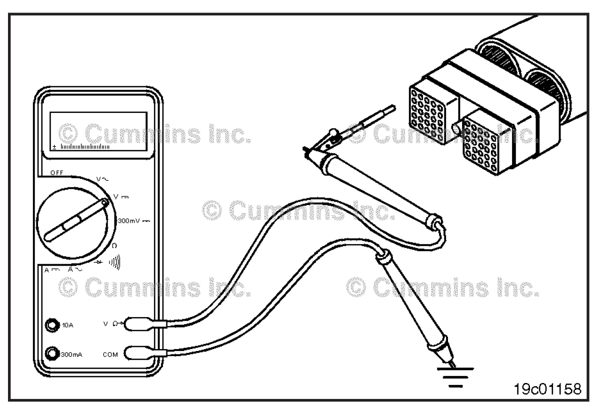
Repair or replace the OEM harness. Refer to Procedure 019-071.

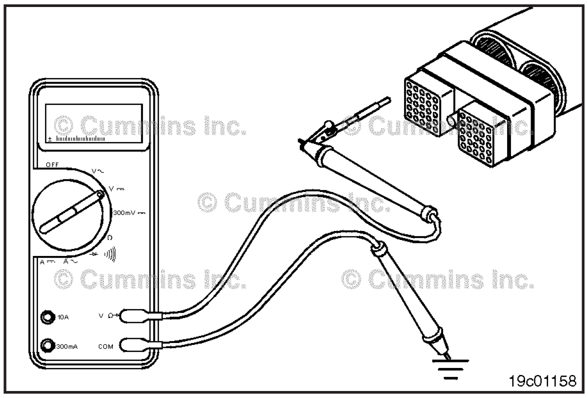


Check for Short Circuit to External Voltage Source

Disconnect the OEM harness connector from the ECM. Disconnect the OEM temperature sensor from the OEM harness. Set the multimeter to measure VDC. Turn the vehicle keyswitch to the ON position.

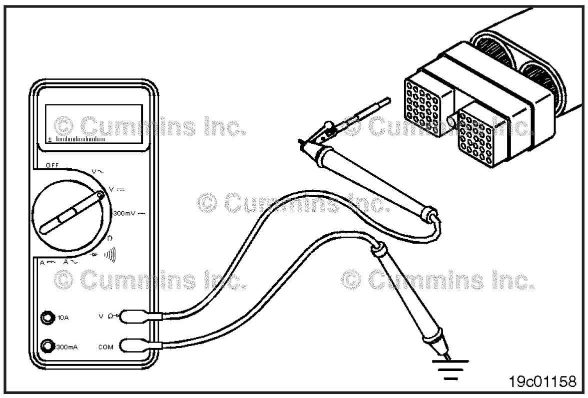
Insert the test lead connected to the positive (+) multimeter probe into the OEM temperature sensor signal pin of the OEM harness connector. Touch the negative (-) multimeter probe to engine block ground and measure the voltage.





The multimeter **must** show voltage of 5.5 VDC or less. If the voltage is incorrect, there is a short circuit from the signal wire to an external voltage source.

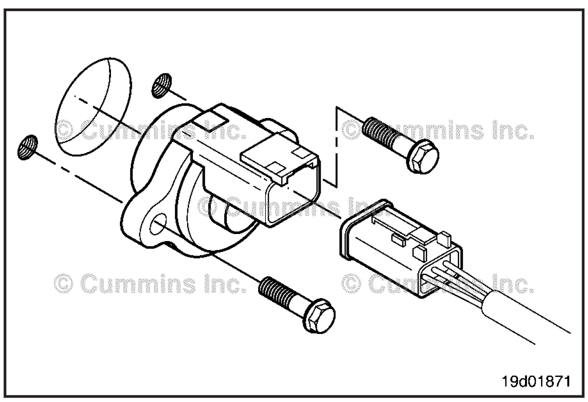
Repair or replace the OEM harness. Refer to Procedure 019-071.



Repeat the short to external voltage source check for the return wire. Measure the voltage from the OEM temperature sensor return pin of the OEM harness connector to engine block ground.

The multimeter **must** show voltage of 5.5 VDC or less. If the voltage is incorrect, there is a short circuit from the return wire to an external voltage source.

Repair or replace the OEM harness. Refer to Procedure 019-071.



Turbocharger Position Sensor (019-405)

General Information

⚠CAUTION⚠

The position sensor pins can be bent if the engine harness connector is mated to the sensor connector at an angle. Therefore, the engine harness connector must be inserted straight into the position sensor connector to reduce the possibility of damaging the pins. Bent pins will result in poor engine performance and intermittent fault codes.

⚠CAUTION⚠

Do not use connector grease on the turbocharger position sensor connector. Use of connector grease can cause damage to the turbocharger control valve and low engine performance.

The turbocharger position sensor outputs a voltage signal to the ECM. The ECM converts this signal into a percentage, 0 to 100 percent, indicating variable geometry turbocharger position. A fully closed turbocharger is equivalent to 100 percent.

The turbocharger position sensor is located on the variable geometry turbocharger actuator assembly.

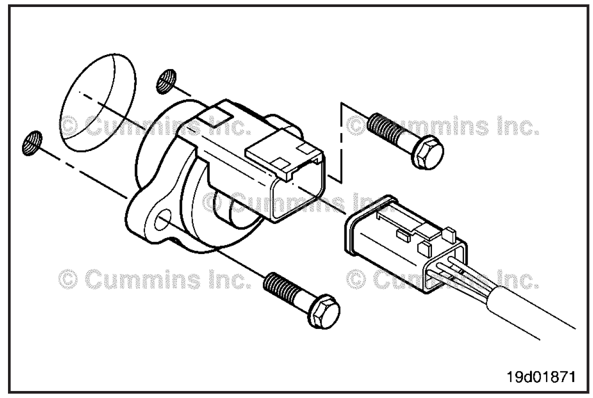
There are two types of position sensors. The original position sensor has the connector molded into the sensor (shown in the diagram). The new hull effect position sensor has a pigtail harness connected to the sensor.

Remove

Push down on the connector tab and detach the connector from the sensor.

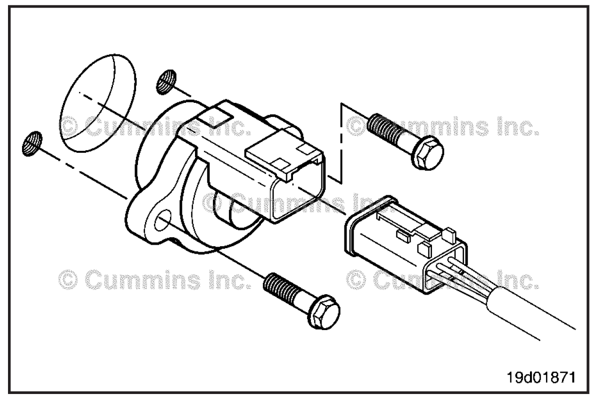
Remove the capscrews that secure the sensor to the variable geometry turbocharger actuator assembly.

Remove the sensor.



Inspect for Reuse

Inspect the turbocharger position sensor for a damaged or missing o-ring and damaged or broken connector pins.

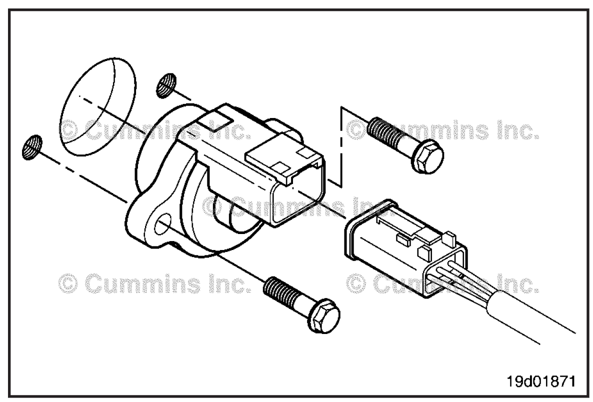


Install

⚠CAUTION⚠

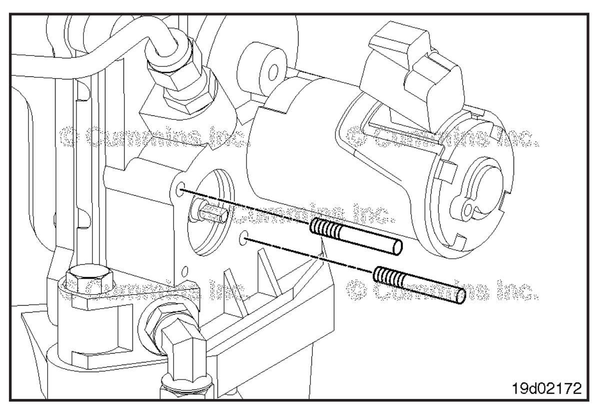
The position sensor pins can be bent if the engine harness connector is mated to the sensor connector at an angle. Therefore, the engine harness connector must be inserted straight into the position sensor connector to reduce the possibility of damaging the pins. Bent pins will result in poor engine performance and intermittent fault codes.

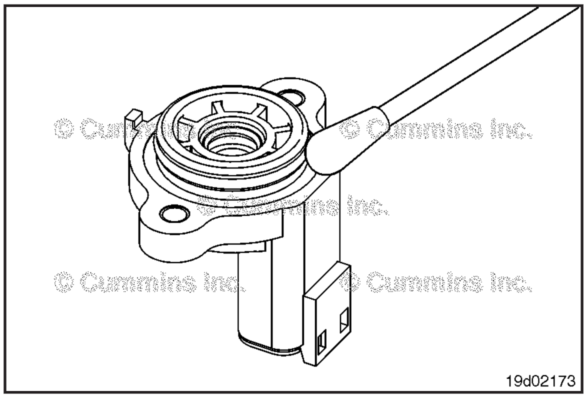
Rotate the internal hub of the sensor so it will align with the flat spot on the shaft.



Guide pins, Part Number 3165138, are necessary for proper alignment between the position sensor and the housing. Improper alignment will result in damage to the sensor.

Insert alignment pins into the capscrew holes in the housing.

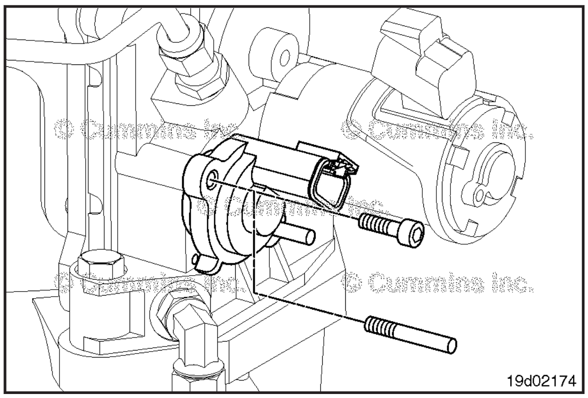




CAUTION

Do not allow any of the solution to get inside the sensor. Damage to electrical components can occur.

Use a cotton swab to lubricate the sensor o-ring with a mild soap and water solution.



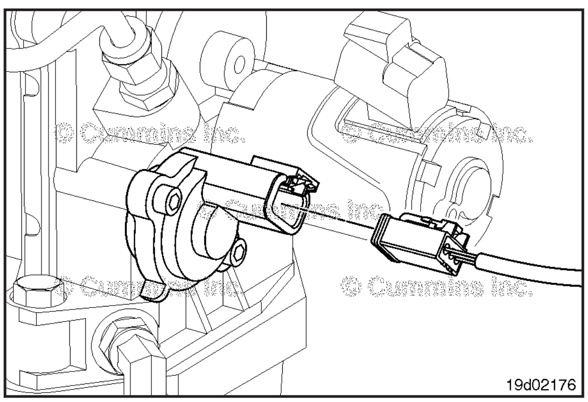
Install the position sensor over the guide pins.

Press the sensor into the bore until the o-ring is fully engaged.

The external locating tab on the sensor should align with the hole in the housing.

When the position sensor is fully seated against the housing, remove the alignment pins and install the two M4 capscrews.

Torque Value: 3.1 N•m [27 in-lb]



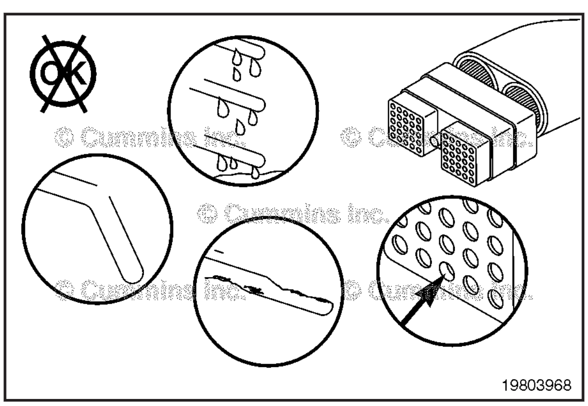
CAUTION

Do not use connector grease on the turbocharger position sensor connector. Use of connector grease can cause damage to the turbocharger control valve and low engine performance.

Connect the engine harness connector to the sensor. Push the connectors together until they lock.

Inspect the wiring harness and connector for excessive tension.

If excessive tension is present, determine the source and relieve the tension on the circuit.



Intake Air Heater Control Relay Circuit (019-408)

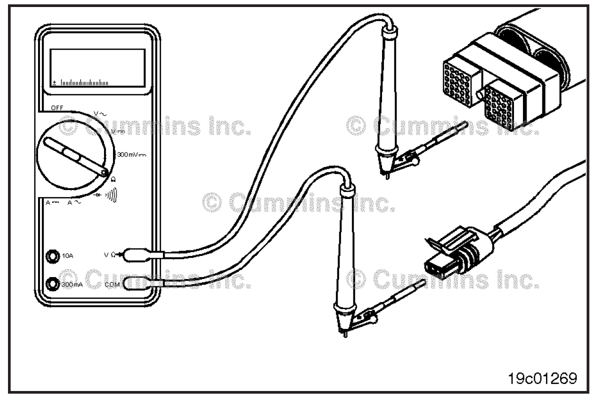
Initial Check

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.

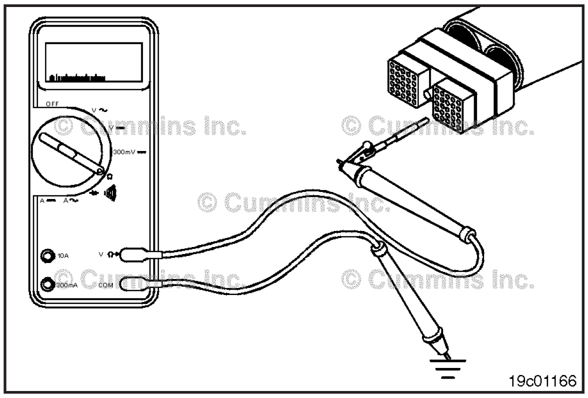
The multimeter **must** show a measurement of 10 ohms or less (closed circuit).

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.

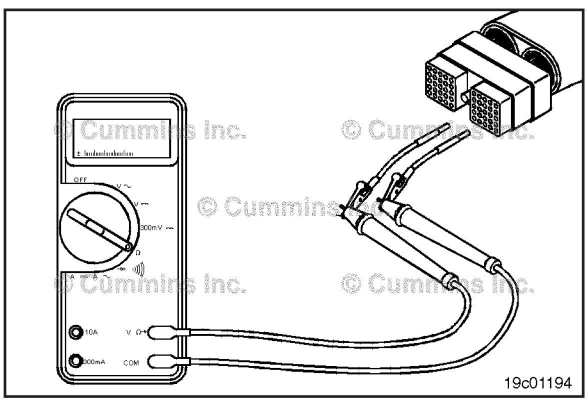
The multimeter **must** show a measurement of 100k ohms or more (open circuit).

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

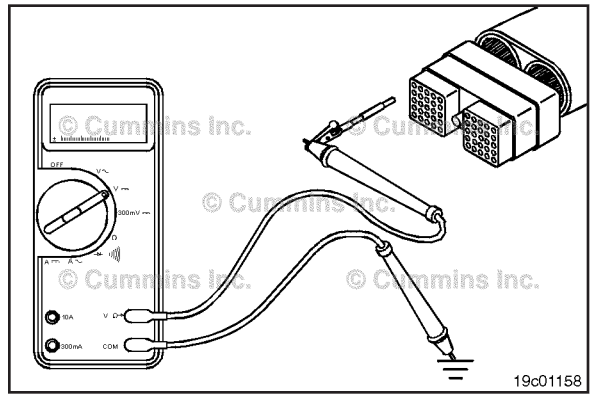
Disconnect the OEM harness connector from the ECM connector. Disconnect the intake air heater control relay from the OEM harness. Set the multimeter to measure resistance.

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.

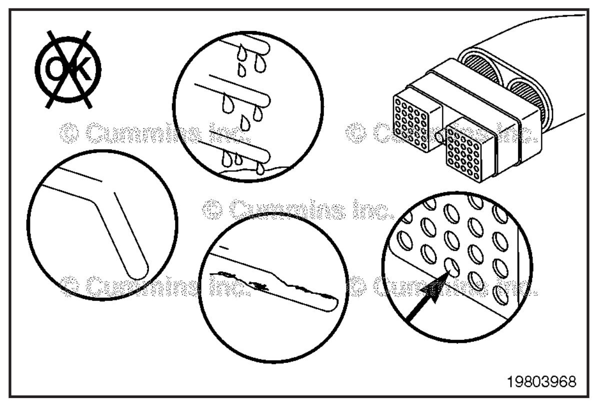
If voltage is present, there is a short circuit from the signal wire to an external voltage source. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

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.

Transmission Shift Modulation Signal Circuit (019-409)

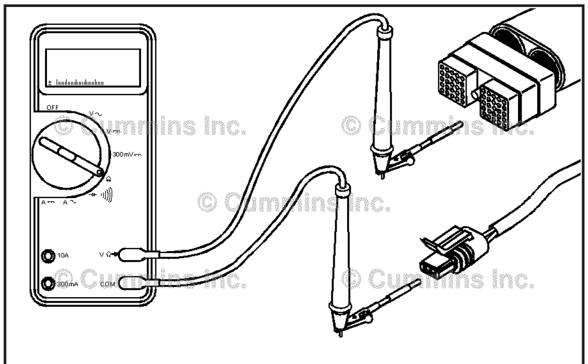
Initial Check



Disconnect the transmission shift modulator from the OEM harness.

Disconnect the OEM harness connector from the ECM connector.

Check the transmission shift modulator and harness connector for broken, bare, or melted wires; loose, dirty, damaged, or missing pins; and other visible signs of damage.



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Resistance Check

CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

Disconnect the OEM harness connector from the ECM connector. Disconnect the transmission shift modulator from the OEM harness. Set the multimeter to measure resistance.

Insert a test lead into the transmission shift modulator 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 transmission shift modulator 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).

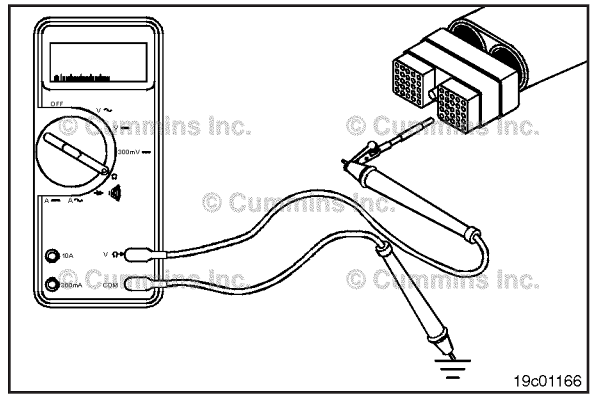
If the measured value is more than 10 ohms, there is an open circuit in the signal wire. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Repeat the resistance check for the return wire. Measure the resistance from the transmission shift modulator return pin of the OEM harness connector to the transmission shift modulator 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 transmission shift modulator from the OEM harness. Set the multimeter to measure resistance.

Insert the test lead into the transmission shift modulator 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).

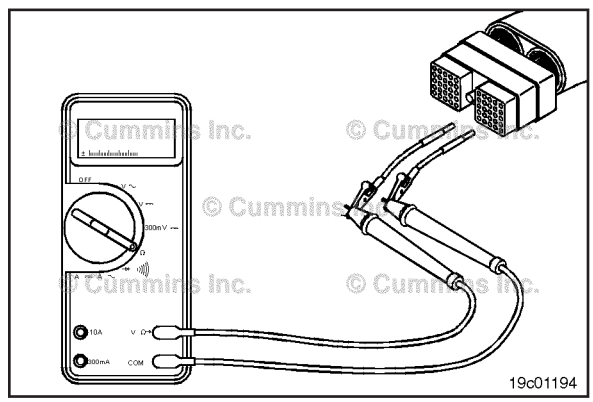
If the measured value is less than 100k ohms, there is a short circuit to ground in the signal wire. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Repeat the short to ground check for the return wire. Measure the resistance from the transmission shift modulator 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

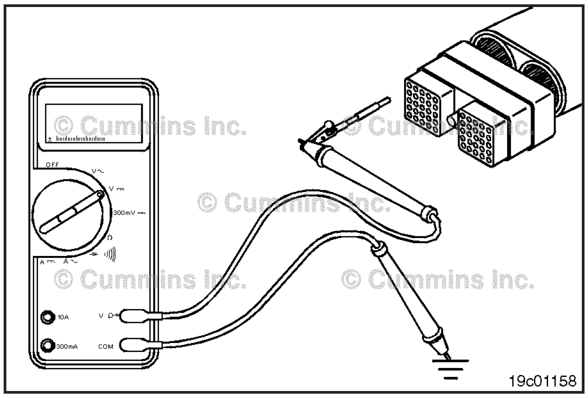


Disconnect the OEM harness connector from the ECM connector. Disconnect the transmission shift modulator from the OEM harness. Set the multimeter to measure resistance.

Measure the resistance from the transmission shift modulator 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 transmission shift modulator from the OEM harness.

Set the multimeter to measure VDC. Turn the keyswitch to the ON position.

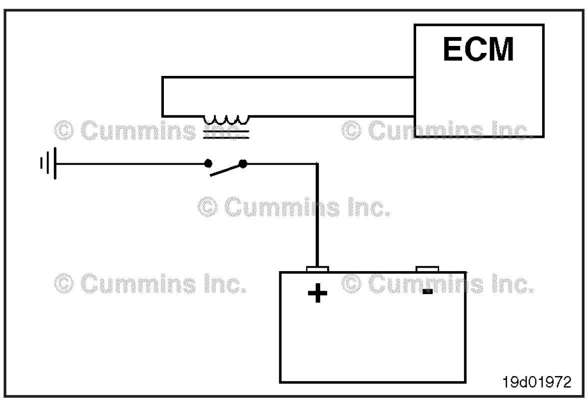
Insert the test lead connected to the positive (+) multimeter probe into the transmission shift modulator signal pin of the OEM harness connector. Touch the negative (-) multimeter probe to engine block ground and measure the voltage.

The voltage **must** be 5.5-VDC or less.

If the voltage is incorrect, there is a short circuit from the signal wire to an external voltage source. Repair or replace the OEM harness. Refer to the OEM troubleshooting and repair manual.

Repeat the short to external voltage source check for the return wire. Measure the voltage from the transmission shift modulator 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.



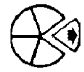
Starter Lockout/Switched Outputs Relay Circuit (019-419)

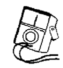
General Information

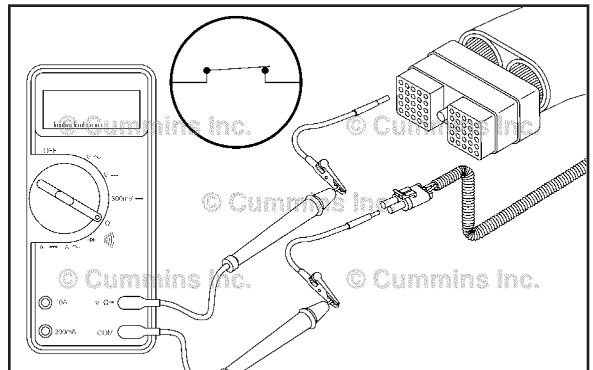
The ECM can control a starter lockout relay or an OEM relay.

Refer to the vehicle manufacturer's publications for more information on troubleshooting and repair of the starter lockout relay or OEM relay.

Resistance Check







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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.

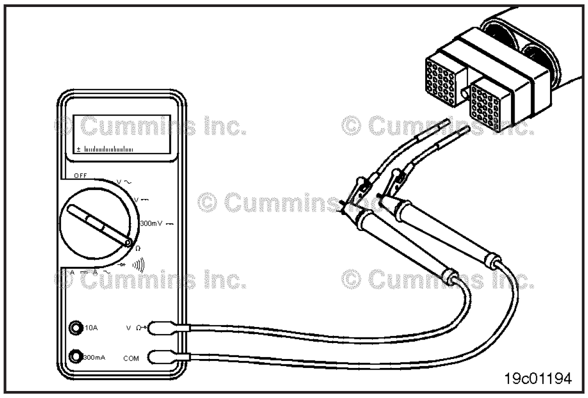
The multimeter **must** show 10 ohms or less (closed circuit).

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.

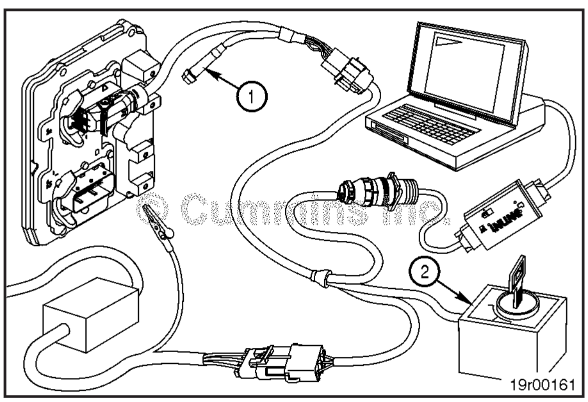
Insert a test lead into the signal pin of the OEM harness connector, and connect the alligator clip to a multimeter probe. Insert the second test lead to the first pin in the OEM harness connector, and connect the alligator clip to the other multimeter probe.

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

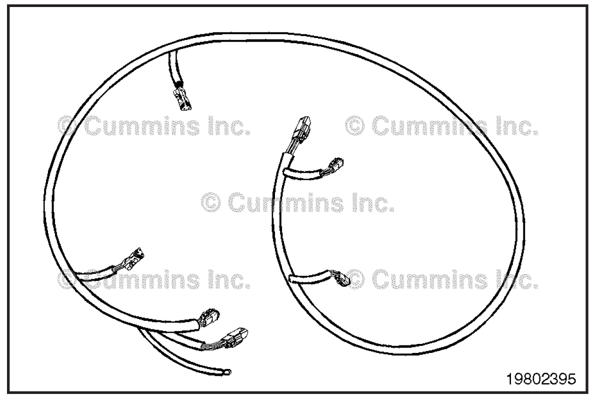
Engine Control Module (ECM) ROM Boot Procedure:

- 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.
- Recalibrate the ECM. Refer to Procedure 019-032 in Section 19.
- Remove the ROM boot cable from the ECM.

For general tool information, including the correct installation configuration, see the ECM-specific calibration adapter cable with ROM boot switch in the ECM Bench Calibration Base Harness, Bulletin 3377791.

Engine Datalinks (019-428)

General Information



CAUTION

Proper leads and/or a Cummins® approved circuit testing tool must be used when working with electrical connectors to prevent pin expansion and damage to the connector.

The engine data link consists of circuitry located in the engine wiring harness. On older engines, the engine data link circuitry supports J1587/J1708 protocol. On newer engines, the engine data link circuitry supports J1939 protocol.

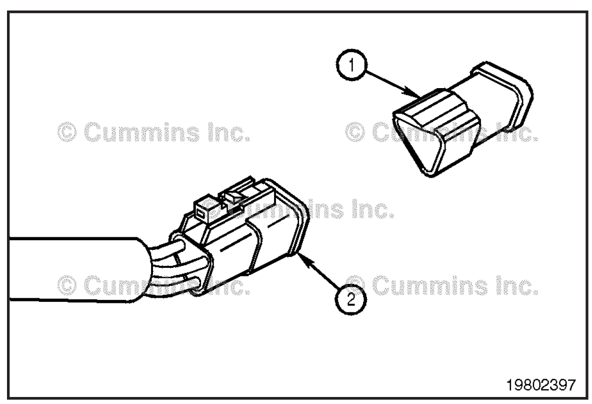
The purpose of the engine data link is to provide an access point for a service tool, such as INSITE™ electronic service tool, to communicate with the engine control module (ECM). A service tool can communicate with the ECM on the engine data link free from data link traffic from other electronic devices that can be present on the OEM data link.

SAE J1939 Backbone Harness Overview:

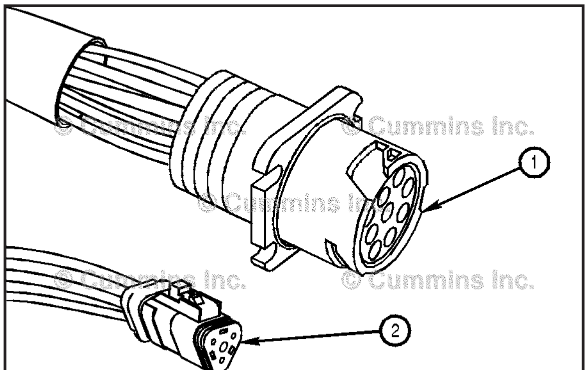
SAE J1939 has strict guidelines that **must** be followed for successful communication. Understanding some fundamentals about SAE J1939 will help make sure these guidelines are followed.

The main component of an SAE J1939 system is a backbone harness. The harness can be up to 40 m [131 ft] long. The backbone harness is terminated at each end with 120 ohm resistors.

A maximum of 30 different devices can be attached to the SAE J1939 backbone at once. Each device, such as the data link adapter, is connected to the backbone through a stub which can be up to 1 m [3.2 ft] in length. The stub connector is a 3-pin plug.



The terminating resistor caps (1) **must** be in place on the OEM backbone harness plugs (2) to maintain proper communication. Each resistor is 120 ohms and is located in a removable cap. This resistance is required when communicating with INSITE™ electronic service tool over the J1939 data link.



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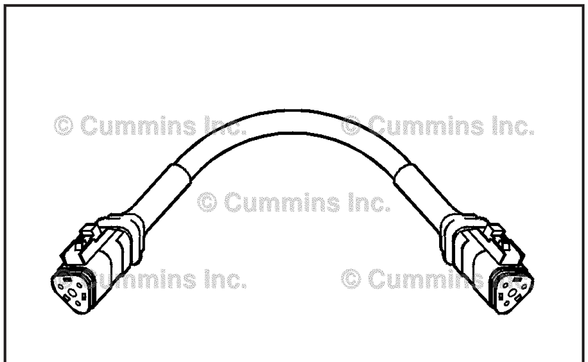
Some engine harnesses include a complete SAE J1939 backbone harness. If this is supplied, connection to INSITE™ electronic service tool is accomplished either by a 9-pin data link connector (1), Part Number 4918416, or a 3-pin receptacle (2), Part Number 3165141.

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.

Engine Data Link Connectors

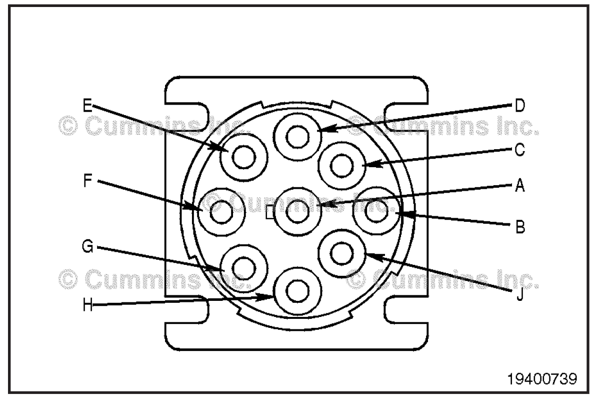
The engine data link connector available on the engine harness will depend upon the data link circuitry in the engine harness and the vintage of the engine. Engine data link connectors available on Cummins® engines are summarized in the table below.

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.

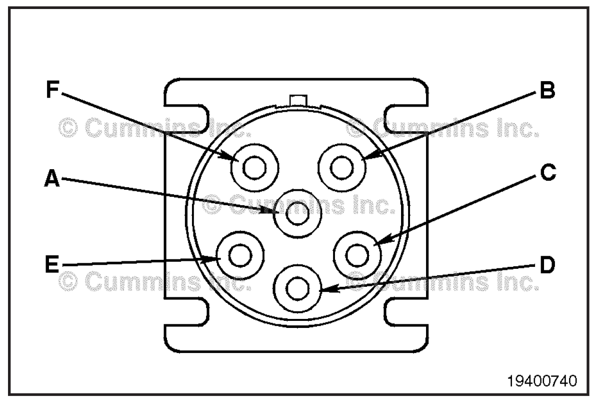
The 9-pin Deutsch™ connector, Part Number 3824018, connector can supply SAE J1587/SAE 1708 and SAE J1939 communications, and battery voltage. The following are pin-outs for the 9-pin connector:

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

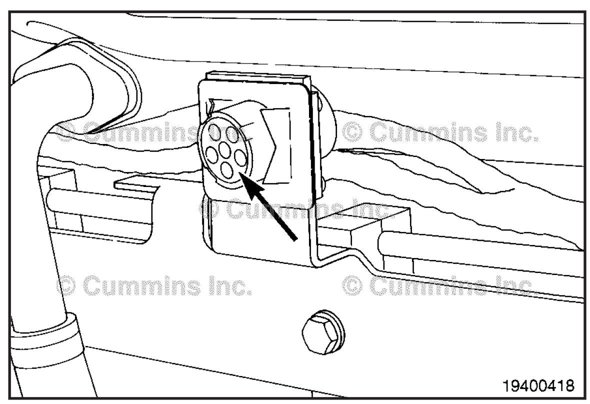


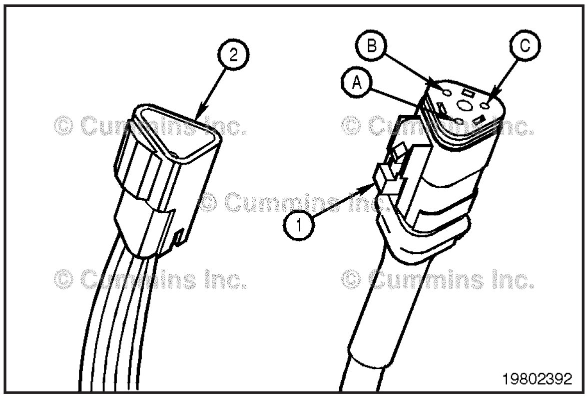
The 6-pin Deutsch™ connector, Part Number 3824805, is found on some engines. This connector supplies SAE J1587/J1708, as well as the battery voltage. The following are pin-outs for the 6-pin connector:

Pin	Signal
A	J1708 data link (+)
B	J1708 data link (-)
C	Unswitched battery (+)
D	Open
E	Ground
F	Open



NOTE: For CELECT 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.





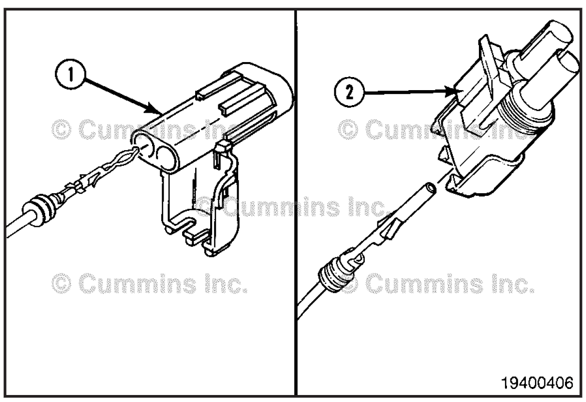
The 3-pin SAE J1939 Deutsch™ connectors are also found on some Cummins® engine harnesses. Two possible types of 3-pin connectors can be present: A 3-pin plug (1), Part Number 3824288; and a 3-pin receptacle (2), Part Number 3824290. The following are the pin-outs for the 3-pin connector:

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.

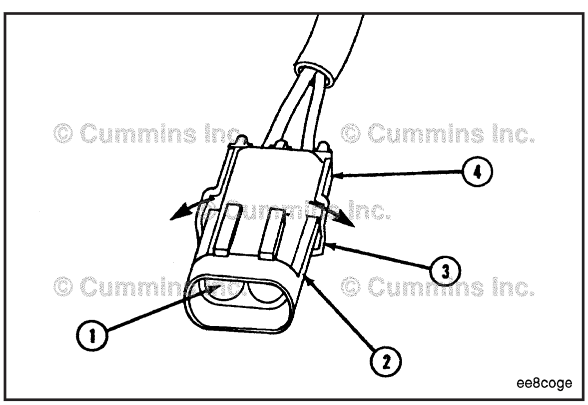
To meet the SAE J1939 standard, the 3-pin receptacle connector **must** be within 0.66 m [2.16 ft] of the ECM. Use of the J1939 mini-backbone harness, Part Number 3163096, may be required for proper termination resistance. The mini-backbone harness is required when **no** backbone is provided on the 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:

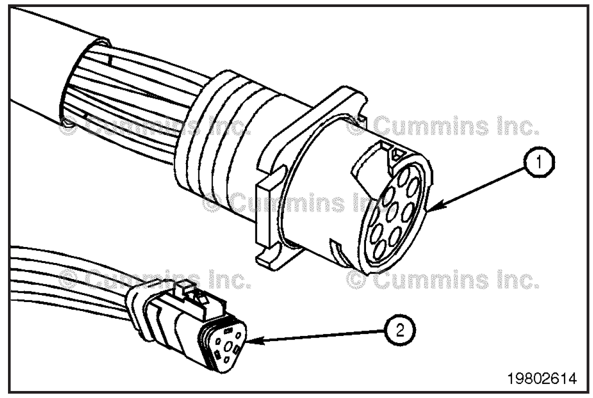
Pin	Signal
A	J1587/J1708 data link (+)
B	J1587/1708 data link (-)



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 (-)

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.

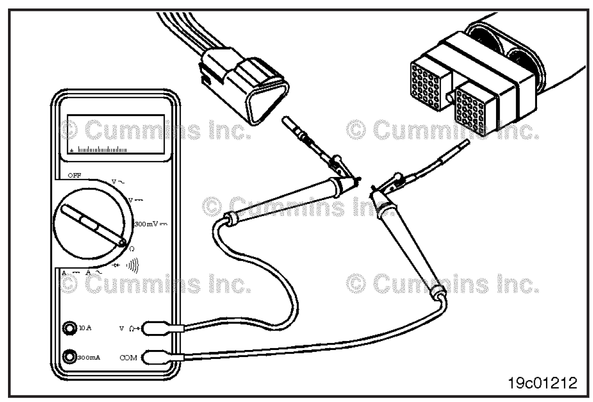
CAUTION

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 led 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).

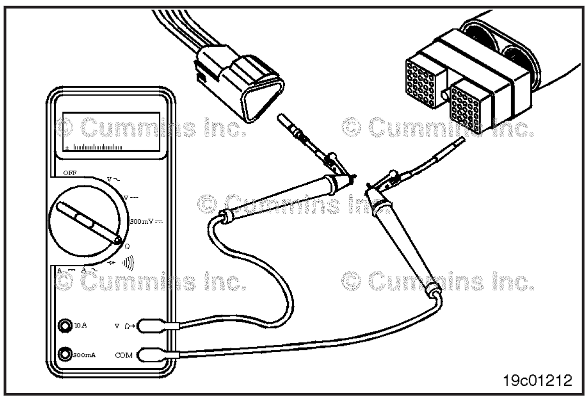
If the circuit is **not** closed, repair or replace the engine harness.

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.

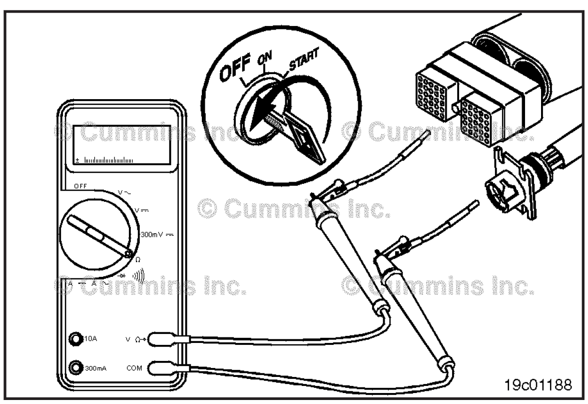
See the Troubleshooting and Repair manual for additional information.



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.

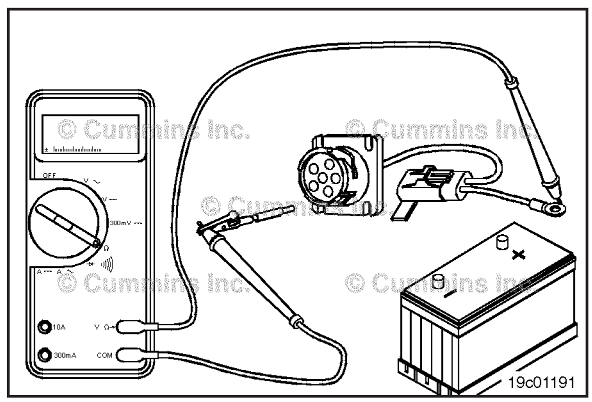
Disconnect the batteries.

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).

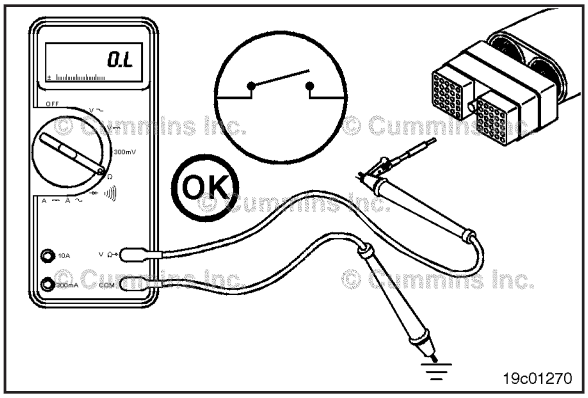
If the circuit is **not** closed, repair or replace the engine harness.

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.

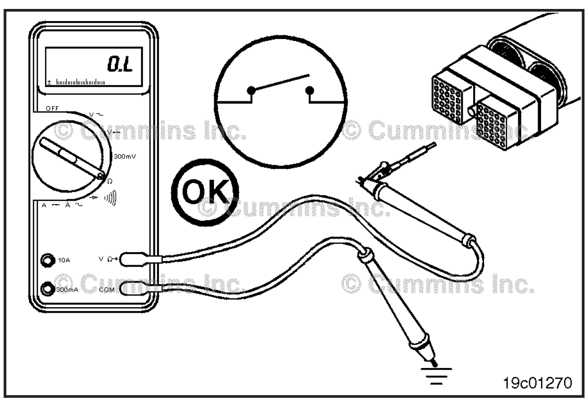
J1939 Engine Data Link

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.



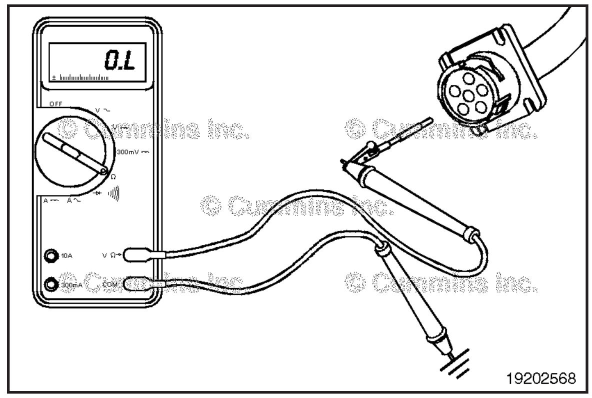
Remove the test lead from the SAE J1939 data link positive (+) pin and insert it into the SAE J1939 data link negative (-) pin of the ECM connector. Measure the resistance from the SAE J1939 data link negative (-) pin of the engine harness ECM connector to the engine block ground. The multimeter **must** 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.



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.

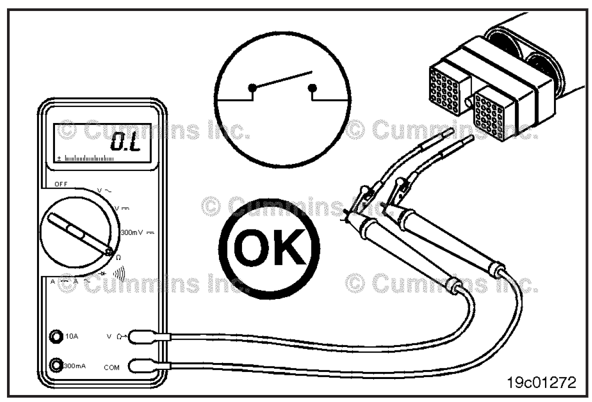
See the Troubleshooting and Repair manual for additional information.

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.

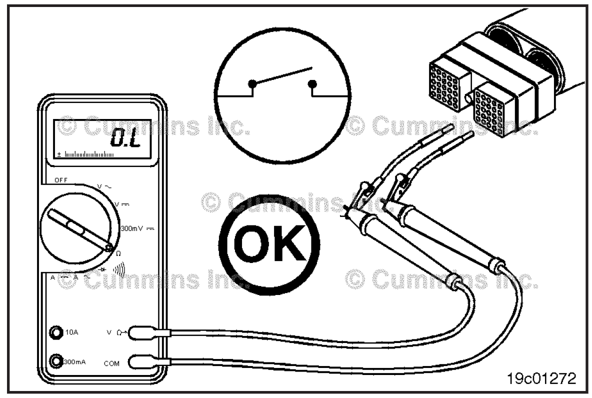
J1587/J1708 Engine Data Link

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.

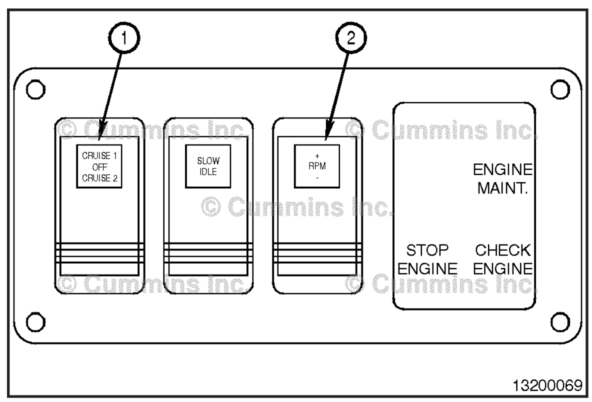
See the Troubleshooting and Repair manual for additional information.

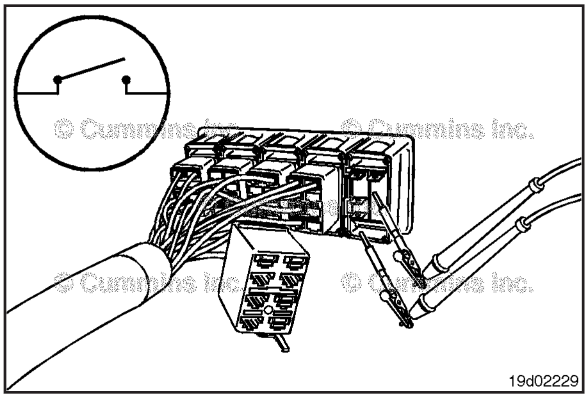
Slow Idle Switch (019-435)

General Information

Marine Applications

The Slow Idle Switch is located on the control panel and has two settings, ON and OFF. The rocker switch is used to activate or disable the slow idle operation. The slow idle circuit consists of the Slow Idle signal line, switch common ground and the rocker switch.





Resistance Check

Marine Applications

If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not** follow the troubleshooting procedures in this section.

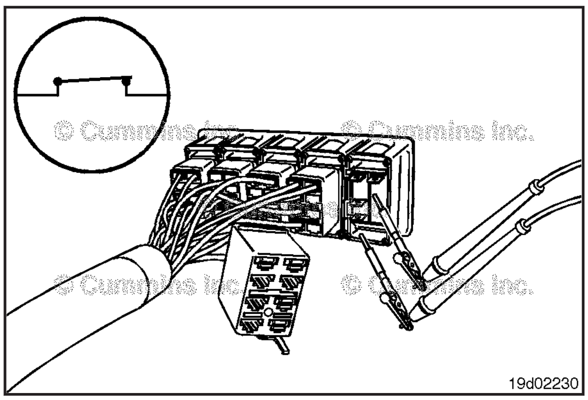
Locate and remove the Slow Idle Switch from the connector.

Adjust the multimeter to measure resistance.

Touch the multimeter probes to the Slow Idle signal switch prong (3) and the battery ground prong switch prong (2).

Turn 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. Replace the switch.

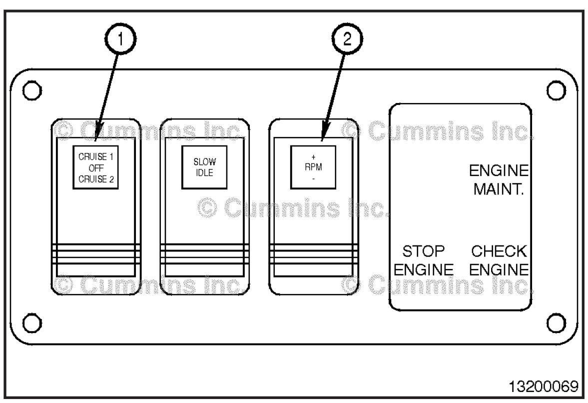


Check for Short Circuit to Ground

Marine Applications

Touch the mulitmeter probes to the Slow Idle Switch signal prong (3) and the battery ground prong (2).

Turn the switch to the ON position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less). Replace the switch.



Slow Idle Switch Circuit (019-436)

General Information

Marine Applications

The slow idle switch is located on the control panel and has two settings. ON and OFF. The rocker switch is used to activate or disable the slow idle operation. The slow idle circuit consists of the Slow Idle signal, switch common ground and the rocker switch.

Resistance Check

Marine Applications

If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

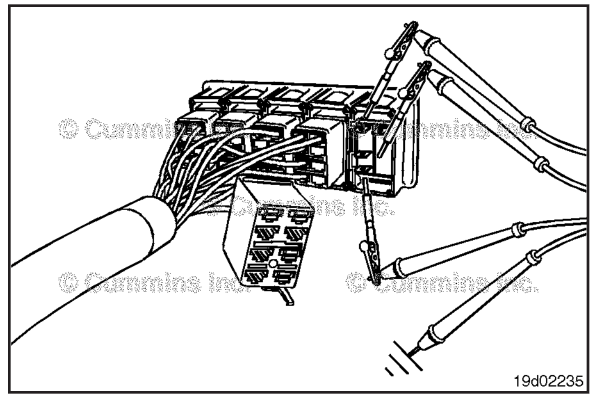
Locate and remove the slow idle switch from the connector.

Adjust the multimeter to measure resistance.

Touch the multimeter probes to the slow idle signal switch prong (3) and the batter ground prong switch prong (2).

Turn 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. Replace the switch.



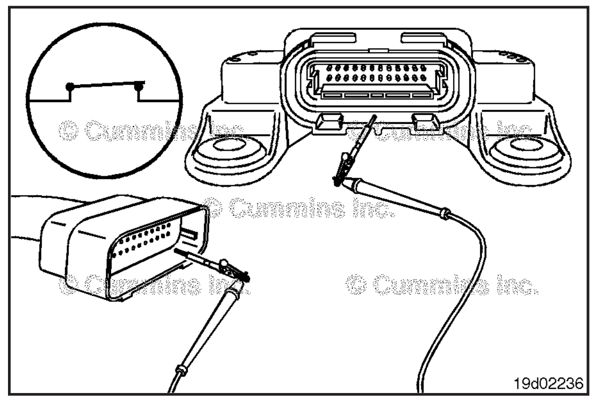
Check for Short Circuit to Ground

Marine Applications

Touch the multimeter probes to the slow idle switch signal prong (3) and the battery ground prong (2).

Turn the switch to the ON position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

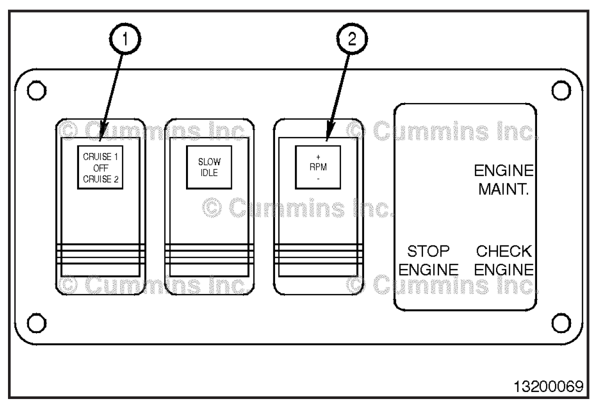


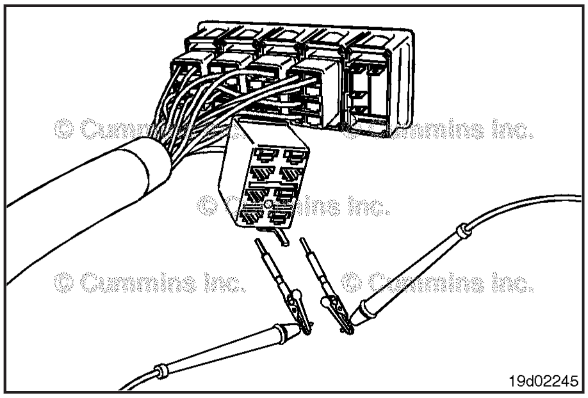
Station Select Switch (019-437)

General Information

Marine Applications

The Station Select Switch is a monetary switch located on the control panel. The rocker switch is used to change the station selected. The station select circuit consists of the station select signal line, the keyswitch line, and the rocker switch.





Resistance Check

Marine Applications

If INSITE™ electronic service tool is available, monitor the switch for proper operation. If **not**, follow the troubleshooting procedures in this section.

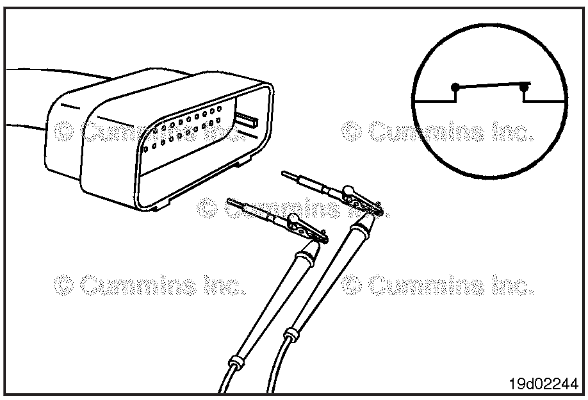
Locate and remove the station select switch from the connector.

Adjust the multimeter to measure resistance.

Touch the multimeter probes to the station select signal switch prong (3) and the keyswitch prong (2).

Turn 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. Replace the switch.



Check for Short Circuit to Ground

Marine Applications

Touch the multimeter probes to the Cruise 1 signal switch prong (3) and the battery ground prong switch prong (2).

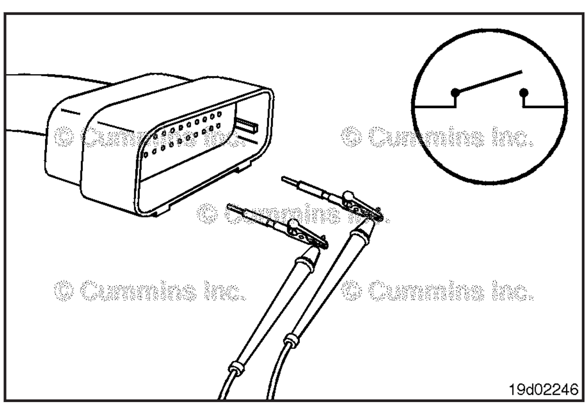
Turn the switch to the Cruise 1 position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.

Touch the multimeter probes to the Cruise 2 signal switch prong (1) and the battery ground prong switch prong (2).

Turn the switch to the Cruise 2 position and measure the resistance. The multimeter **must** show an closed circuit (10 ohms or less).

If the circuit is **not** closed, the switch has failed. Replace the switch.



Check for Short Circuit to Ground

Marine Applications

Check for a short circuit from pin to pin.

Touch the multimeter probe to the Cruise 1 switch signal prong (3). touch the other multimeter probe to the Cruise 2 switch signal prong(1).

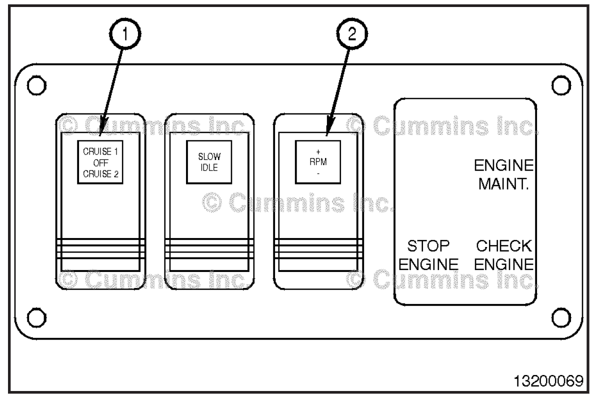
Turn the cruise control switch to the OFF position.

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 1 and 2 signal lines. Replace the switch.

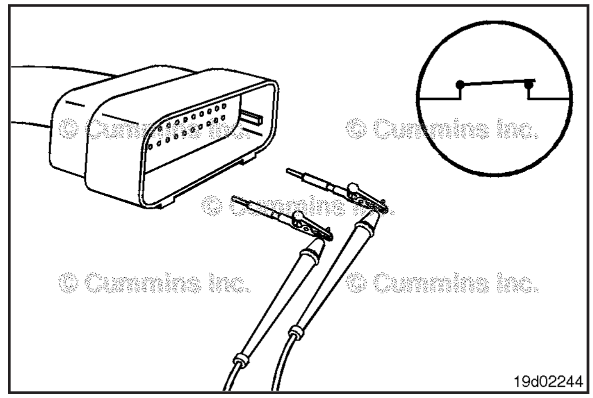
Station Select Switch Circuit (019-438)

General Information



The station select switch is a momentary switch located on the control panel and has two settings, ON and OFF (default position).

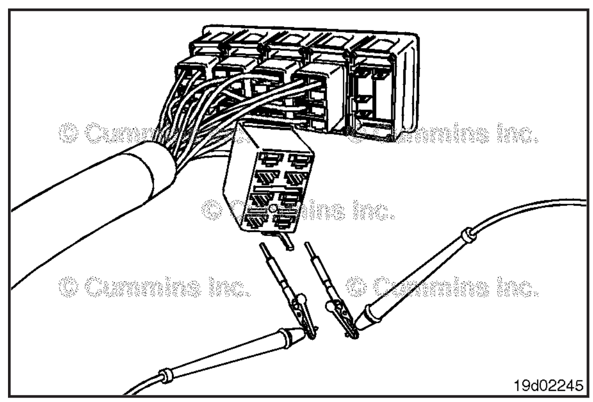
Resistance Check



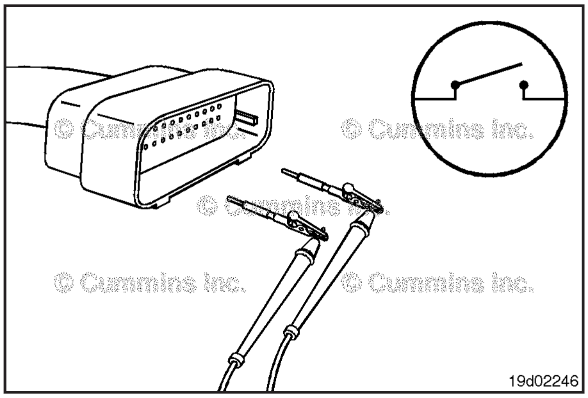
Disconnect the Smart Multiplex module connector from the Smart Multiplex module.

Touch the probe to the station select switch signal pin of the Smart Multiplex module connector. Touch the other probe to the keyswitch pin of the Smart Multiplex module connector.

Hold the switch depressed to the ON position. The multimeter **must** show a closed circuit (10 ohms or less). If the circuit is **not** closed, inspect the station select switch for an open circuit. Refer to Procedure 019-437.



If the resistance is within specification, the station select switch circuit **must** be checked for a short circuit to ground, and a short circuit from terminal to terminal.



Check for Short Circuit to Ground

Disconnect the Smart Multiplex module connector from the Smart Multiplex module.

Adjust the multimeter to measure resistance.

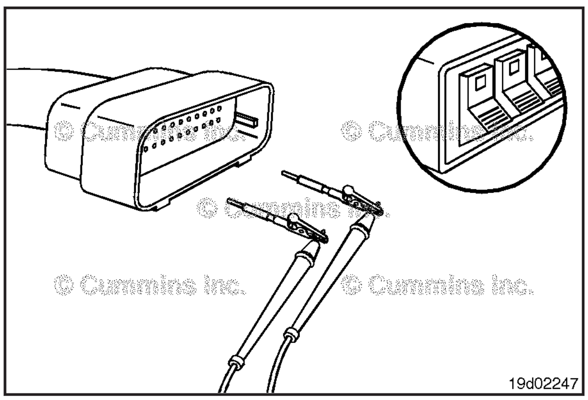
Touch the multimeter probe to the station select switch signal pin of the Smart Multiplex module connector. Touch the other probe to the unswitched battery (-) pin of the Smart Multiplex module connector.

Leave the slow idle switch in the OFF position.

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 station select circuit, checked.

Repair or replace the signal wire connected to the station select switch and/or the signal wire connected to the Smart Multiplex module.



Check for Short Circuit from Pin to Pin

Check for a short circuit from pin to pin. Set all switches of the C-Cruise Switch control module to the OFF position. Touch the multimeter probe to the station select switch signal pin on the Smart Multiplex module connector. Touch the other probe to all of the other signal pins of the Smart Multiplex module connector in succession.

The multimeter **must** show and open circuit (100k ohms of more) for each pin check.

If the circuit is **not** open, there is a short circuit between the station select circuit and any pin that shows a closed circuit, provided the switch has previously checked.

Repair or replace the appropriate wire in the Smart Multiplex module harness or C-Cruise switch panel harness.

Aftertreatment Diesel Exhaust Fluid Dosing Unit (019-440)

General Information

⚠WARNING⚠

The diesel exhaust fluid (DEF) 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. Refer to the Material Safety Data Sheet (MSDS) for additional information.

⚠WARNING⚠

The air solenoid is hot to the touch after initial shutdown. Use eye protection, gloves, and appropriate personal protective equipment.

The DEF dosing unit is used to administer the correct amount of DEF for the aftertreatment system.

The DEF dosing unit receives commands from the engine ECM via the Cummins® data link. Based on various operating conditions, the engine ECM will command the DEF dosing unit to administer the DEF.

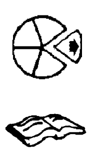
NOTE: The DEF dosing unit is **not** serviceable. Do **not** open the case.

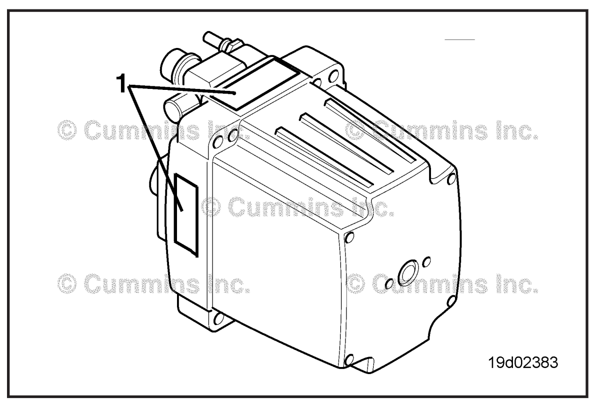
NOTE: The nozzle supply hose **must** be made from PTFE (Polytetraflouroethylene).

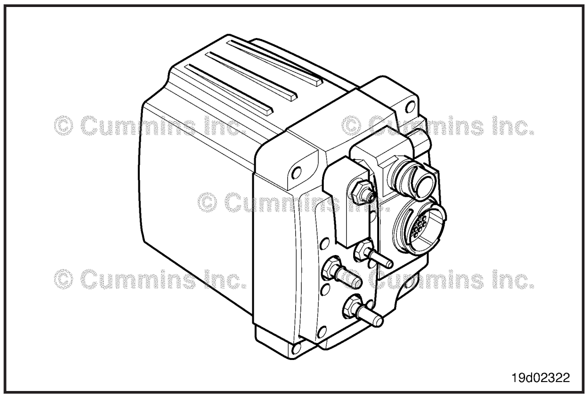
Initial Check

Locate the DEF dosing unit on the vehicle.

The DEF dosing unit dataplate is located either on the top, or on the side of the unit, as illustrated (1).

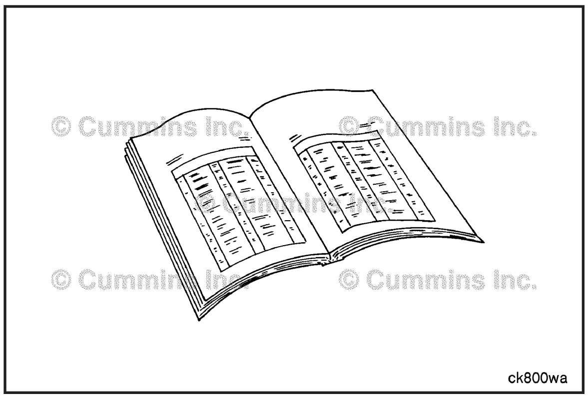






Check the pipework going to and returning from the DEF dosing unit for any signs of a leak.

DEF leaks will leave a white deposit around the fittings.



Preparatory Steps

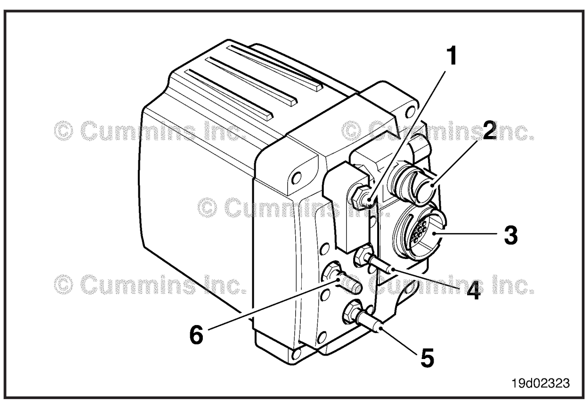
WARNING

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.

- Disconnect the batteries. Refer to the OEM service manual.
- Release the pressure in all vehicle air tanks. Refer to the OEM service manual.



Remove

The DEF dosing unit is secured to the chassis by four mounting bolts. Depending on the installation, it can be easier to remove the pipework and connectors either before or after the DEF dosing unit is removed from its mounting bracket.

The DEF dosing unit must be wiped with a clean damp cloth and/or a spray bottle with mild detergent. This will remove any contamination and reduce the risk of debris entering the DEF dosing unit.

NOTE: Do **not** jet wash or steam clean this unit.

Disconnect the electrical connections and pipework that is attached to the DEF dosing unit.

1 Compressed air supply

2 Air solenoid connector (2 pin)

3 37-pin ITT Cannon™ connector

4 DEF supply to aftertreatment nozzle (PTFE line)

5 DEF supply to pump

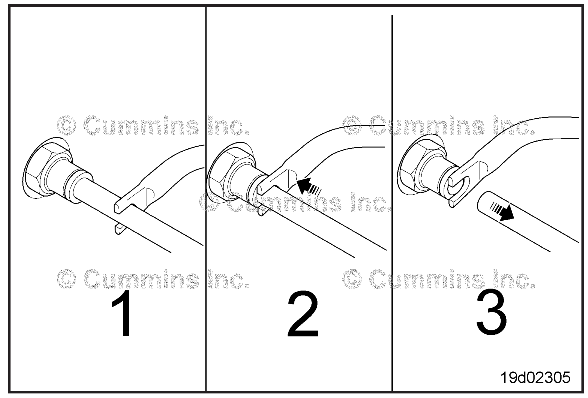
6 DEF return

Lines 4, 5 and 6 have quick-fit connections.

⚠CAUTION⚠
Be sure the vehicle air supply to the dosing unit is either drained down or isolated before removing the air supply line.

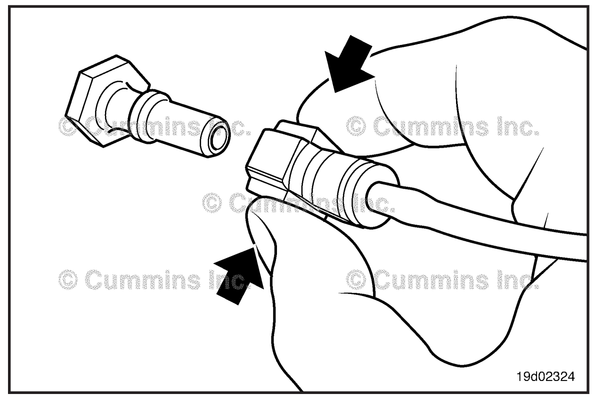
Air Connector

- A quick release fitting is also used for the air connection at the top of the DEF dosing unit. To release this fitting, apply equal pressure to both sides of the release collar and pull the pipe from the fitting.



DEF Dosing Unit Pipe Fittings

- The pipework is connected to the front of the DEF dosing unit by quick release fittings. To remove the fittings, press either side of the fitting, as shown in the illustration.



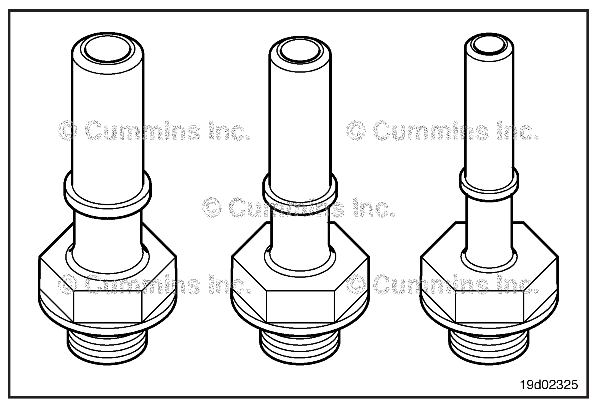
⚠CAUTION⚠
Some OEMs use fittings of different sizes to avoid confusion. However, some OEMs use the same connections on the DEF supply and DEF return. Be sure the lines are connected to the correct location on the DEF dosing unit.

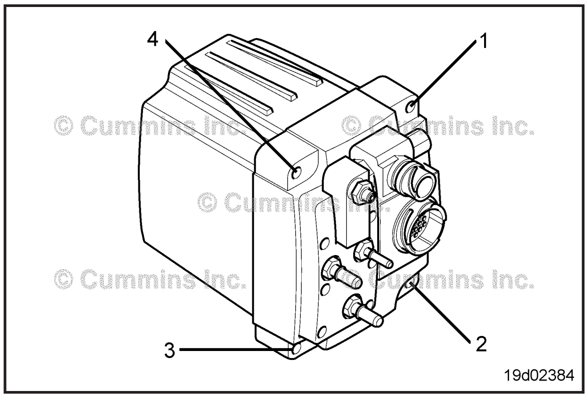
⚠CAUTION⚠
If these fittings need to be replaced, and they are of different sizes, be sure they are fitted to the correct location on the front of the DEF dosing unit.

The fittings are three different sizes.

There is an o-ring on the rear of each of these fittings.

Torque Value: 15 N•m [133 in-lb]



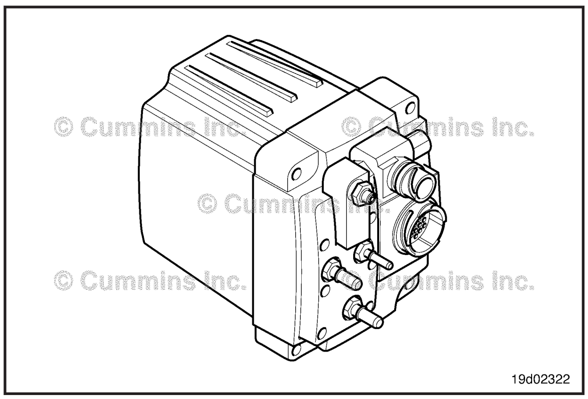


WARNING

The DEF 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 DEF is ingested, contact a physician immediately. Refer to the Material Safety Data Sheet (MSDS) for more information.

Remove the four mounting bolts (1-4) from each corner of the DEF dosing unit.

The DEF dosing unit **must** be wiped with a clean damp cloth and/or a spraybottle with mild detergent. This will remove any contamination and reduce the risk of debris entering the DEF dosing unit.



Clean and Inspect for Reuse

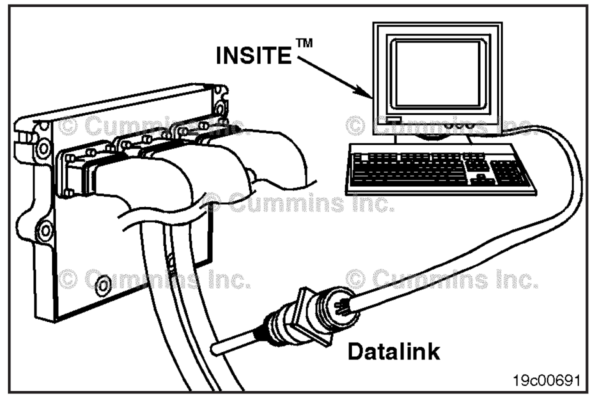
NOTE: This unit is **not** serviceable. Do **not** open the case. Return the unit to a Cummins® Authorized Repair Location.

Inspect the outside of the unit. If there are any cracks or damage to the mounting flanges, the exterior case or the electrical connectors, replace the DEF dosing unit.

Check all connections, lines, and fittings for any signs of leaks or damage.

Repair or replace the connections as necessary.

Test



WARNING

The DEF 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 DEF is ingested, contact a physician immediately. Refer to the Material Safety Data Sheet (MSDS) for more information.

WARNING

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

DEF Dosing Unit Override Test

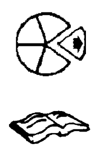
The purpose of this test is to run the DEF dosing pump through a dosing cycle and check for a specific amount of DEF to be delivered in a specified time.

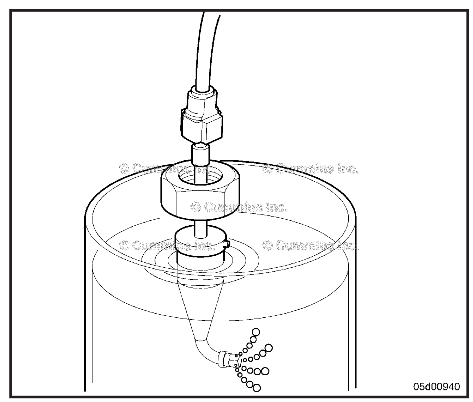
The DEF Dosing Unit Override Test is a fully automated test. There are three main parts to the SCR aftertreatment cycle.

1 Priming

2 Dosing

3 Purging.





CAUTION

The DEF injection nozzle must be removed from the exhaust system before starting the test. Failure to do so can result in excessive ammonia emissions on subsequent startup or damage to the catalyst.

Remove the aftertreatment nozzle from the exhaust system.

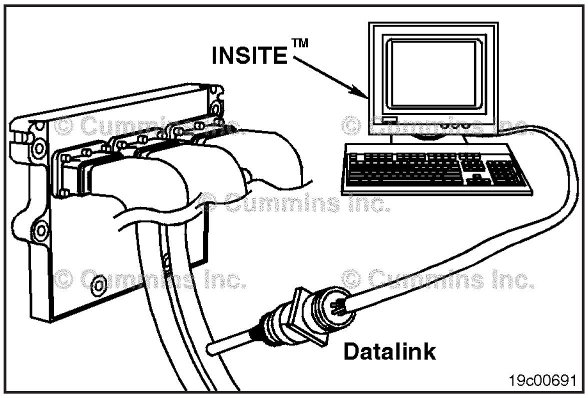
- For ISC and ISL engines, use the following procedure in the Troubleshooting and Repair Manual, ISC, ISCe, QSC8.3, ISL, ISLe3, ISLe4, and QSL9, Bulletin 4021418. Refer to Procedure 011-040 in Section 11.
- For ISB engines, use the following procedure in the Service Manual, ISBe, ISB, and QSB (Common Rail Fuel Systems), Bulletin 4021271. Refer to Procedure 011-040 in Section 11.

The aftertreatment nozzle mounting hole in the exhaust system **must** be capped to eliminate exhaust leaks.

Place the nozzle in a measured container with a capacity of at least 200 militer [6.8 fl oz].

Make sure the top of the container is covered to keep any DEF from spraying out of the container and affecting the test result.

NOTE: A properly sized cup plug can be inserted under the aftertreatment nozzle retaining nut and hand-tightened to block exhaust leaks during the test.



This test **must only** be run with the vehicle stationary, in neutral, and the engine at idle.

Use INSITE™ electronic service tool to perform the DEF Dosing Unit Override Test.

Measure the amount of DEF injected into the container.

Override Test DEF Injection Volume (Old 10 Minute Test)

ml		fl-oz
900	MIN	30
1100	MAX	37

Override Test DEF Injection Volume (New 6 Minute Test)

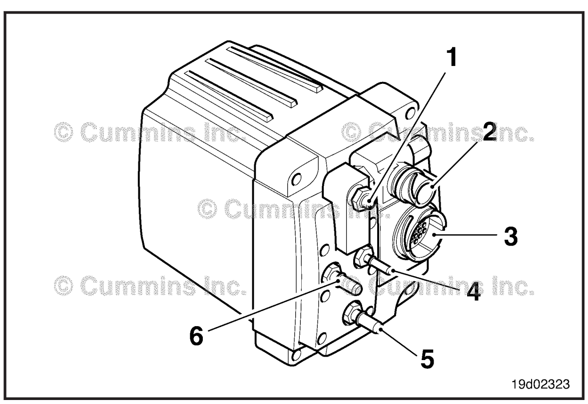
ml		fl-oz
90	MIN	3.04
110	MAX	3.72

NOTE: If the test lasts for 6 minutes, use the "New 6 Minute Test" specification. If the test lasts for 10 minutes, use the "Old 10 Minute Test" specification.

NOTE: If the New 6 Minute Test is used, check the INCAL™ DVD History Sheet to see if an update is available for your ECM code. The update will be labeled as "New DOT Test Specification to 100 ml in 6 Minutes".

The expected amount is 100 ml [3.38 fl oz] in 6 minutes, within the above tolerance. If the amount of DEF is **not** within specification:

- Check the air supply to the DEF dosing unit for blockages or restrictions.
- Check to be sure the DEF dosing unit is priming properly. Remove the DEF lines from the DEF dosing unit to check for blockages or restrictions.
- Check the inlet connector with integral strainer for blockage, if applicable.
- Perform the test again. If the amount of DEF is **not** within specification, replace the DEF dosing pump.



Install

NOTE: Make sure the new unit is kept free from any contamination during installation to the vehicle.

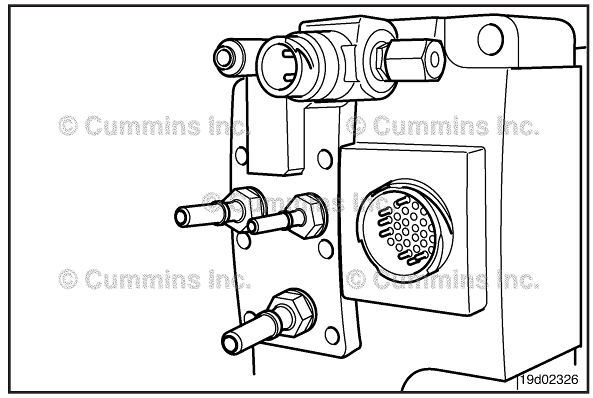
Install the electrical connections and pipework that is attached to the DEF dosing unit.

1 Compressed air supply
2 Air solenoid connector (2 pin)
3 37-pin ITT Cannon™ connector
4 DEF supply to aftertreatment nozzle
5 DEF supply to pump
6 DEF return

Remove the push fit fittings from the damaged DEF dosing unit and install the fittings to the replacement DEF dosing unit, if required.

Torque Value: 15 N•m [133 in-lb]

The three hoses, DEF supply to nozzle, DEF supply to pump, and DEF return, are all quick connections.



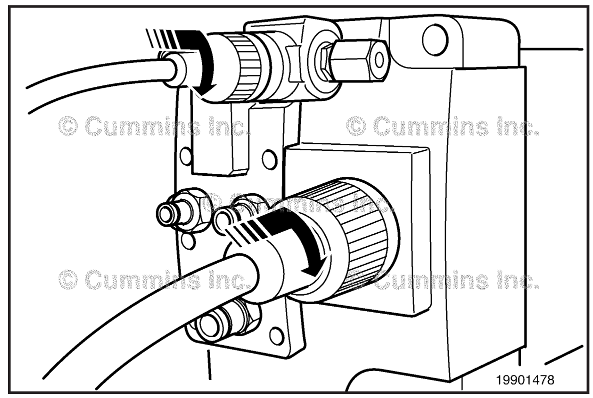
WARNING

The air solenoid is hot to the touch. Use eye protection, gloves and appropriate personal protective equipment.

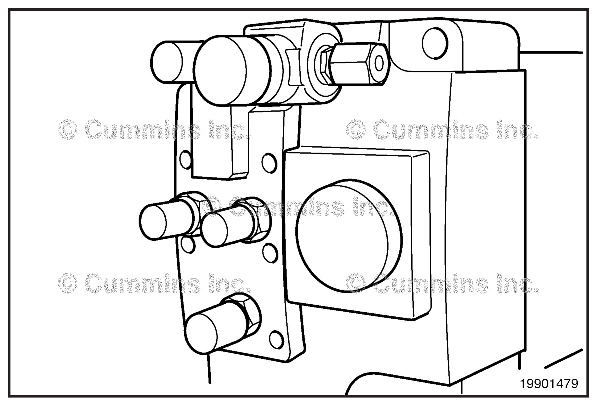
Connect the two electrical connections, the air solenoid and the 37-pin connector. These are push-and-twist type fit connectors.

Twist these connectors until a click is felt.

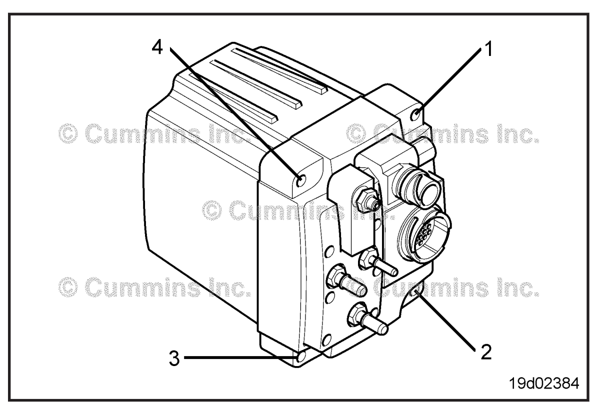
Connect the air supply line to the DEF dosing unit.

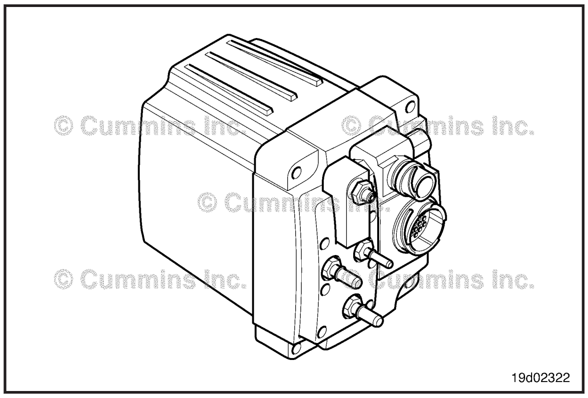


Insert the blanks from the replacement DEF dosing unit or blank the fittings if possible. Install them on the damaged DEF dosing unit.



The DEF dosing unit is bolted to the chassis by four bolts (1-4), one in each corner of the DEF dosing unit. Attach the DEF dosing unit to the OEM mounting bracket. Refer to the OEM service manual.



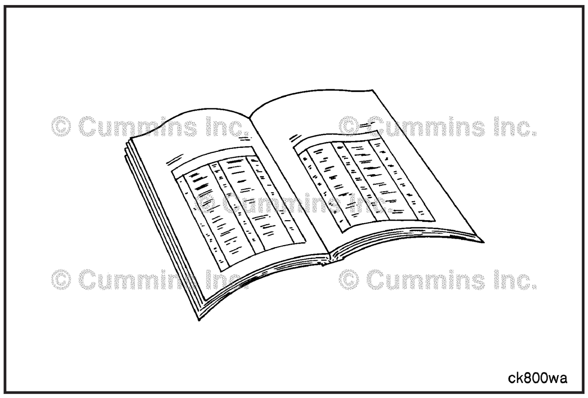


Finishing Steps

WARNING

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

- Connect the batteries. Refer to the OEM service manual.
- Start and operate the engine to build up air pressure.
- Check for air or DEF leaks.
- Check for active fault codes.



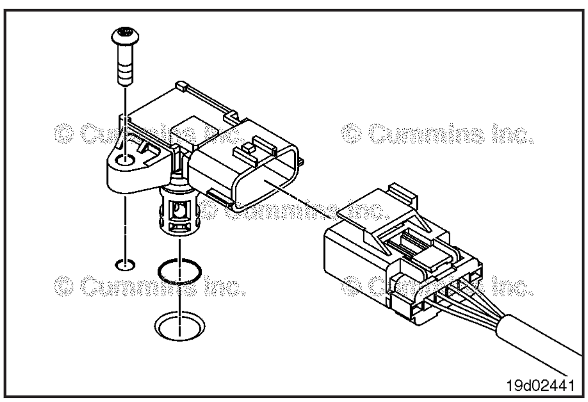
Crankcase Pressure Sensor (019-445)

General Information

NOTE: This procedure applies to the ISL engine in Recreational Vehicle applications **only**.

The crankcase pressure sensor is used to monitor the pressure in the crankcase.

The crankcase pressure sensor is located on top of the rocker lever cover.



Remove

Clean the area around the crankcase pressure sensor.

Disconnect the pressure sensor connector from the engine harness.

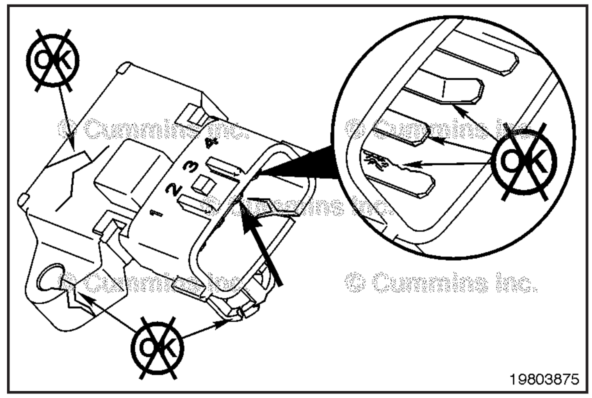
Remove the mounting capscrew.

Remove the sensor from the engine by pulling straight up on the sensor. Be careful **not** to damage the o-ring seal when removing the sensor.

Inspect for Reuse

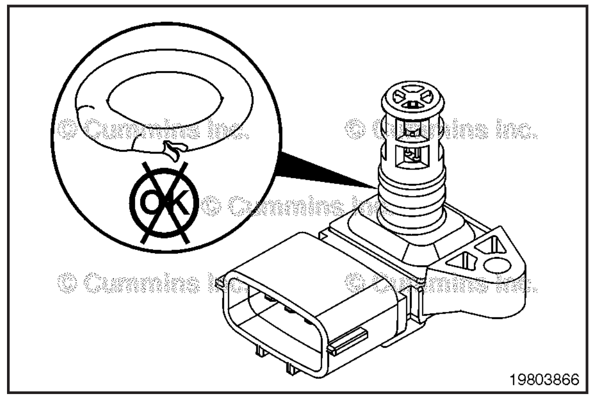
Inspect the engine harness connector and the crankcase pressure sensor for the following:

- 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.



Inspect the crankcase pressure sensor for the following:

- swollen o-ring
- nicks or cuts in or on the o-ring.



Install

Lubricate the o-ring with clean engine oil before installation.

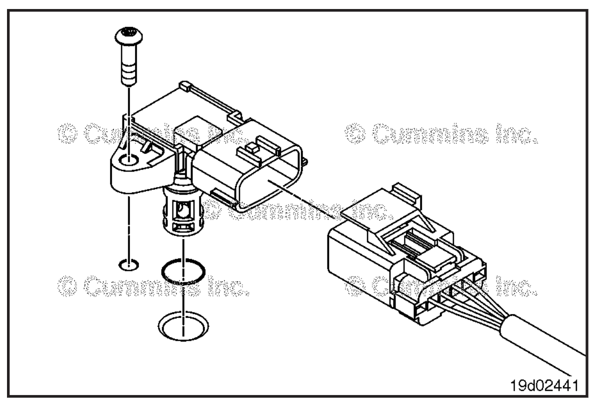
Install the crankcase pressure sensor by pressing firmly on the top of the sensor until the o-ring is fully seated.

Install and tighten the mounting capscrew.

Torque Value: 2.3 N•m [20 in-lb]

Connect the engine harness to the crankcase pressure sensor.

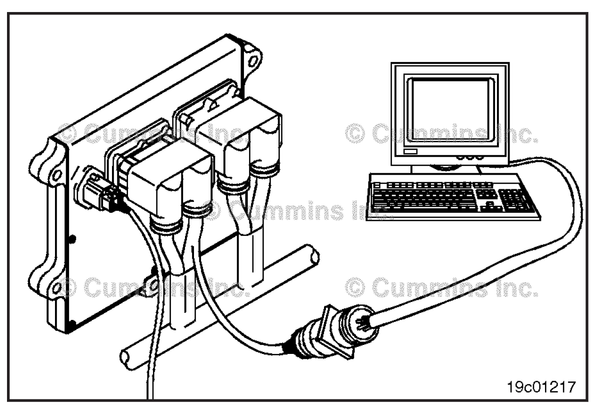
Start the engine and check for leaks.

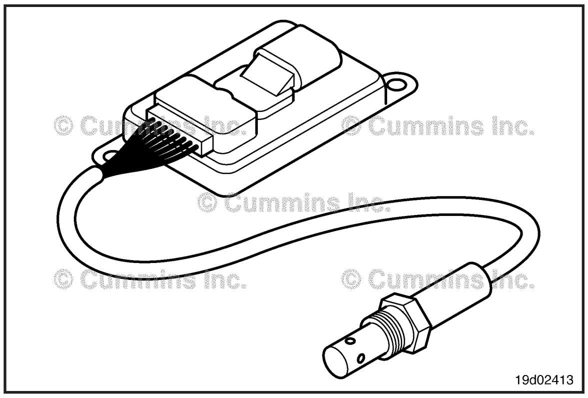


Shut off the engine.

Connect INSITE™ electronic service tool.

Operate the engine and check for fault codes.





Aftertreatment Outlet NOx Sensor (019-451)

General Information

The NOx sensor is located either in the exhaust muffler or in the exhaust tailpipe.

The NOx sensor is a one-piece unit made up of two parts, a small module with a wire connection to the metal sensor body that sits in the exhaust system. The parts must **not** be separated.

The NOx sensor is **not** serviceable. If proved to be faulty, the part **must** be replaced.

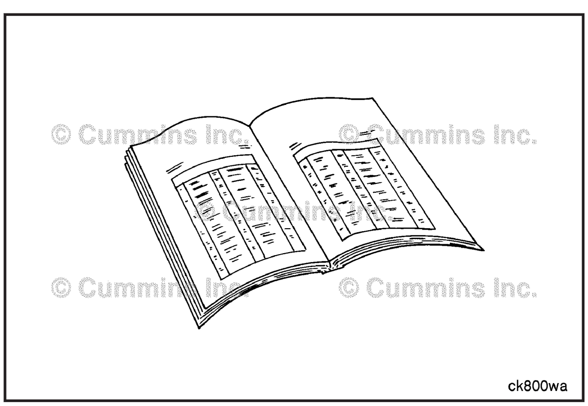
CAUTION
Exhaust catalyst will stay hot to touch for long periods of time after the engine has been switched off.

CAUTION
The NOx sensor will stay hot to touch for long periods of time after the engine has been switched off. The NOx sensor will also be hot if the engine keyswitch is on.

CAUTION
Do not underseal or coat/paint any part of the NOx sensor.

CAUTION
Wear goggles and protective clothing to reduce the possibility of personal injury.

WARNING
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.



Preparatory Steps

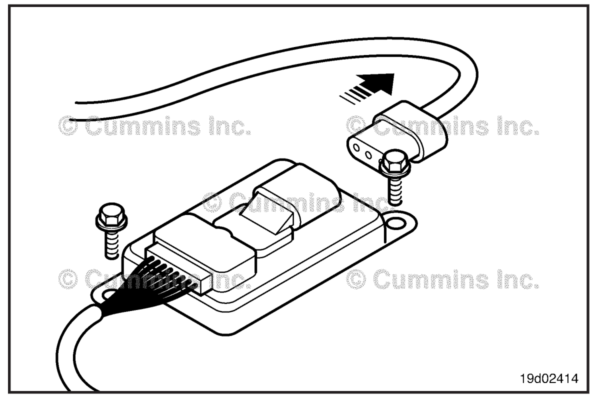
WARNING
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

- Check for active fault codes with INSITE™.
- Disconnect the batteries. Refer to the OEM instructions.

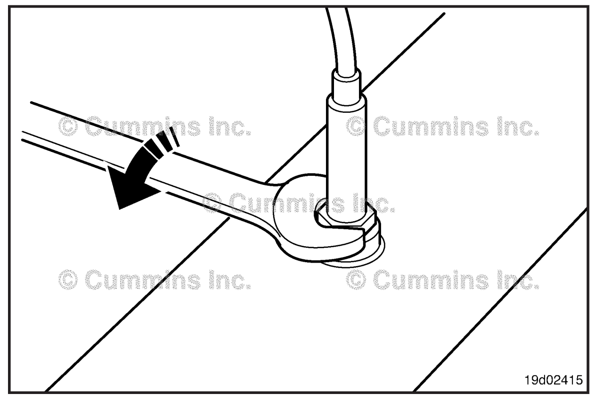
Remove

Disconnect the push-fit connector from the NOx sensor module.

Remove the two retaining bolts.

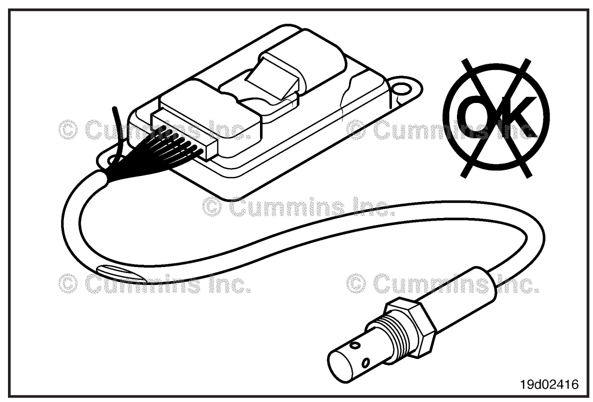


Remove the retaining nut and pull out the NOx sensor from the exhaust catalyst/exhaust pipework.



Clean and Inspect for Reuse

Visually inspect the NOx sensor for damage to wiring or the body of the sensor.

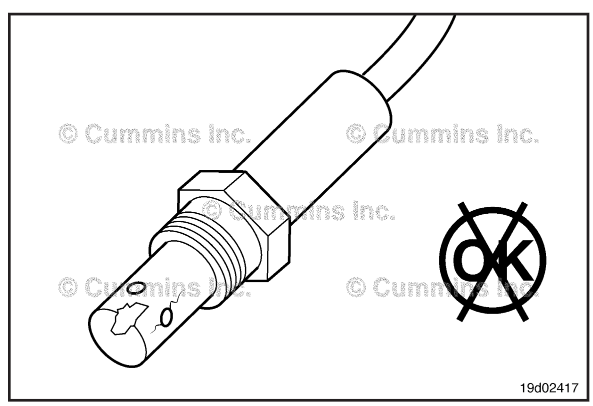


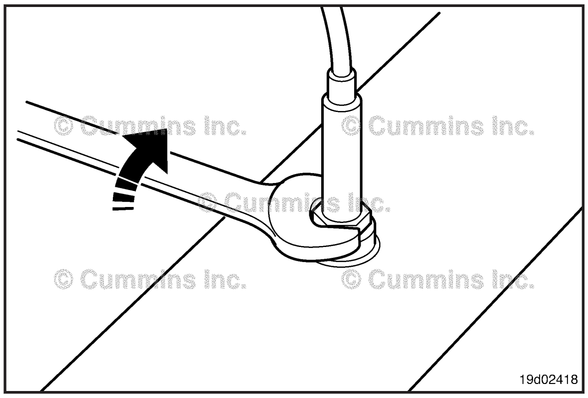
CAUTION
Do not clean the NOx sensor with any kind of fluid.

CAUTION
Do not immerse the NOx sensor in water or any kind of chemical wash.

CAUTION
Do not jet-wash or steam clean the NOx sensor.

Visually inspect the tip of the NOx sensor for damage.



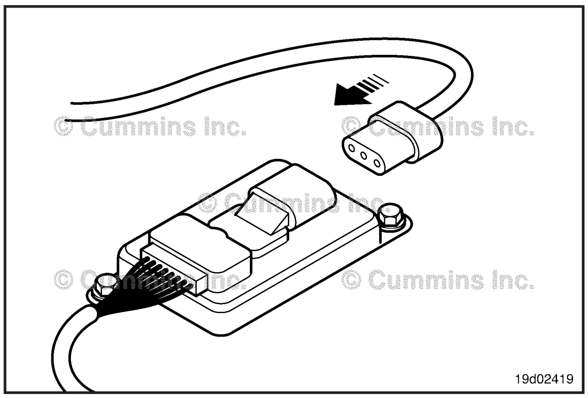


Install

Apply a light coating of anti-seize compound, Part Number 3824879, to the threads of the NOx sensor.

Install the NOx sensor to the exhaust system and tighten the retaining nut.

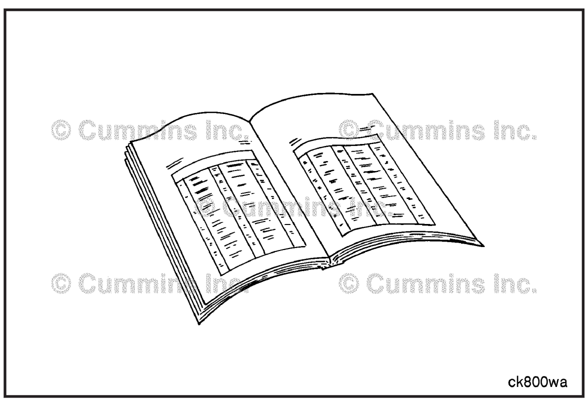
Torque Value: 50 N•m [37 ft-lb]



Ensure that the NOx sensor is connected to the OEM wiring harness.

Ensure that the small module is secured to the application by the two mounting bolts.

Refer to OEM service information for location and torque.

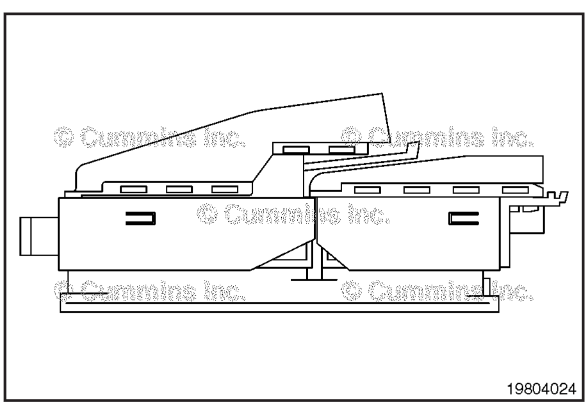


Finishing Steps

WARNING

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

- Connect the batteries. Refer to the OEM instructions.
- Run the engine.
- Check there are no active faults codes using INSITE™.



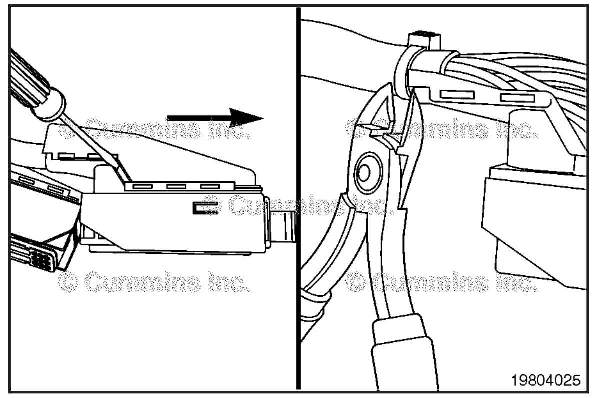
Bosch Aftertreatment DEF Controller Connector (019-474)

Pin Replacement

This connector is used to attach the appropriate harness to the DEF (Diesel Exhaust Fluid) Controller.

Remove the connector cover by inserting a small screwdriver into the angled slot on the side of the cover and twisting. Then slide the cover off of the connector.

Cut the wire tie holding the wire bundle to free the wires.

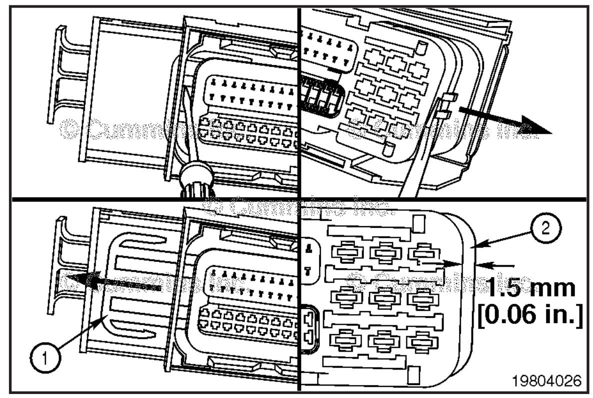


53 Pin Connector

Before the 1.2mm terminals can be removed it is necessary to remove the secondary lock #1 from the small terminal block using a small screwdriver to move from the closed detent and completely remove from connector body.

Before the 2.8mm terminals can be removed it is necessary to unlock the secondary lock #2 by using a small screwdriver to move secondary lock #2 from closed detent to the open detent position approximately 1.5mm travel.

DO NOT REMOVE COMPLETELY.

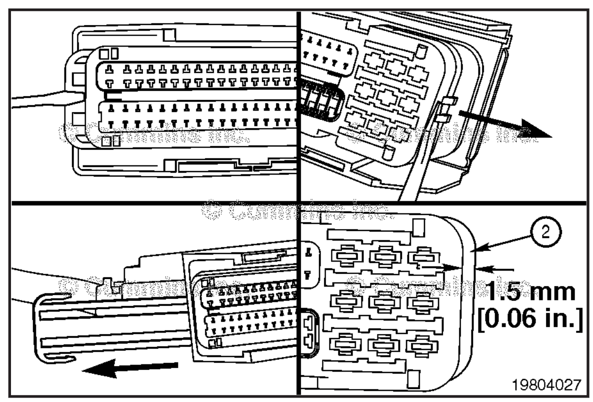


86 Pin Connector

Repeat steps from 53 way connector.

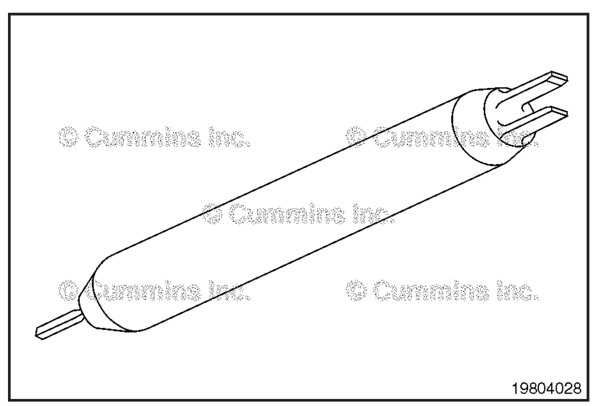
NOTE: The secondary locks are on opposite ends of the 86 way connector than the 53 way connector

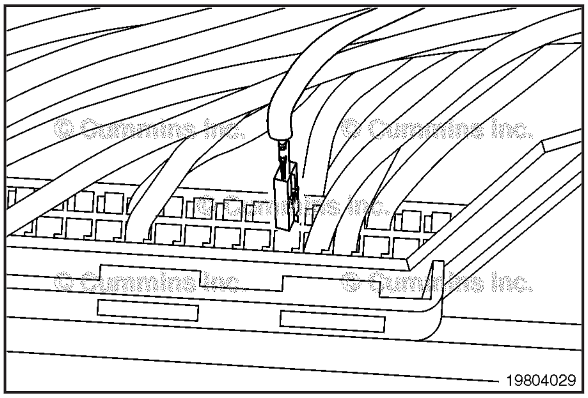
Notice that the secondary lock #2 should only move about 1.5mm and stop in an open detent position.



The same procedure is used to remove the wires from both connectors.

Use Cummins electrical terminal replacer part number 4919735 to remove the wire terminals from the connector.

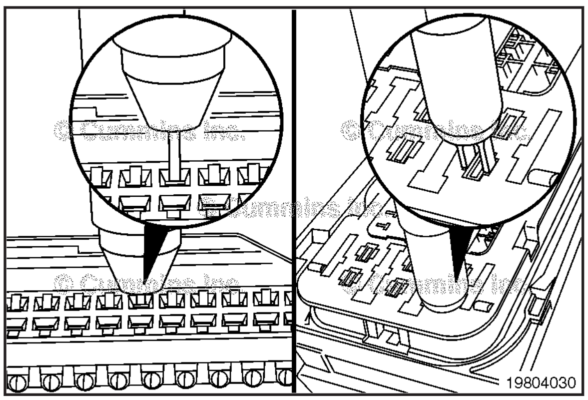




Replace one terminal wire at a time. If more than one terminal wire must be replaced, attach an identification tag to each wire removed.

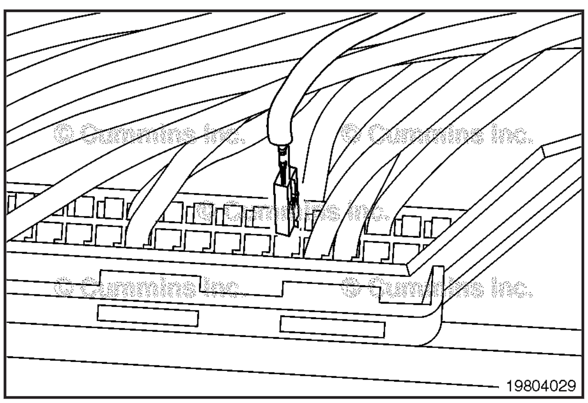
Refer to the wiring diagram in Section E for terminal locations.

Refer to the appropriate wiring harness repair kit in the service tools table in front of section 19 for the correct repair wire.



Removing Terminal

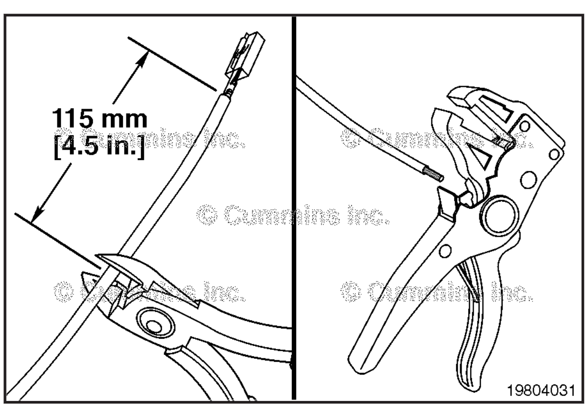
Insert the proper end of the replacer into the terminal unlocking holes in the face of the connector being careful to hold the replacer perpendicular to the face of the connector.



⚠CAUTION⚠

If the wire is difficult to remove, do not pull hard on the wire, otherwise, the locking tang of the terminal will stick or the terminal will pull off the wire and remain in the connector.

Carefully pull the wire from the connector. If it is difficult to remove, repeat the entire process.



NOTE: The repair wire is 115mm [4.5 in] long.

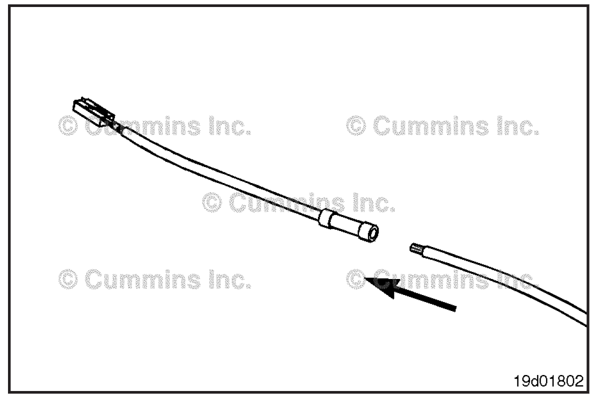
Use wire cutters to remove 115mm [4.5 in.] of the terminal and wire to be replaced.

Use wire stripping tool, Part Number 3400045, to remove 6mm [¼ in.] of insulation from the wire.

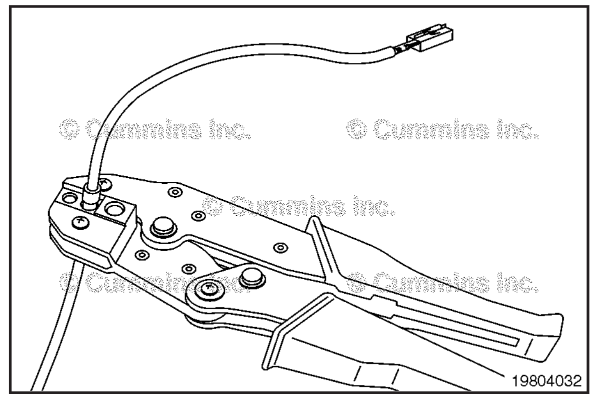
Before installing the new repair wire, perform a test fit to make sure the wire is the correct size.

Install the repair wire on the bare wire.

Make sure the bare wire extends into the splice connector properly.

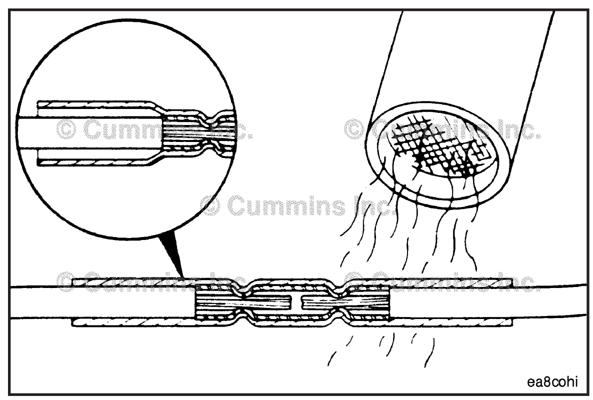


Use wire crimping tool, Part Number 3163109, to crimp the repair wire onto the bare wire.



Use Heat Gun, Part Number 3822860, to heat the shrink tubing around the wire.

The tubing will shrink and make the connection waterproof.



Inserting Terminal

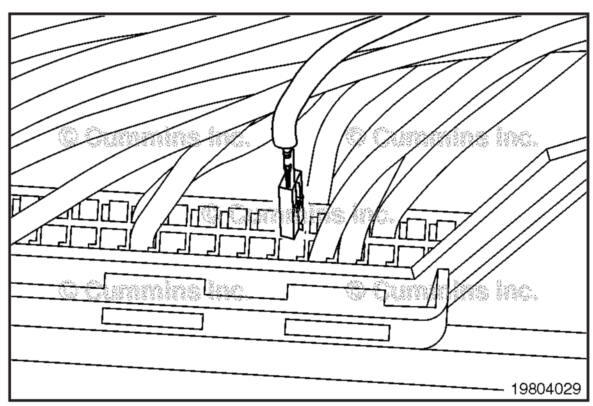
The wire terminals have locating features that only allow the terminal to be inserted in the proper orientation.

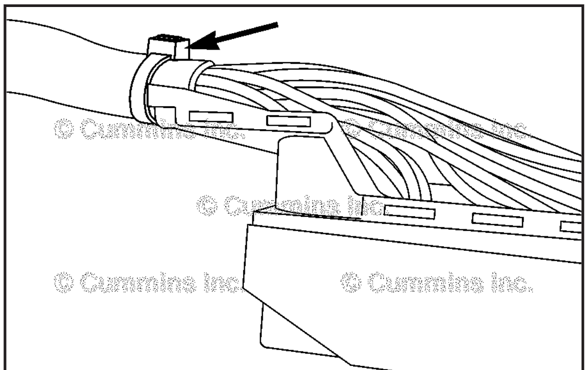
Insert the wire from the top of the connector.

Push the wire until the terminal locks into place.

Pull on the wire gently to make sure it is locked into the connector.

Reinstall secondary locks and snap into locked position.





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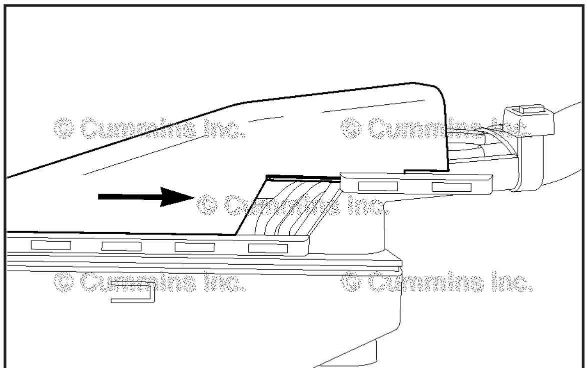
Position the wire bundle into place.

Install a wire tie to hold the wire bundle in place on the connector.

Remove the excess wire tie.



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Replace the connector shell by inserting the bottom sliding guides into the connector guide rails.

Slide toward the wire bundle and align the top slide guides into the upper connector guides.

Slide toward the wire bundle until the connector cover is snapped into place.

Aftertreatment Diesel Exhaust Fluid Dosing Unit Extended Priming (019-476)

General Information

WARNING

The diesel exhaust fluid 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 diesel exhaust fluid is ingested, contact a physician immediately. Refer to the Material Safety Data Sheet (MSDS) for additional information.

WARNING

The air solenoid is hot to the touch after initial shutdown. Use eye protection, gloves, and appropriate personal protective equipment.

This procedure is used to remove air from urea lines greater than 3 meters in length after any service intervention at the DEF tank, DEF lines, or dosing control unit. During normal priming, the dosing unit pumps DEF from the tank feed through the dosing unit and back to the return. Every 30 seconds the dosing control unit performs an ‘aeration check’ by closing the return line and increasing the pressure in the DEF gallery. If air is found to be present the dosing unit is commanded to re-prime for another 30 seconds.

Long lines can cause air to become trapped, because the full volume of the line is **not** able to pass through the dosing unit in a 30 second period.

NOTE: The diesel exhaust fluid dosing unit is **not** serviceable. Do **not** open the case.

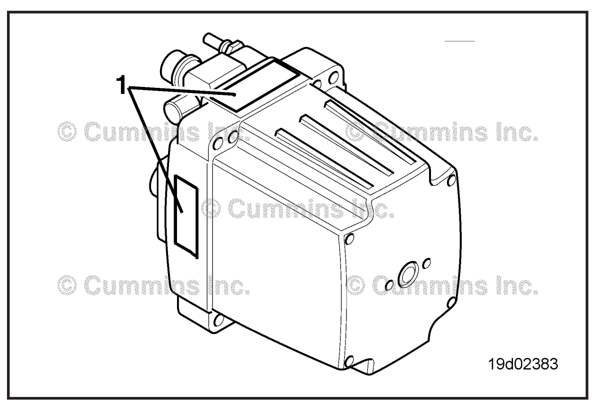
Initial Check

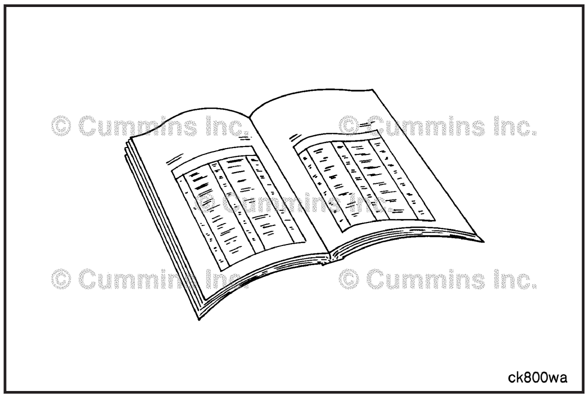
Locate the diesel exhaust fluid dosing unit on the vehicle.

The diesel exhaust fluid dosing unit dataplate is located either on the top, or on the side of the unit, as illustrated (1).

Check the pipework going to and returning from the diesel exhaust fluid dosing unit for any signs of a leak.

Diesel exhaust fluid leaks will leave a white deposit around the fittings.





Preparatory Steps

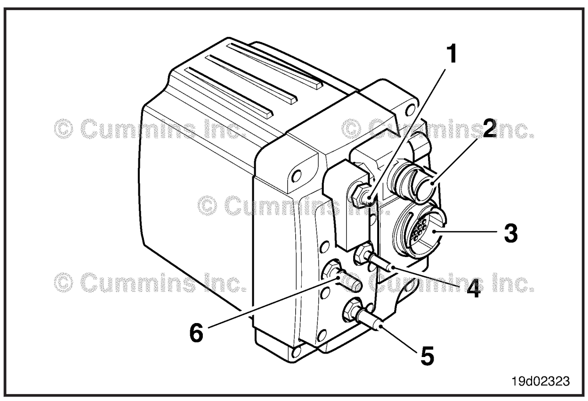
WARNING

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.

- Disconnect the batteries. Refer to the OEM service manual.
- Release the pressure in all vehicle air tanks. Refer to the OEM service manual.



Prime

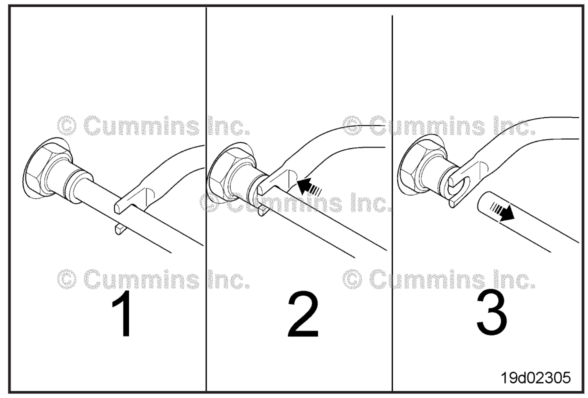
NOTE: Do **not** jet wash or steam clean this unit.

The diesel exhaust fluid dosing unit **must** be wiped with a clean damp cloth and/or a wash bottle with mild detergent. This will remove any contamination and reduce the risk of debris entering the diesel exhaust fluid dosing unit.

The dosing control unit connections are listed below:

1 Compressed air supply
2 Air solenoid connector (2-pin)
3 ITT Cannon™ on connector (37-pin)
4 Diesel exhaust fluid supply to aftertreatment nozzle (PTFE line)
5 Diesel exhaust fluid supply to pump
6 Diesel exhaust fluid return.

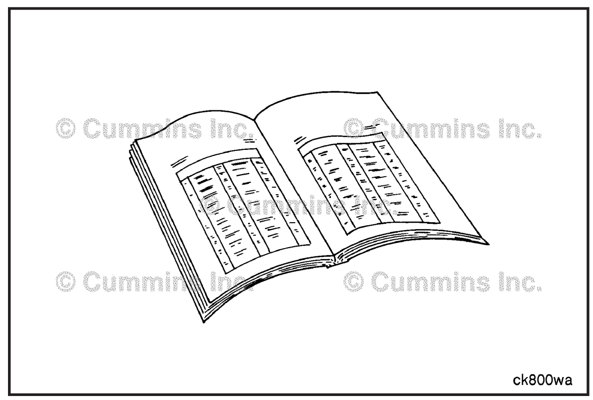
Lines 4, 5, and 6 have quick-fit connections. A quick release fitting is also used for the air connection at the top of the diesel exhaust fluid dosing unit. To release this fitting, apply equal pressure to both sides of the release collar and pull the pipe from the fitting.



NOTE: Make sure the vehicle air supply to the diesel exhaust fluid dosing unit is either drained down or isolated before removing air supply line.

- Disconnect the the air supply to the dosing unit.
- Secure and plug the removed air supply line.
- Connect the batteries. Refer to the OEM service manual.
- Start and operate the engine.
- The vehicle will attempt to prime for 10 to 13 minutes and then shut down. Fault Code 1682 or Fault Code 3548 will become active.
- Turn the keyswitch to the OFF position once the fault code becomes active.
- Connect the air supply to the dosing unit.
- Start the engine and allow the vehicle to prime. Fault Code 1682 or Fault Code 3548 will become inactive.
- The pump is now primed.

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.

- Start and operate the engine to build up air pressure.
- Check for air or diesel exhaust fluid leaks.
- Check for active fault codes.

Notes

Section L - Service Literature

Section Contents

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Additional Service Literature

General Information

The following publications can be purchased.

Bulletin Number	Title of Publication
4021271	Service Manual, ISB, ISBe, ISBe4, QSB4.5, QSB5.9 and QSB6.7 (Common Rail Fuel System) Series Engines
4021418	Troubleshooting and Repair Manual, ISC, ISCe, QSC8.3, ISL, ISLe3, and QSL9 Engines
4021355	Owner's ISB ^{e} and ISB (Common Rail Fuel System) Series Engines
4021427	Owner's Manual, ISC and ISL Engines
4021481	Owner's Manual, QSC8.3 and QSL9 Marine Engines
4021482	Owner's Manual, QSB5.9 Marine Engines
4915536	Owner's Manual, QSC8.3 and QSL9
4021347	Wiring Diagram, ISB CM850 Electronic Control Module
4021421	Wiring Diagram, ISC and ISL CM850 Electronic Control Module
4021524	Wiring Diagram, QSB4.5, QSB6.7, QSC8.3 and QSL9 CM850 Electronic Control Module
4021532	Wiring Diagram, ISBe4 CM850 Electronic Control Module
4021586	Wiring Diagram, QSB4.5, QSB6.7 and QSL9 CM850 Power Generation
4021598	Wiring Diagram, ISLe4 CM850
4021670	Wiring Diagram, ISBe2/ISBe3 CM850
4081885	Wiring Diagram, QSL9 and QSC8.3 Marine CM850 Electronic Control Module
4081886	Wiring Diagram, QSB5.9 Marine CM850 Electronic Control Module
3379000	Air for Your Engines
3379001	Fuel for Cummins Engines
3387622	Cold Weather Operation
3666132	Coolant Requirements and Maintenance
3810340	Cummins Engine Oil Recommendations

Service Literature Ordering Location
Contact Information

Region	Ordering Location
United States and Canada	Cummins Distributors or Credit Cards at https://store.cummins.com
All Other Countries	Cummins Distributors or Dealers

Cummins Customized Parts Catalog

General Information

Cummins is pleased to announce the availability of a parts catalog compiled specifically for you. Unlike the generic versions of parts catalogs that support general high volume parts content; Cummins Customized catalogs contain only the new factory parts that were used to build your engine.

The catalog cover, as well as the content, is customized with you in mind. You can use it in your shop, at your worksite, or as a coffee table book in your RV or boat. The cover contains your name, company name, address, and telephone number.

This new catalog was designed to provide you with the exact information you need to order parts for your engine. This will be valuable for customers that do not have easy access to Cummins QuickServe Online.

Additional Features of the Customized Catalog include:

- Engine Configuration Data
- Table of Contents
- Separate Option and Parts Indexes
- Service Kits (when applicable)
- ReCon Part Numbers (when applicable)

Ordering the Customized Parts Catalog

Ordering by Telephone

- 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.

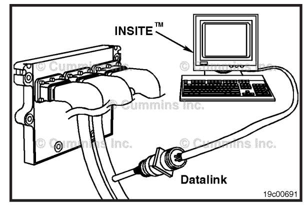
Notes

Section V - Specifications

Section Contents

Component or Assembly (Procedure)	Ref.No./ Steps	Metric		U.S.

Electronic Controls - Group 19 - Specifications



Aftertreatment Diesel Exhaust Fluid Dosing Unit (019-440)

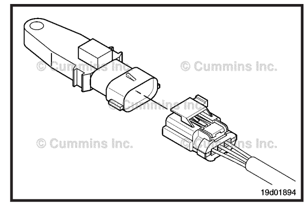
Override Test DEF Injection Volume (Old 10 Minute Test)		900 ml	MIN	30 fl-oz
		1100 ml	MAX	37 fl-oz
Override Test DEF Injection Volume (New 6 Minute Test)		90 ml	MIN	3.04 fl-oz
		110 ml	MAX	3.72 fl-oz

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.

Electronic Controls - Group 19 - Torque Values

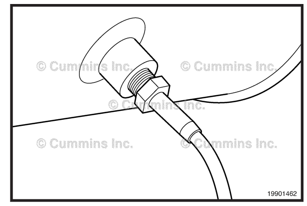
Barometric Air Pressure Sensor (019-004)

		9 N•m	[80 in-lb]



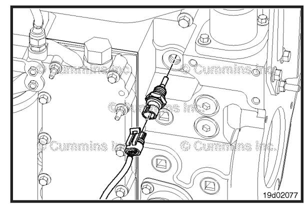
Exhaust Gas Temperature Sensor (019-013)

		30 N•m	[22 ft-lb]



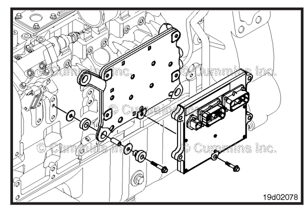
Engine Coolant Temperature Sensor (019-019)

Engine Coolant Temperature Sensor		23 N•m	[17 ft-lb]

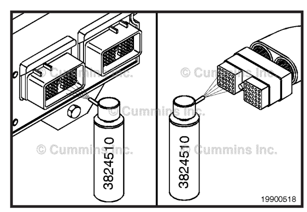


Engine Control Module (019-031)

Electronic Control Module (ECM) Mounting Capscrews		18 N•m	[159 in-lb]

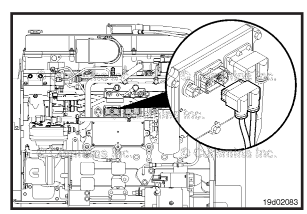


Electronic Control Module (ECM) Mounting Capscrews		3 N•m	[27 in-lb]



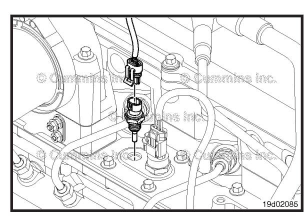
Engine Wiring Harness (019-043)

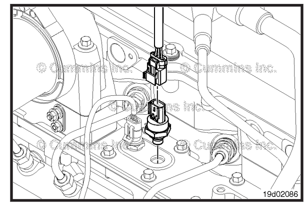
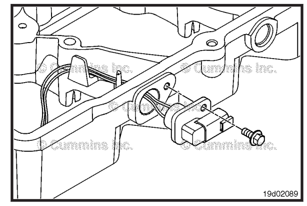
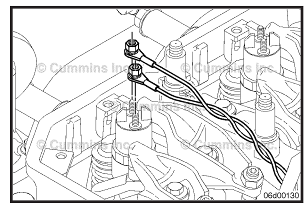
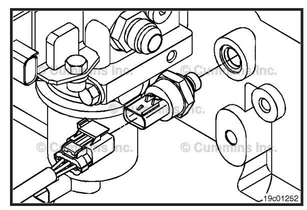
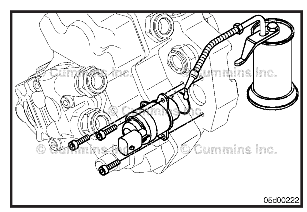
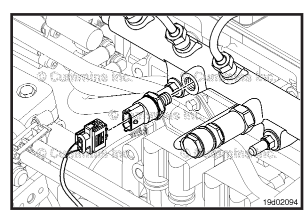
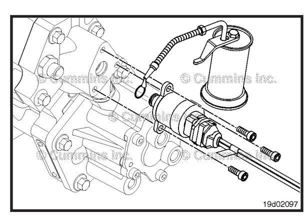
Ecm 60-Pin Connector		3 N•m	[27 in-lb]

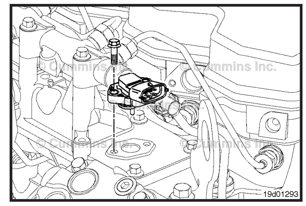
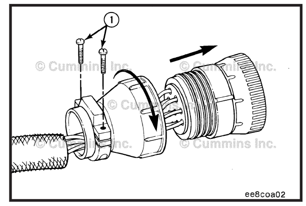
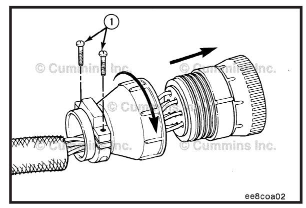
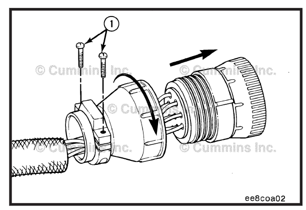
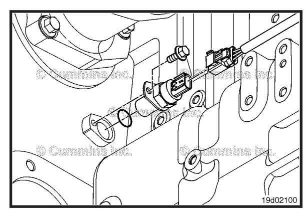
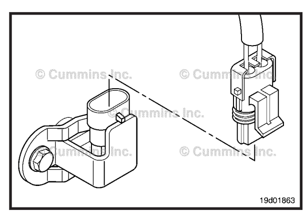
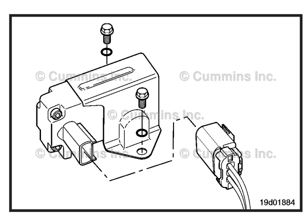


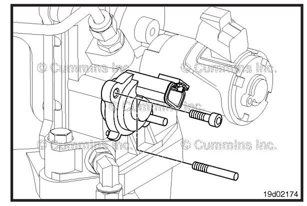
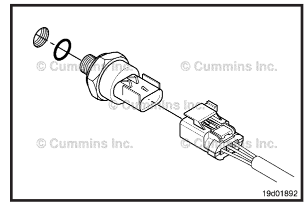
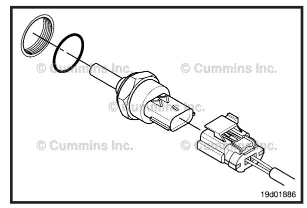
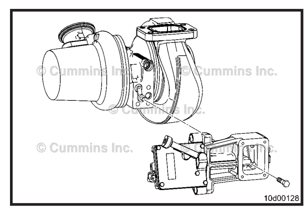
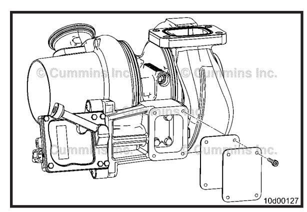
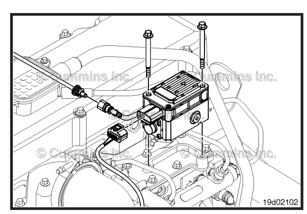
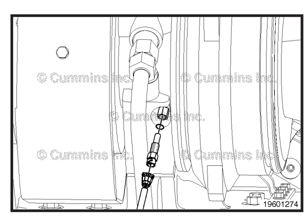
Intake Manifold Air Temperature Sensor (019-059)

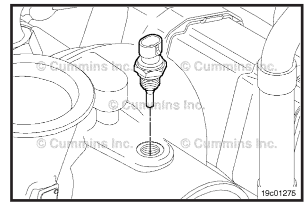
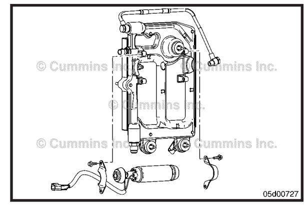
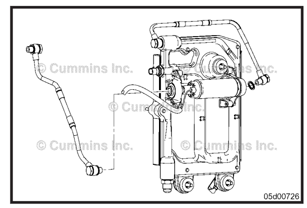
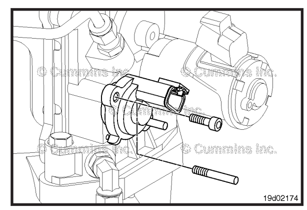
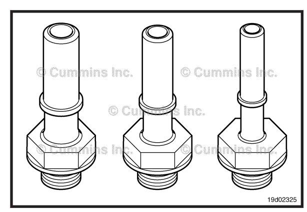
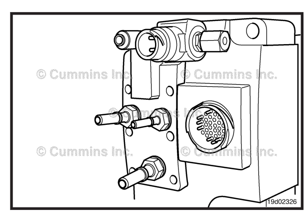
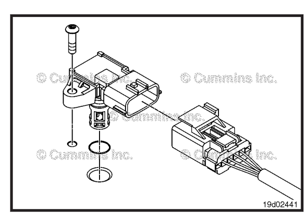
Intake Manifold Air Temperature Sensor		23 N•m	[17 ft-lb]

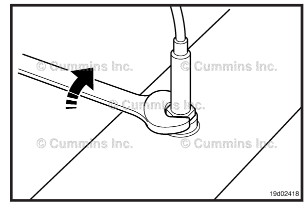


Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
Intake Manifold Pressure Sensor (019-061)				
Intake Manifold Pressure Sensor		23 N•m	[17 ft-lb]	
Internal Actuator Wiring Harness (019-063)				
Internal Wiring Harness Pass-Through Connector		10 N•m	[89 in-lb]	
Injector Pigtail Nuts		1.25 N•m	[11 in-lb]	
Engine Oil Pressure Sensor/Switch (019-066)				
Engine Oil Pressure Sensor		23 N•m	[17 ft-lb]	
Fuel Control Valve (019-102)				
Efc Actuator Capscrews	1	3 N•m	[27 in-lb]	
	2	7 N•m	[62 in-lb]	
Rail Fuel Pressure Sensor (019-115)				
Rail Fuel Pressure Sensor		70 N•m	[52 ft-lb]	
Fuel Pump Actuator (019-117)				
Fuel Pump Actuator Capscrews	1	3 N•m	[27 in-lb]	
	2	6 N•m	[50 in-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
Intake Manifold Pressure/Temperature Sensor (019-159)				
Intake Manifold Pressure/Temperature Sensor		6 N•m	[53 in-lb]	
Deutsch HD10 Connector Series (019-207)				
		1 N•m	[9 in-lb]	
Deutsch HDP20 and HD30 Connector Series (019-208)				
Clamp Capscrews		1 N•m	[9 in-lb]	
Clamp Capscrews		1 N•m	[9 in-lb]	
Camshaft Position Sensor (019-363)				
Camshaft Position Sensor		10 N•m	[89 in-lb]	
Crankshaft Position Sensor (019-365)				
Crankshaft Position Sensor		25 N•m	[221 in-lb]	
EGR Differential Pressure Sensor (019-370)				
Egr Valve Differential Pressure Sensor		24 N•m	[212 in-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
EGR Valve Position Sensor (019-372) Turbocharger Position Sensor M4 Capscrews		3.1 N•m	[27 in-lb]	
Exhaust Gas Pressure Sensor (019-376) Exhaust Gas Pressure Sensor		18 N•m	[159 in-lb]	
EGR Temperature Sensor (019-378) Egr Cooler Outlet Temperature Sensor		15 N•m	[133 in-lb]	
Turbocharger Control Valve (019-388) Turbocharger Mounting Capscrews		17 N•m	[150 in-lb]	
Turbocharger Mounting Capscrews		6 N•m	[53 in-lb]	
		15 N•m	[133 in-lb]	
Turbocharger Speed Sensor (019-390) Turbocharger Speed Sensor Capscrew		15 N•m	[133 in-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
Turbocharger Compressor Inlet Air Temperature Sensor (019-395)				
Turbocharger Compressor Inlet Air Temperature Sensor		23 N•m	[17 ft-lb]	
Fuel Lift Pump (019-396)				
		7 N•m	[62 in-lb]	
		24 N•m	[212 in-lb]	
Turbocharger Position Sensor (019-405)				
Turbocharger Position Sensor M4 Capscrews		3.1 N•m	[27 in-lb]	
Aftertreatment Diesel Exhaust Fluid Dosing Unit (019-440)				
		15 N•m	[133 in-lb]	
		15 N•m	[133 in-lb]	
Crankcase Pressure Sensor (019-445)				
Crankcase Pressure Sensor Mounting Capscrew		2.3 N•m	[20 in-lb]	

Component or Assembly (Procedure)	Ref.No./ Steps	Metric	U.S.	
Aftertreatment Outlet NOx Sensor (019-451)				
Nox Sensor Installation Torque		50 N•m	[37 ft-lb]	

Specifications

General Information

WARNING

This diagram is provided as a diagnostic tool for trained, experienced technicians only. Improper troubleshooting or repair can result in severe personal injury or death or property damage. See important instructions in Service Manual.

Electrical Specifications

DATA LINK
- Positive wire to chassis ground (J1587 **only**)
  - 3.5 to 5.0 VDC
- Negative wire to chassis ground (J1587 **only**)
  - 0.0 to 2.5 VDC

J1939 BACKBONE RESISTANCE
- Positive wire to return wire
  - 50 to 70 Ohms
- J1939 Termination Resistance
  - 110 to 130 Ohms

ALL CONTINUITY CHECKS
- OK (no open circuit) if less than 10 Ohms

ALL SHORTS TO GROUND
- OK (no short circuit) if more than 100k Ohms

SHORT CIRCUIT TO EXTERNAL VOLTAGE
- OK if less than 1.5 VDC

SENSOR SUPPLY VOLTAGE
- @ ECM = 4.75 to 5.25 VDC

SOLENOIDS
- EFC Actuator = 2.0 to 4.5 Ohms

ECM CONNECTOR
- Retaining Cap Screw Torque = 2.8 N•m [25 in-lb]

Sensor Specifications

NOTE: To convert to gauge pressure on all psi pressure sensors subtract the barometric pressure from the absolute pressure.

BAROMETRIC (AMBIENT) AIR PRESSURE SENSOR

Altitude [m]	Altitude [ft]	Pressure [psi]	Pressure [in Hg]	Voltage (VDC)
0 (sea level)	0	14.7	29.9	3.65 to 4.28
915	3000	13.2	28.9	3.06 to 3.50
1830	6000	11.8	24.0	2.52 to 2.96
2744	9000	10.5	21.4	2.01 to 2.36
3659	12000	9.35	19.0	1.57 to 1.84

INTAKE MANIFOLD PRESSURE SENSOR

Torque = 23 N•m [204 in-lb]

Pressure (mm Hg)	Pressure [in Hg]	Pressure [psi]	Voltage (VDC)
0	0	0	0.90 to 1.06
381	15	22	1.30 to 1.53
635	25	27	1.57 to 1.84
1549	61	45	2.53 to 2.96
2057	81	55	3.07 to 3.60
2590	102	65	3.61 to 4.23

TURBOCHARGER COMPRESSOR INLET AIR TEMPERATURE AND INTAKE MANIFOLD TEMPERATURE SENSORS

Torque = 23 N•m [204 in-lb]

Temperature (C°)	Temperature [F°]	Resistance (Ohms)
-10	14	49k to 62k
0	32	29k to 36k
20	68	11k to 14k
40	104	4.9k to 5.8k
70	158	1.6k to 1.9k

EXHAUST GAS PRESSURE SENSOR

Torque = 23 N•m [204 in-lb]

Pressure (mmHg)	Pressure [inHg]	Pressure [psi]	Voltage (VDC)
0	0	0	0.5 to 0.54
381	15	7	0.57 to 0.68
635	25	12	0.7 to 0.98
1549	61	30	1.48 to 1.8
2057	81	40	1.85 to 2.42
3886	153	75	3.53 to 4.21

EGR TEMPERATURE SENSOR

Torque = 57 N•m [42 ft-lb]

Temperature (C°)	Temperature [F°]	Resistance (Ohms)
0	32	256k to 423k

EGR TEMPERATURE SENSOR

Torque = 57 N•m [42 ft-lb]

Temperature (C°)	Temperature [F°]	Resistance (Ohms)
20	68	99k to 154k
40	104	42k to 63k
100	212	5.5k to 7.1k
140	284	1.9k to 2.3k
200	392	520 to 580

FUEL RAIL PRESSURE SENSOR

Torque = 70 N•m [52 ft-lb]

Pressure (mPa)	Pressure [psi]	Voltage (VDC)
0	0	0.50
40	5801	1.39
70	10153	2.06
100	14504	2.72

TURBOCHARGER SPEED SENSOR

- Torque = 8.5 N•m [75 in-lb]

ENGINE SPEED SENSOR

- Torque = 25 N•m [221 in-lb]

CAMSHAFT POSITION SENSOR

- Torque = 9.5 N•m [84 in-lb]

EGR POSITION SENSOR AND TURBOCHARGER POSITION SENSOR CAP SCREWS

- Torque = 1.7 N•m [15 in-lb]

VEHICLE SPEED SENSOR

- Torque = 34 N•m [25 ft-lb]

OIL PRESSURE SWITCH

- Torque = 23 N•m [204 in-lb]

NOTE: Released resistance minus depressed resistance **must** be 1000 Ohms.

FUEL RAIL PRESSURE SENSOR

Torque = 70 N•m [52 ft-lb]

Pressure (mPa)	Pressure [psi]	Voltage (VDC)
140	20305	3.61
180	26107	4.50

ENGINE COOLANT TEMPERATURE SENSOR

Torque = 23 N•m [204 in-lb]

Temperature (C °)	Temperature [F °]	Resistance (Ohms)
0	32	30k to 37k
25	77	9.3k to 10.7k
50	122	3.2k to 3.8k
80	176	1.1k to 1.3k
95	203	700 to 800

ACCELERATOR PEDAL (IVS, ISS, AND APS)

- Idle validation circuit resistance:
  - For ON and OFF Idle states
  - IVS - Maximum closed circuit resistance less than 10 Ohms
  - ISS - Maximum closed circuit resistance less than 125 Ohms
  - IVS and ISS - Minimum open circuit resistance less than 100k Ohms
- Accelerator Position Coil Resistance:
  - Between supply and return pins = 2000 to 3000 Ohms
  - Between supply and signal pins (pedal released) = 1500 to 3000 Ohms
  - Between supply and signal pins (pedal depressed) = 200 to 1500 Ohms

Specifications

General Information

WARNING

This diagram is provided as a diagnostic tool for trained, experienced technicians only. Improper troubleshooting or repair can result in severe personal injury or death or property damage. See important instructions in Troubleshooting and Repair Manual.

Electrical Specifications

SAE J1587/J1708 DATALINK

- Positive wire to chassis ground (J1587 **only**)
  - 3.5 to 5.0 VDC
- Negative wire to chassis ground (J1587 **only**)
  - 0.0 to 2.5 VDC

J1939 BACKBONE RESISTANCE

- Positive wire to return wire
  - 50 to 70 Ohms
- J1939 Termination Resistance
  - 110 to 130 Ohms

All Continuity Checks

- OK (no open circuit) if less than 10 Ohms

All Shorts To Ground

- OK (no short circuit) if more than 100k Ohms

Short Circuit To External Voltage

- OK if less than 1.5 VDC

Sensor Supply Voltage

- @ ECM = 4.75 to 5.25 VDC

Solenoids

- Fuel Pump Actuator = 2.0 to 4.5 Ohms
- Injectors
  - Less than 2 ohms
- Turbocharger Control Valve
  - 800 to 1000 ohms

ECM Connector

- Retaining Cap Screw Torque = 2.8 N•m [25 in-lb]

Sensor Specifications

NOTE: To convert to gauge pressure on all psia pressure sensors, subtract the barometric pressure from the absolute pressure.

BAROMETRIC PRESSURE SENSOR

Altitude (m)	Altitude [ft]	Pressure [psia]	Pressure [inHg]	Voltage (VDC)
0 (sea level)	0	14.7	29.9	3.65 to 4.28
915	3000	13.2	26.9	3.06 to 3.60
1830	6000	11.8	24.0	2.52 to 2.96
2744	9000	10.5	21.4	2.01 to 2.36
3659	12000	9.35	19.0	1.57 to 1.84

INTAKE MANIFOLD PRESSURE SENSOR

Torque = 23 N•m [204 in-lb]

Pressure (mmHg)	Pressure [inHg]	Pressure [psig]	Voltage (VDC)
0	0	0	0.90 to 1.06
381	15	7	1.30 to 1.53
635	25	12	1.57 to 1.84
1549	61	30	2.53 to 2.96
2057	81	40	3.07 to 3.60
2590	102	50	3.61 to 4.23

ENGINE OIL PRESSURE SENSOR

Torque = 23 N•m [204 in-lb]

Pressure (kPa)	Pressure [psig]	Voltage (VDC)
0	0	0.75 to 0.90
274	25	1.68 to 2.01
446	50	2.59 to 3.10
515	60	2.96 to 3.54
653	80	3.69 to 4.42

FUEL RAIL PRESSURE SENSOR

Torque = 70 N•m [52 ft-lb]

Pressure (bar)	Pressure [psi]	Voltage (VDC)
0	0	0.50
400	5801	1.39
700	10153	2.06
1000	14504	2.72
1400	20305	3.61
1800	26107	4.50

TURBOCHARGER COMPRESSOR INLET AIR TEMPERATURE AND INTAKE MANIFOLD AIR TEMPERATURE SENSORS

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance Ohms
-10	14	49k to 62k
0	32	29k to 36k
20	68	11k to 14k
40	104	4.9k to 5.8k

70	158	1.6k to 1.9k

ENGINE COOLANT TEMPERATURE SENSOR

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
0	32	30k to 37k
25	77	9.3k to 10.7k
50	122	3.2k to 3.8k
80	176	1.1k to 1.3k
95	203	700 to 800

ENGINE SPEED SENSOR

- Torque = 25 N•m [221 in-lb]

CAMSHAFT POSITION SENSOR

- Torque = 10 N•m [89 in-lb]

VEHICLE SPEED SENSOR

- Torque = 47 N•m [35 ft-lb]

OIL PRESSURE SWITCH

- Torque = 23 N•m [204 in-lb]

TURBOCHARGER SPEED SENSOR

Torque = 8.5 N•m [75 in-lb]

Resistance = 600 to 1600 Ohms

ACCELERATOR PEDAL (NISS, ISS)

- Idle validation Circuit Resistance (For ON and OFF Idle States):
  - NISS - Maximum closed circuit resistance < 10 Ohms
  - ISS - Maximum closed circuit resistance < 125 Ohms
  - NISS and ISS - Minimum open circuit resistance < 100 kOhms
- Accelerator Position Coil Resistance
  - Between Supply and Return Pins = 2000 to 3000 Ohms
  - Between Supply and Signal Pins (Pedal Released) = 1500 to 3000 Ohms
  - Between Supply and Signal Pins (Pedal Depressed) = 200 to 1500 Ohms

NOTE: Released resistance minus depressed resistance **must** be 1000 Ohms.

Specifications

General Information

WARNING

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Electrical Specifications

Data Link

- Positive wire to chassis ground (J1587 **only**) 3.5 to 5.0 VDC
- Negative wire to chassis ground (J1587 **only**) 0.0 to 2.5 VDC

J1939 BackBone Resistance

- Positive wire to return wire 50 to 70 ohms
- J1939 Termination Resistance 110 to 130 ohms

All Continuity Checks

- OK (no open circuit if less than 10 ohms

Sensor Specifications

NOTE: To convert to gauge pressure on all psia pressure sensors subtract the barometric pressure from the absolute pressure.

BAROMETRIC (AMBIENT) AIR PRESSURE SENSOR

Altitude (m)	Altitude (ft)	Pressure [psia]	Pressure [inHg]	Voltage (VDC)
0 (sea level)	0	14.7	29.9	3.65 to 4.28
915	3000	13.2	28.9	3.06 to 3.50
1830	6000	11.8	24.0	2.52 to 2.96
2744	9000	10.5	21.4	2.01 to 2.36
3659	12000	9.35	19.0	1.57 to 1.84

INTAKE MANIFOLD PRESSURE SENSOR

10 N•m [88 in-lb]

Pressure (mmHg)	Pressure [in-Hg]	Pressure [psia]	Voltage (VDC)
0	0	0	0.90 to 1.06
381	15	22	1.30 to 1.53
635	25	27	1.57 to 1.84
1549	61	45	2.53 to 2.96
2057	81	55	3.07 to 3.60
2590	102	65	3.61 to 4.23

INTAKE MANIFOLD TEMPERATURE SENSORS

10 N•m [88 in-lb]

Temperature (C°)	Temperature [F°]	Resistance (Ohms)
-10	14	8.7k to 9.7k
0	32	5.5k to 6.1k
20	68	2.4k to 2.5k
40	104	1.1k to 1.2k

All Shorts to Ground

- OK (no short circuit) if more than 100k ohms

Short Circuit to External Voltage

- OK if less than 1.5 VDC

Sensor Supply Voltage

- @ ECM = 4.75 to 5.25 ohms

Solenoids

- Fuel Pump Actuator (EFC) = 2.0 to 4.5 ohms

ECM Connector

- Retaining Cap Screw Torque = 3 N•m [27 in-lb]

INTAKE MANIFOLD TEMPERATURE SENSORS

10 N•m [88 in-lb]

Temperature (C°)	Temperature [F°]	Resistance (Ohms)
70	158	418 to 436

ENGINE COOLANT TEMPERATURE SENSOR

Torque = 23 N•m [204 in-lb]

Temperature (C °)	Temperature [F °]	Resistance (Ohms)
0	32	30k to 37k
25	77	9.3k to 10.7k
50	122	3.2k to 3.8k
80	176	1.1k to 1.3k
95	203	700 to 800

ENGINE SPEED SENSOR AND CAMSHAFT POSITION SENSOR

Torque = 10 N•m [88 in-lb]

OIL PRESSURE SWITCH

Torque = 23 N•m [204 in-lb]

ACCELERATOR PEDAL (IVS, ISS, AND APS)

- Idle validation circuit resistance:
  - For ON and OFF idle states
  - IVS - Maximum closed circuit resistance less than 10 ohms

  - ISS - Maximum closed circuit resistance less than 125 ohms
  - IVS and ISS - Minimum open circuit resistance less than 100k ohms
- Accelerator Position Coil Resistance:
  - Between supply and return pins 2000 to 3000 Ohms
  - Between supply and signal pins (pedal released) 1500 to 3000 ohms
  - Between supply and signal pins (pedal depressed) 200 to 1500 ohms

NOTE: Released resistance minus depressed resistance **must** be 1000 ohms.

Specifications

General Information

WARNING

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Electrical Specifications

SAE J1939 BACKBONE RESISTANCE

- Positive wire to return wire
  - 50 to 70 Ohms
- Termination Resistance
  - 110 to 130 Ohms

ALL CONTINUITY CHECKS

- OK (no open circuit) if < 10 Ohms

ALL SHORTS TO GROUND

- OK (no short circuit) if > 100k Ohms

SHORT CIRCUIT TO EXTERNAL VOLTAGE SOURCE

- OK if < 1.5 VDC

SENSOR SUPPLY VOLTAGE

- @ ECM - 4.75 to 5.25 VDC

SOLENOIDS

- Fuel Pump Actuator
  - 2.0 to 4.5 Ohms
- Injectors
  - Less than 2 Ohms

ECM CONNECTOR

- Retaining Cap Screw Torque = 3 N•m [25 in-lb]

Sensor Specifications

Intake Manifold Air Temperature Sensor

- Torque = 23 N•m [17 ft-lb]

Engine Coolant Temperature Sensor

- Torque = 23 N•m [17 ft-lb]

Engine Oil Pressure Switch

- Torque = 23 N•m [17 ft-lb]

Engine Position Sensor

- Torque = 20 N•m [180 in-lb]

Fuel Rail Pressure Sensor

- Torque = 70 N•m [52 ft-lb]

Specifications

General Information

WARNING

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Electrical Specifications

J1939 BackBone Resistance

- Positive wire to return wire 50 to 70 ohms
- J1939 Termination Resistance 110 to 130 ohms

All Continuity Checks

- OK (no open circuit) if less than 10 ohms

All Shorts to Ground

- OK (no short circuit) if more than 100k ohms

Short Circuit to External Voltage

- OK if less than 1.5 volts direct current (VDC)

Sensor Supply Voltage

- @ Engine Control Module (ECM) = 4.75 to 5.25 ohms

Solenoids

- Fuel Pump Actuator (EFC) = 2.0 to 4.5 ohms

ECM Connector

- Retaining Cap Screw Torque = 3 N•m [27 in-lb]

Sensor Specifications

NOTE: To convert to gauge pressure on all psia pressure sensors subtract the barometric pressure from the absolute pressure.

Barometric (ambient) Air Pressure Sensor

Altitude (m)	Altitude (ft)	Pressure [psia]	Pressure [inHg]	Voltage (VDC)
0 (sea level)	0	14.7	29.9	3.65 to 4.28
914	3000	13.2	26.9	3.06 to 3.50
1829	6000	11.8	24.0	2.52 to 2.96
2743	9000	10.5	21.4	2.01 to 2.36
3658	12000	9.35	19.0	1.57 to 1.84

Intake Manifold Pressure Sensor

10 N•m [89 in-lb]

Pressure (mm Hg)	Pressure [in-Hg]	Pressure [psia]	Voltage (VDC)
0	0	0	0.90 to 1.06
381	15	22	1.30 to 1.53
635	25	27	1.57 to 1.84
1549	61	45	2.53 to 2.96
2057	81	55	3.07 to 3.60
2590	102	65	3.61 to 4.23

Intake Manifold Temperature Sensors

10 N•m [89 in-lb]

Temperature (C °)	Temperature [F °]	Resistance (ohms)
-10	14	8.7k to 9.7k
0	32	5.5k to 6.1k
20	68	2.4k to 2.5k
40	104	1.1k to 1.2k
70	158	418 to 436

Engine Coolant Temperature Sensor

Torque = 23 N•m [204 in-lb]

Temperature (C°)	Temperature [F°]	Resistance (ohms)
0	32	30k to 37k
25	77	9.3k to 10.7k
50	122	3.2k to 3.8k
80	176	1.1k to 1.3k
95	203	700 to 800

Engine Speed Sensor and Camshaft Position Sensor

Torque = 10 N•m [89 in-lb]

Oil Pressure Switch

Torque = 23 N•m [204 in-lb]

Fault Code Information

FAULT CODE {LAMP}	J1939 SPN(S) {FMI}	REASON
111 {Red}	629 {12}	Engine Control Module Critical Internal Malfunction - Bad Intelligent Device or Component.
115 {Red}	612 {2}	Engine Magnetic Crankshaft Speed/Position Lost Both of Two Signals - Data Erratic, Intermittent, or Incorrect. The ECM has detected that the primary engine speed sensor and the backup engine speed sensor signals are reversed.
122 {Amber}	102 {3}	Intake Manifold 1 Pressure Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the intake manifold pressure circuit.
123 {Amber}	102 {4}	Intake Manifold 1 Pressure Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the intake manifold pressure circuit.
124 {Amber}	102 {16}	Intake Manifold 1 Pressure - Data Valid But Above Normal Operating Range - Moderately Severe Level.
135 {Amber}	100 {3}	Engine Oil Rifle Pressure 1 Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the engine oil pressure circuit.
141 {Amber}	100 {4}	Engine Oil Rifle Pressure 1 Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the engine oil pressure circuit.
143 {Amber}	100 {18}	Engine Oil Rifle Pressure - Data Valid But Below Normal Operating Range - Moderately Severe Level. Engine oil pressure signal indicates the engine oil pressure is below the engine protection warning limit.
144 {Amber}	110 {3}	Engine Coolant Temperature 1 Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage or an open circuit has been detected at the engine coolant temperature circuit.
145 {Amber}	110 {4}	Engine Coolant Temperature 1 Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the engine coolant temperature circuit.
146 {Amber}	110 {16}	Engine Coolant Temperature - Data Valid But Above Normal Operating Range - Moderately Severe Level. Engine coolant temperature signal indicates the engine coolant temperature is above the engine protection warning limit.
151 {Red}	110 {0}	Engine Coolant Temperature - Data Valid But Above Normal Operating Range - Most Severe Level. Engine coolant temperature signal indicates the engine coolant temperature is above the engine protection critical limit.
153 {Amber}	105 {3}	Intake Manifold 1 Temperature Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the intake manifold air temperature circuit.
154 {Amber}	105 {4}	Intake Manifold 1 Temperature Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the intake manifold air temperature circuit.
155 {Red}	105 {0}	Intake Manifold 1 Temperature - Data Valid But Above Normal Operating Range - Most Severe Level. Intake manifold air temperature signal indicates the intake manifold air temperature is above the engine protection critical limit.
187 {Amber}	3510 {4}	Sensor Supply 2 Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the sensor supply number 2 circuit.
195 {Amber}	111 {3}	Coolant Level Sensor 1 Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the engine coolant level circuit.
196 {Amber}	111 {4}	Coolant Level Sensor 1 Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the engine coolant level circuit.
197 {Amber}	111 {18}	Coolant Level - Data Valid But Below Normal Operating Range - Moderately Severe level. Low engine coolant level has been detected.
221 {Amber}	108 {3}	Barometric Pressure Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the barometric pressure circuit.
222 {Amber}	108 {4}	Barometric Pressure Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the barometric pressure circuit.
227 {Amber}	3510 {3}	Sensor Supply 2 circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the sensor supply number 2 circuit.
234 {Red}	190 {0}	Engine Crankshaft Speed/Position - Data Valid But Above Normal Operating Range - Most Severe Level. Engine speed signal indicates the engine speed is above the engine protection limit.
235 {Red}	111 {1}	Coolant Level - Data Valid But Below Normal Operating Range - Most Severe Level. Low engine coolant level has been detected.
238 {Amber}	3511 {4}	Sensor Supply 3 Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected on the +5 VDC sensor supply circuit to the engine speed sensor.
239 {Amber}	3511 {3}	Engine Position Sensor Main Supply - Out of Range High - Error
271 {Amber}	1347 {4}	Fuel Pump Pressurizing Assembly 1 Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the fuel pump pressurizing assembly 1 circuit.
272 {Amber}	1347 {3}	Fuel Pump Pressurizing Assembly 1 Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage or an open circuit has been detected at the fuel pump pressurizing assembly 1 circuit.
281 {Amber}	1347 {7}	APC Diesel Cylinder Pressure Imbalance Error. A pumping imbalance between the front and rear pumping plungers has been detected.

FAULT CODE {LAMP}	J1939 SPN(S) {FMI}	REASON
285 {Amber}	639 {9}	SAE J1939 Multiplexing PGN Timeout Error - Abnormal Update Rate. The ECM did **not** receive a multiplexed message from an original equipment manufacturer (OEM) vehicle electronic control unit within the time limit or did **not** receive it at all.
286 {Amber}	639 {13}	SAE J1939 Multiplexing Configuration Error - Out of Calibration. The ECM expected information from a multiplexed device but **only** received a portion of the necessary information.
295 {Amber}	108 {2}	Ambient Air Pressure Sensor - Key-On Error. The ambient air pressure sensor is reading an erratic value at initial key-on.
322 {Amber}	651 {5}	Injector Solenoid Driver Cylinder 1 Circuit - Current Below Normal or Open Circuit. High resistance or no current has been detected at number 1 Injector driver or return pin.
323 {Amber}	655 {5}	Injector Solenoid Driver Cylinder 5 Circuit - Current Below Normal or Open Circuit. High resistance or no current has been detected at number 5 injector driver or return pin.
324 {Amber}	653 {5}	Injector Solenoid Driver Cylinder 3 Circuit - Current Below Normal or Open Circuit. High resistance or no current has been detected at number 3 injector driver or return pin.
325 {Amber}	656 {5}	Injector Solenoid Driver Cylinder 6 Circuit - Current Below Normal or Open Circuit. High resistance or no current has been detected at number 6 injector driver or return pin.
331 {Amber}	652 {5}	Injector Solenoid Driver Cylinder 2 Circuit - Current Below Normal or Open Circuit. High resistance or no current has been detected at number 2 injector driver or return pin.
332 {Amber}	654 {5}	Injector Solenoid Driver Cylinder 4 Circuit - Current Below Normal or Open Circuit. High resistance or no current has been detected at number 4 injector driver or return pin.
343 {Amber}	629 {12}	Electronic Control Module Warning Internal Hardware Malfunction - Bad Intelligent Device or Component.
351 {Amber}	627 {12}	Injector Power Supply - Bad Intelligent Device or Component. The ECM-measured injector boost voltage is low.
352 {Amber}	3509 {4}	Sensor Supply 1 Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the sensor supply number 1 circuit.
386 {Amber}	3509 {3}	Sensor Supply 1 Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the sensor supply number 1 circuit.
415 {Red}	100 {1}	Engine Oil Rifle Pressure - Data Valid But Below Normal Operating Range - Most Severe Level. Oil pressure signal indicates the oil pressure below the engine protection critical limit.
418 {Mainten ance}	97 {15}	Water-in-Fuel Indicator - Data Valid But Above Normal Operating Range - Least Severe Level. Water has been detected in the fuel filter.
422 {Amber}	111 {2}	Coolant Level Reading Incorrect.

FAULT CODE {LAMP}	J1939 SPN(S) {FMI}	REASON
426 {None}	639 {2}	SAE J1939 Data Link - Data Erratic, Intermittent, or Incorrect. Communication between the ECM and another device on the SAE J1939 data link has been lost.
435 {Amber}	100 {2}	Engine Oil Pressure Switch Error. An error in the engine oil pressure switch signal has been detected by the ECM.
441 {Amber}	168 {18}	Battery 1 Voltage - Data Valid But Below Normal Operating Range - Moderately Severe Level. ECM supply voltage is below the minimum system voltage level.
442 {Amber}	168 {16}	Battery 1 Voltage - Data Valid But Above Normal Operating Range - Moderately Severe Level. ECM supply voltage is above the maximum system voltage level.
449 {Red}	157 {0}	Injector Metering Rail 1 Pressure - Data Valid But Above Normal Operating Range - Most Severe Level.
451 {Amber}	157 {3}	Injector Metering Rail 1 Pressure Sensor Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the rail fuel pressure sensor circuit.
452 {Amber}	157 {4}	Injector Metering Rail 1 Pressure Sensor Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the rail fuel pressure sensor circuit.
488 {Amber}	105 {16}	Intake Manifold 1 Temperature - Data Valid But Above Normal Operating Range - Moderately Severe Level. Intake manifold air temperature signal indicates the intake manifold air temperature is above the engine protection warning limit.
553 {Amber}	157 {16}	Injector Metering Rail 1 Pressure - Data Valid But Above Normal Operating Range - Moderately Severe Level. The ECM has detected that fuel pressure is higher than commanded pressure.
554 {Amber}	157 {2}	Injector Metering Rail 1 Pressure - Data Erratic, Intermittent, or Incorrect. The ECM has detected that the fuel pressure signal is **not** changing.
559 {Amber}	157 {18}	Injector Metering Rail 1 Pressure - Data Valid But Below Normal Operating Range - Moderately Severe Level. The ECM has detected that fuel pressure is lower than commanded pressure.
689 {Amber}	190 {2}	Engine Crankshaft Speed/Position - Data Erratic, Intermittent, or Incorrect. Loss of signal from the crankshaft sensor.
731 {Amber}	723 {7}	Engine Speed/Position Camshaft and Crankshaft Misalignment - Mechanical System Not Responding Properly or Out of Adjustment. Mechanical misalignment between the crankshaft and camshaft engine speed sensors.
757 {Amber}	2802 {31}	Electronic Control Module Data Lost - Condition Exists
1117 {None}	627 {2}	Power Supply Lost With Ignition On - Data Erratic, Intermittent, or Incorrect. Supply voltage to the ECM fell below 6.2 VDC momentarily, or the ECM was **not** allowed to power down correctly, retaining battery voltage for 30 seconds after key OFF.

FAULT CODE {LAMP}	J1939 SPN(S) {FMI}	REASON
1139 {Amber}	651 {7}	Injector Solenoid Driver Cylinder 1 - Mechanical System Not Responding Properly or Out of Adjustment
1141 {Amber}	652 {7}	Injector Solenoid Driver Cylinder 2 - Mechanical System Not Responding Properly or Out of Adjustment
1142 {Amber}	653 {7}	Injector Solenoid Driver Cylinder 3 - Mechanical System Not Responding Properly or Out of Adjustment
1143 {Amber}	654 {7}	Injector Solenoid Driver Cylinder 4 - Mechanical System Not Responding Properly or Out of Adjustment
1144 {Amber}	655 {7}	Injector Solenoid Driver Cylinder 5 - Mechanical System Not Responding Properly or Out of Adjustment
1145 {Amber}	656 {7}	Injector Solenoid Driver Cylinder 6 - Mechanical System Not Responding Properly or Out of Adjustment
1376 {Mainten ance}	723 {2}	Engine Camshaft Speed/Position Sensor - Data Erratic, Intermittent, or Incorrect. The ECM has detected an error in the engine camshaft speed/position signal.
1411 {Amber}	5202 79 {3}	Generator Output Frequency Adjust Potentiometer Circuit - Voltage Above Normal or Shorted to High Source.
1412 {Amber}	5202 80 {3}	Droop Adjust Potentiometer Circuit - Voltage Above Normal or Shorted to High Source.
1418 {Amber}	5202 71 {3}	Gain Adjust Potentiometer Circuit - Voltage Above Normal or Shorted to High Source.
1427 {Amber}	4185 {31}	Overspeed Shutdown Relay Driver Diagnostic Has Detected an Error - Condition Exists.
1428 {Amber}	4186 {31}	Low Oil Pressure Shutdown Relay Driver Diagnostic Has Detected an Error - Condition Exists.
1597 {Mainten ance}	629 {12}	Electronic Control Module Critical Internal Malfunction - Bad Intelligent Device or Component.
1654 {Amber}	1323 {31}	Engine Misfire Cylinder 1 - Condition Exists
1655 {Amber}	1324 {31}	Engine Misfire Cylinder 2 - Condition Exists
1656 {Amber}	1325 {31}	Engine Misfire Cylinder 3 - Condition Exists
1657 {Amber}	1326 {31}	Engine Misfire Cylinder 4 - Condition Exists
1658 {Amber}	1327 {31}	Engine Misfire Cylinder 5 - Condition Exists
1659 {Amber}	1328 {31}	Engine Misfire Cylinder 6 - Condition Exists
1695 {Amber}	3513 {3}	Sensor Supply 5 - Voltage High Error.
1696 {Amber}	3513 {4}	Sensor Supply 5 - Voltage Low Error.
1718 {Amber}	1322 {31}	Multiple Cylinder Misfire Error
1845 {Mainten ance}	97 {3}	Water-In-Fuel Indicator Sensor Circuit - Voltage Above Normal or Shorted to High Source.
1846 {Mainten ance}	97 {4}	Water-In-Fuel Indicator Sensor Circuit - Voltage Below Normal or Shorted to Low Source.
1847 {Red}	110 {14}	Engine Coolant Temperature - Above Engine Protection Warning Limit
1852 {Amber}	97 {16}	Water-in-Fuel Indicator - Data Valid But Above Normal Operating Range - Moderately Severe Level
1911 {Amber}	157 {0}	Injector Metering Rail 1 Pressure - Data Valid But Above Normal Operating Range - Most Severe Level.
1978 {Amber}	5202 75 {3}	Generator Speed/Load Governing Bias Circuit - Voltage Above Normal or Shorted to High Source.
1979 {Amber}	5202 75 {4}	Generator Speed/Load Governing Bias Circuit - Voltage Below Normal or Shorted to Low Source.
1992 {Red}	190 {16}	Engine Crankshaft Speed/Position - Data Valid But Above Normal Operating Range - Moderately Severe Level.
2249 {Amber}	157 {1}	Injector Metering Rail 1 Pressure - Data Valid But Below Normal Operating Range - Most Severe Level. The ECM has detected that the fuel pressure is lower than the commanded pressure.
2265 {Amber}	1075 {3}	Electric Lift Pump for Engine Fuel Supply Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage or an open circuit has been detected at the fuel lift pump circuit.
2266 {Amber}	1075 {4}	Electric Lift Pump for Engine Fuel Supply Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the fuel lift pump circuit.
2292 {Amber}	611 {16}	Fuel Inlet Meter Device - Data Valid But Above Normal Operating Range - Moderately Severe Level. The flow demand is higher than expected.
2293 {Amber}	611 {18}	Fuel Inlet Meter Device Flow Demand Lower Than Expected - Data Valid But Below Normal Operating Range - Moderately Severe Level. The flow demand is lower than expected.
2311 {Amber}	633 {31}	Electronic Fuel Injection Control Valve Circuit - Condition Exists. Fuel pump actuator circuit resistance is too high or too low.
2321 {None}	190 {2}	Engine Crankshaft Speed/Position Sensor - Data Erratic, Intermittent, or Incorrect. Crankshaft engine speed sensor intermittent synchronization.
2322 {None}	723 {2}	Engine Camshaft Speed/Position Sensor - Data Erratic, Intermittent, or Incorrect. Camshaft engine speed sensor intermittent synchronization.
2555 {Amber}	729 {3}	Intake Air Heater 1 Circuit - Voltage Above Normal or Shorted to High Source. High signal voltage has been detected at the intake air heater signal circuit.
2556 {Amber}	729 {4}	Intake Air Heater 1 Circuit - Voltage Below Normal or Shorted to Low Source. Low signal voltage has been detected at the intake air heater signal circuit.
2661 {Red}	629 {31}	At Least One Unacknowledged Most Severe Fault - Condition Exists

FAULT CODE {LAMP}	J1939 SPN(S) {FMI}	REASON
2662 {Amber}	629 {31}	At Least One Unacknowledged Moderately Severe Fault - Condition Exists
2973 {Amber}	102 {2}	Intake Manifold 1 Pressure - Data Erratic, Intermittent, or Incorrect. The ECM has detected an intake manifold pressure signal that is too high or too low for the current engine operating conditions.

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Specifications

General Information

WARNING

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Electrical Specifications

SAE J1939 BACKBONE RESISTANCE
- Positive wire to return wire
  - 50 to 70 Ohms
- Termination Resistance
  - 110 to 130 Ohms

ALL CONTINUITY CHECKS
- OK (no open circuit) if < 10 Ohms

ALL SHORTS TO GROUND
- OK (no short circuit) if > 100k Ohms

SHORT CIRCUIT TO EXTERNAL VOLTAGE SOURCE
- OK if < 1.5 VDC

SENSOR SUPPLY VOLTAGE
- @ ECM - 4.75 to 5.25 VDC

SOLENOIDS
- Fuel Pump Actuator
  - 2.0 to 4.5 Ohms
- Injectors
  - Less than 2 Ohms

ECM CONNECTOR
- Retaining Cap Screw Torque = 3 N•m [25 in-lb]

Sensor Specifications

Intake Manifold Air Temperature Sensor
- Torque = 23 N•m [17 ft-lb]

Engine Coolant Temperature Sensor
- Torque = 23 N•m [17 ft-lb]

Engine Oil Pressure Switch
- Torque = 23 N•m [17 ft-lb]

Engine Position Sensor
- Torque = 20 N•m [180 in-lb]

Fuel Rail Pressure Sensor
- Torque = 70 N•m [52 ft-lb]

Specifications

General Information

WARNING

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Electrical Specifications

SAE J1939 BACKBONE RESISTANCE
- Positive wire to return wire
  - 50 to 70 Ohms
- Termination Resistance
  - 110 to 130 Ohms

ALL CONTINUITY CHECKS
- OK (no open circuit) if < 10 Ohms

ALL SHORTS TO GROUND
- OK (no short circuit) if > 100k Ohms

SHORT CIRCUIT TO EXTERNAL VOLTAGE SOURCE
- OK if < 1.5 VDC

SENSOR SUPPLY VOLTAGE
- @ ECM - 4.75 to 5.25 VDC

SOLENOIDS
- Fuel Pump Actuator
  - 2.0 to 4.5 Ohms
- Injectors
  - Less than 2 Ohms

ECM CONNECTOR
- Retaining Cap Screw Torque = 3 N•m [25 in-lb]

Sensor Specifications

Intake Manifold Air Temperature Sensor
- Torque = 23 N•m [17 ft-lb]

Engine Coolant Temperature Sensor
- Torque = 23 N•m [17 ft-lb]

Engine Oil Pressure Switch
- Torque = 23 N•m [17 ft-lb]

Engine Position Sensor
- Torque = 20 N•m [180 in-lb]

Fuel Rail Pressure Sensor
- Torque = 70 N•m [52 ft-lb]

Specifications

General Information

WARNING

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Electrical Specifications

J1939 BackBone Resistance
- Positive wire to return wire 50 to 70 Ohms
- J1939 Termination Resistance 110 to 130 Ohms

All Continuity Checks
- OK (no open circuit if less than 10 Ohms

All Shorts to Ground
- OK (no short circuit) if more than 100k Ohms

Short Circuit to External Voltage
- OK if less than 1.5 VDC

Sensor Specifications

NOTE: To convert to gauge pressure on all psia pressure sensors subtract the barometric pressure from the absolute pressure.

BAROMETRIC (AMBIENT) AIR PRESSURE SENSOR

Altitude (m)	Altitude (ft)	Pressure [psia]	Pressure [inHg]	Voltage (VDC)
0 (sea level)	0	14.7	29.9	3.65 to 4.28
914	3000	13.2	26.9	3.06 to 3.50
1829	6000	11.8	24.0	2.52 to 2.96
2743	9000	10.5	21.4	2.01 to 2.36
3658	12000	9.35	19.0	1.57 to 1.84

INTAKE MANIFOLD PRESSURE SENSOR

10 N•m [89 in-lb]

Pressure (mmHg)	Pressure [in-Hg]	Pressure [psia]	Voltage (VDC)
0	0	0	0.90 to 1.06
381	15	22	1.30 to 1.53
635	25	27	1.57 to 1.84
1549	61	45	2.53 to 2.96
2057	81	55	3.07 to 3.60
2590	102	65	3.61 to 4.23

INTAKE MANIFOLD TEMPERATURE SENSORS

10 N•m [89 in-lb]

Temperature (C°)	Temperature [F°]	Resistance (Ohms)
-10	14	8.7k to 9.7k

Sensor Supply Voltage
- @ ECM = 4.75 to 5.25 Ohms

Solenoids
- Fuel Pump Actuator (EFC) = 2.0 to 4.5 Ohms

ECM Connector
- Retaining Capscrew Torque = 3 N•m [27 in-lb]

INTAKE MANIFOLD TEMPERATURE SENSORS

10 N•m [89 in-lb]

Temperature (C°)	Temperature [F°]	Resistance (Ohms)
0	32	5.5k to 6.1k
20	68	2.4k to 2.5k
40	104	1.1k to 1.2k
70	158	418 to 436

ENGINE COOLANT TEMPERATURE SENSOR

Torque = 23 N•m [204 in-lb]

Temperature (C °)	Temperature [F °]	Resistance (Ohms)
0	32	30k to 37k
25	77	9.3k to 10.7k
50	122	3.2k to 3.8k
80	176	1.1k to 1.3k
95	203	700 to 800

ENGINE SPEED SENSOR AND CAMSHAFT POSITION SENSOR

Torque = 10 N•m [89 in-lb]

OIL PRESSURE SWITCH

Torque = 23 N•m [204 in-lb]

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Specifications

General Information

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Electrical Specifications

SAE™ J1939 BACKBONE RESISTANCE
- High wire to low wire
  - 50 to 70 Ohms
- J1939 Termination Resistance
  - 110 to 130 Ohms

ALL CONTINUITY CHECKS
- OK (no open circuit) if less than 10 Ohms

ALL SHORTS TO GROUND
- OK (no short circuit) if more than 100k Ohms

SHORT CIRCUIT TO EXTERNAL VOLTAGE
- OK if less than 1.5 VDC

5 VOLT POWER SUPPLY (Sensor Only)
- @ ECM/Harness: 4.75 to 5.25 VDC

SOLENOIDS
- Fuel pump actuator = 2.0 to 4.5 Ohms
- Injectors
  - Less than 2 Ohms

ECM CONNECTOR
- Retaining capscrew torque = 2.8 N•m [25 in-lb]

Sensor Specifications

NOTE: To convert gauge pressure on all psia sensors, subtract the barometric pressure from the absolute pressure.

Fuel Pressure Sensor
Torque = 70 N•m [52 ft-lb]

Pressure [bar]	Pressure [psia]	Voltage (VDC)
0	0	0.50
400	5816	1.39
700	10168	2.06
1000	14519	2.72
1400	20320	3.61
1800	26122	4.50

Intake Manifold Pressure Sensor
(QSB5.9/QSC8.3/QSL9)
Torque = 23 N•m [204 in-lb]

Pressure (mm Hg)	Pressure [in Hg]	Pressure [psia]	Voltage (VDC)
0	0	0	0.9 to 1.06
381	15	22	1.30 to 1.53
635	25	27	1.57 to 1.84
1549	61	45	2.53 to 2.96
2057	81	55	3.07 to 3.60

Engine Oil Pressure Sensor
Torque = 23 N•m [204 in-lb]

Pressure (kPa)	Pressure [psia]	Voltage (VDC)
0	0	0.75 to 0.90
274	55	1.68 to 2.01
446	80	2.59 to 3.10
515	90	2.96 to 3.54
653	110	3.69 to 4.42

Intake Manifold Air Temperature Sensor
(QSB5.9)
Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
-10	14	8.7k to 9.72k
0	32	5.5k to 6.16k
20	68	2.4k to 2.54k
40	104	1.1k to 1.2k
70	158	418 to 436

Intake Manifold Air Temperature Sensor (QSC8.3/QSL9)

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
-10	14	49k to 62k
0	32	29k to 36k
20	68	11k to 14k
40	104	4.9k to 5.8k
70	158	1.6k to 1.9k

Engine Coolant Temperature Sensor

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
0	32	30k to 37k
25	77	9.3k to 10.7k

Engine Coolant Temperature Sensor

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
50	122	3.2k to 3.8k
80	176	1.1k to 1.3k
95	203	700 to 800

Crankshaft Speed Sensor

Torque = 25 N•m [221 in-lb]

Camshaft Position Sensor

Torque = 10 N•m [89 in-lb]

Engine Coolant Level Sensor

Torque = 5 N•m [44 in-lb]

Specifications

General Information

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Electrical Specifications

SAE™ J1939 BACKBONE RESISTANCE
- High wire to low wire
  - 50 to 70 Ohms
- J1939 Termination Resistance
  - 110 to 130 Ohms

ALL CONTINUITY CHECKS
- OK (no open circuit) if less than 10 Ohms

ALL SHORTS TO GROUND
- OK (no short circuit) if more than 100k Ohms

SHORT CIRCUIT TO EXTERNAL VOLTAGE
- OK if less than 1.5 VDC

Sensor Specifications

NOTE: To convert gauge pressure on all psia sensors, subtract the barometric pressure from the absolute pressure.

Fuel Pressure Sensor
Torque = 70 N•m [52 ft-lb]

Pressure [bar]	Pressure [psia]	Voltage (VDC)
0	0	0.50
400	5816	1.39
700	10168	2.06
1000	14519	2.72
1400	20320	3.61
1800	26122	4.50

Intake Manifold Pressure Sensor
Torque = 23 N•m [204 in-lb]

Pressure (mm Hg)	Pressure [in Hg]	Pressure [psia]	Voltage (VDC)
0	0	0	0.9 to 1.06
381	15	22	1.30 to 1.53
635	25	27	1.57 to 1.84
1549	61	45	2.53 to 2.96
2057	81	55	3.07 to 3.60

Engine Oil Pressure Sensor
Torque = 23 N•m [204 in-lb]

Pressure (kPa)	Pressure [psia]	Voltage (VDC)
0	0	0.75 to 0.90

SENSOR SUPPLY VOLTAGE
- at ECM - 4.75 to 5.25 VDC

SOLENOIDS
- Fuel pump actuator = 2.0 to 4.5 Ohms
- Injectors
  - Less than 2 Ohms

ECM CONNECTOR
- Retaining capscrew torque = 2.8 N•m [25 in-lb]

Engine Oil Pressure Sensor
Torque = 23 N•m [204 in-lb]

Pressure (kPa)	Pressure [psia]	Voltage (VDC)
274	55	1.68 to 2.01
446	80	2.59 to 3.10
515	90	2.96 to 3.54
653	110	3.69 to 4.42

Intake Manifold Air Temperature Sensor
Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
-10	14	49k to 62k
0	32	29k to 36k
20	68	11k to 14k
40	104	4.9k to 5.8k
70	158	1.6k to 1.9k

Engine Coolant Temperature Sensor
Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
0	32	30k to 37k
25	77	9.3k to 10.7k
50	122	3.2k to 3.8k

Engine Coolant Temperature Sensor

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
80	176	1.1k to 1.3k
95	203	700 to 800

Crankshaft Speed Sensor

Torque = 25 N•m [221 in-lb]

Camshaft Position Sensor

Torque = 10 N•m [89 in-lb]

Engine Coolant Level Sensor

Torque = 5 N•m [44 in-lb]

Specifications

General Information

WARNING

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Electrical Specifications

SAE™ J1939 BACKBONE RESISTANCE

- High wire to low wire
  - 50 to 70 Ohms
- J1939 Termination Resistance
  - 110 to 130 Ohms

ALL CONTINUITY CHECKS

- OK (no open circuit) if less than 10 Ohms

ALL SHORTS TO GROUND

- OK (no short circuit) if more than 100k Ohms

SHORT CIRCUIT TO EXTERNAL VOLTAGE

- OK if less than 1.5 VDC

Sensor Specifications

NOTE: To convert gauge pressure on all psia sensors, subtract the barometric pressure from the absolute pressure.

Fuel Pressure Sensor

Torque = 70 N•m [52 ft-lb]

Pressure [bar]	Pressure [psia]	Voltage (VDC)
0	0	0.50
400	5816	1.39
700	10168	2.06
1000	14519	2.72
1400	20320	3.61
1800	26122	4.50

Intake Manifold Pressure Sensor

Torque = 23 N•m [204 in-lb]

Pressure (mm Hg)	Pressure [in Hg]	Pressure [psia]	Voltage (VDC)
0	0	0	0.9 to 1.06
381	15	22	1.30 to 1.53
635	25	27	1.57 to 1.84
1549	61	45	2.53 to 2.96
2057	81	55	3.07 to 3.60

Engine Oil Pressure Sensor

Torque = 23 N•m [204 in-lb]

Pressure (kPa)	Pressure [psia]	Voltage (VDC)
0	0	0.75 to 0.90

SENSOR SUPPLY VOLTAGE

- at ECM - 4.75 to 5.25 VDC

SOLENOIDS

- Fuel pump actuator = 2.0 to 4.5 Ohms
- Injectors
  - Less than 2 Ohms

ECM CONNECTOR

- Retaining capscrew torque = 2.8 N•m [25 in-lb]

Engine Oil Pressure Sensor

Torque = 23 N•m [204 in-lb]

Pressure (kPa)	Pressure [psia]	Voltage (VDC)
274	55	1.68 to 2.01
446	80	2.59 to 3.10
515	90	2.96 to 3.54
653	110	3.69 to 4.42

Intake Manifold Air Temperature Sensor

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
-10	14	8.7k to 9.72k
0	32	5.5k to 6.16k
20	68	2.4k to 2.54k
40	104	1.1k to 1.2k
70	158	418 to 436

Engine Coolant Temperature Sensor

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
0	32	30k to 37k
25	77	9.3k to 10.7k
50	122	3.2k to 3.8k

Engine Coolant Temperature Sensor

Torque = 23 N•m [204 in-lb]

Temperature (°C)	Temperature [°F]	Resistance (Ohms)
80	176	1.1k to 1.3k
95	203	700 to 800

Crankshaft Speed Sensor

Torque = 25 N•m [221 in-lb]

Camshaft Position Sensor

Torque = 10 N•m [89 in-lb]

Engine Coolant Level Sensor

Torque = 5 N•m [44 in-lb]

General Engine

Specifications

Listed below are the general specifications for this engine.

Horsepower........Refer to engine dataplate
Firing Order........1.5.3.6.2.4
Crankshaft Rotation (viewed from front of engine)........Clockwise
Displacement - ISB/QSB5.9........5.9 liters [360 in^3]
Displacement - ISBe4 4.5/QSB4.5........4.5 liters [275 in^3]
Displacement - ISBe4 6.7/QSB6.7........6.7 liters [409 in^3]
Displacement - ISC/QSC........8.3 liters [504.5 in^3]
Displacement - ISL/QSL........8.9 liters [540 in^3]
Bore and Stroke - ISB/QSB5.9........102 mm [4.02 in] X 120 mm [4.72 in]
Bore and Stroke - ISBe4........107 mm [4.21 in] X 124 mm [4.88 in]
Bore and Stroke - ISC/QSC........114 mm [4.49 in] x 135 mm [5.32 in]
Bore and Stroke - ISL/QSL........114 mm [4.49 in] x 144.5 mm [5.69 in]
Dry Weight - ISB/QSB5.9 - Automotive and Industrial........519 kg [1144 lb]
Dry Weight - ISBe4 4.5/QSB4.5........371 kg [818 lb]
Dry Weight - ISBe4 6.7/QSB6.7........485 kg [1069 lb]
Dry Weight - Marine with Heat Exchanger System - Average........612 kg [1350 lb]
Dry Weight - ISC/QSC Automotive and Industrial........694 kg [1530 lb]
Dry Weight - ISC/QSC Marine........880 kg [1940 lb]
Dry Weight - ISC/QSC Marine with Heat Exchanger System - Average........896 kg [1975 lb]
Dry Weight - ISL/QSL Automotive and Industrial........706 kg [1555 lb]
Dry Weight - ISL/QSL Marine........891 kg [1965 lb]
Dry Weight - ISL/QSL Marine with Heat Exchanger System - Average........907 kg [2000 lb]

Overhead Adjustment

ISB/ISBe4/QSB - Intake Valve Adjustment........0.254 mm [0.010 in]
ISB/ISBe4/QSB - Exhaust Valve Adjustment........0.508 mm [0.020 in]

Overhead Adjustment

ISC/QSC/ISL/QSL - Intake Valve Adjustment........0.305 mm [0.012 in]
ISC/QSC/ISL/QSL - Exhaust Valve Adjustment........0.559 mm [0.022 in]
Engine Brake Adjustment........2.286 mm [0.090 in]

NOTE: The ISB and QSB engines feature a no-adjust overhead. The valve train is designed such that adjustment of the valve lash is **not** required for normal service during the first 241,402 km [150,000 mi]. The valve train operates acceptably within the limits of 0.152- to 0.381-mm [0.006- to 0.015-in] intake valve lash and 0.381- to 0.762-mm [0.015- to 0.030-in] exhaust valve lash. It is recommended that the valve lash be checked around 241,402 km [150,000 mi] and every 81,000 km [50,000 mi] thereafter.

Fuel System

Specifications

For performance and fuel rate values, use the Engine Data Sheet or the fuel injection pump for the particular model involved.

ISB/QSB

Automotive and Industrial

Engine Idle Speed....Minimum 600 to maximum 800 rpm
Maximum Fuel Inlet Restriction (gear pump inlet)....20.3 kPa [6 in Hg]
Maximum Fuel Inlet Temperature....70°C [158°F]
Fuel Pressure Range at Fuel Filter Outlet (engine cranking)....0.0 to 79.9 kPa [0.0 to 11.6 psi]
Fuel Pressure Range at Fuel Filter Inlet (engine running)....0.0 to 79.9 kPa [0.0 to 11.6 psi]
Maximum Pressure Drop across Fuel Filter....34 kPa [5 psi]
Rail Pressure....250 to 1600 bar [3626 to 23,206 psi]
Maximum Fuel Drain Line Restriction....19 kPa [2.7 psi]
Maximum Fuel Inlet Restriction - ISB Automotive (to lift pump)....20.3 kPa [6 in Hg]

ISB/QSB

Marine

Engine Idle Speed....Minimum 600 to maximum 800 rpm
Maximum Fuel Inlet Temperature....60°C [140°F]
Fuel Pressure Range at Fuel Filter Outlet (engine cranking)....0.0 to 79.9 kPa [0.0 to 11.6 psi]
Fuel Pressure Range at Fuel Filter Inlet (engine running)....0.0 to 79.9 kPa [0.0 to 11.6 psi]
Maximum Pressure Drop across Fuel Filter....34 kPa [5 psi]
Rail Pressure....250 to 1440 bar [3626 to 20,885 psi]
Maximum Fuel Drain Line Restriction....14 kPa [2 psi]
Maximum Fuel Inlet Restriction - QSB Marine (to lift pump)....14 kPa [4 in Hg]

ISC/QSC

Maximum Fuel Inlet Restriction - Dirty Filter (OEM connection point)....27.0 kPa [8 in Hg]
Maximum Fuel Inlet Restriction (gear pump inlet)....33.9 kPa [10 in Hg]
Maximum Fuel Drain Line Restriction....254 mm Hg [10 in Hg]
Minimum Gear Pump Pressure (during cranking)....69 kPa [10 psi]
Minimum Lift Pump Pressure (gear pump inlet during cranking)....34 kPa [5 psi]
Minimum Engine Cranking Speed....150 rpm
Maximum Pressure Drop across Fuel Filter....138 kPa [20 psi]

Lubricating Oil System

Specifications

ISB/QSB

Automotive and Industrial

Oil Pressure - At Low Idle (minimum allowable)....69 kPa [10 psi]
At Rated Speed (minimum allowable)....207 kPa [30 psi]
Oil Pan Capacity, Low to High - Standard Oil Pan....12.3 to 14.2 liters [13 to 15 qt]
Lubricating Oil Filter Capacity....0.95 liters [1 qt]
Total System Capacity (Oil Pan and New Oil Filter) - Standard Oil Pan....16.7 liters [17.6 qt]
Regulated Oil Pressure....517 kPa [75 psi]

ISB/QSB

Marine

Oil Pressure - At Low Idle (minimum allowable)....55 kPa [8 psi]
At Rated Speed (minimum allowable)....193 kPa [28 psi]
Oil Pan Capacity, Low to High - Standard Oil Pan....12.3 to 14.2 liters [13 to 15 qt]
Lubricating Oil Filter Capacity....0.95 liters [1 qt]
Total System Capacity (Oil Pan and New Oil Filter) - Standard Oil Pan....15.1 liter [16 qt]
Regulated Oil Pressure....517 kPa [75 psi]

ISC/QSC/ISL/QSL

Oil Pressure - At Low Idle (minimum allowable)....69 kPa [10 psi]
At Rated Speed (minimum allowable)....207 kPa [30 psi]
Lubricating Oil Filter Capacity....2.84 liters [3 qt]
Regulated Oil Pressure....517 kPa [75 psi]

ISC/QSC

Automotive and Industrial

Oil Pan Capacity, Low to High - Standard Oil Pan....15.1 to 18.9 liters [16 to 20 qt]
Standard Oil Pan with Cylinder Block Stiffener Plate....16.1 to 19.9 liters [17 to 21 qt]
Total System Capacity (Oil Pan and New Oil Filter) - Standard Oil Pan....22.7 liters [24 qt]
Standard Oil Pan with Cylinder Block Stiffener Plate....23.7 liters [25 qt]

ISL/QSL

Automotive and Industrial

Oil Pan Capacity, Low to High - Standard Oil Pan....18.9 to 22.7 liters [20 to 24 qt]
Standard Oil Pan with Cylinder Block Stiffener Plate....19.9 to 23.7 liters [21 to 25 qt]
Total System Capacity (Oil Pan and New Oil Filter) - Standard Oil Pan....26.5 liters [28 qt]
Standard Oil Pan with Cylinder Block Stiffener Plate....27.4 liters [29 qt]

ISC/QSC

Marine

Oil Pan Capacity, Low to High - Standard Oil Pan....13.2 to 17.0 liters [3.5 to 4.5 gal]
Total System Capacity (Oil Pan and New Oil Filter) - Standard Oil Pan....19.7 liters [5.2 gal]

ISL/QSL

Marine

Oil Pan Capacity, Low to High - Standard Oil Pan....18.9 to 22.7 liters [5 to 6 gal]
Total System Capacity (Oil Pan and New Oil Filter) - Standard Oil Pan....25.4 liters [6.7 gal]

Cooling System

Specifications

ISB/QSB

Automotive and Industrial

Coolant Capacity (engine **only**)........11 liters [2.9 gal]
Standard Modulating Thermostat Range........88 to 97°C [190 to 207°F]
Minimum Recommended Pressure Cap........103 kPa [15 psi]

ISB/QSB

Marine

Engine Only........10 liters [2.6 gal]
Engine Including Heat Exchanger and Wet Manifold........25 liters [6.6 gal]
Standard Modulating Thermostat Range........74° to 85°C [165° to 185°F]
Minimum Recommended Pressure Cap........103 kPa [15 psi]

ISC/QSC/ISL/QSL

Automotive and Industrial

Standard Modulating Thermostat Range........82 to 93°C [180 to 200°F]
Minimum Recommended Pressure Cap........48 kPa [7 psi]
Coolant Capacity (engine **only**)........11.1 liters [11.7 qt]

ISC/QSC/ISL/QSL

Marine

Standard Modulating Thermostat Range........68 to 75°C [155 to 167°F]
Minimum Recommended Pressure Cap........103 kPa [15 psi]
Minimum Fill Rate (without low-level alarm)........19 liters/min [5 gpm]
Coolant Capacity (engine **only**)........11.1 liters [11.7 qt]

Coolant Capacity (engine including heater exchanger and wet manifold)

QSB........25 liters [6.6 gal]
QSC/QSL........29 liters [7.75 gal]

Maximum Deaeration Time........25 minutes
Maximum Top Tank Coolant Temperature........107°C [225°F]

Winterfronts - Automotive Only

Air Passage Area........774 cm^2 [120 in^2]

Air Intake System

Specifications

CAUTION

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

Automotive and Industrial

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

QSB Marine

Maximum Intake Restriction (clean air filter element)..381 mm H_2O [15 in H_2O]
Maximum Intake Restriction (dirty air filter element)..635 mm H_2O [25.0 in H_2O]
Charge Air Cooler Restriction (maximum)...152 mm Hg [6.0 in Hg]

Exhaust System

Specifications

Maximum Exhaust Restriction - Muffler

Hg....................76 mm Hg [3 in Hg]

H_2O....................1016 mm H_2O [40 in H_2O]

ISB/QSB

Exhaust Pipe Size (normally acceptable inside diameter)....................76 mm [3 in]

ISC/ISL

Exhaust Restriction - Diesel Oxidation Catalyst....................114 mm Hg [4.5 in Hg]

Exhaust Restriction - Exhaust Gas Filter....................140 mm Hg [5.5 in Hg]

Electrical System

Specifications

Minimum Recommended Battery Capacity for ISC/QSC/ISL/QSL engines

System Voltage	Ambient Temperatures	
	−18°C [0°F]	
	Cold Cranking Amperes	Reserve Capacity[1] (Minutes)
12-VDC	1800	640
24-VDC[2]	900	320

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 [80°F] can supply 25 amperes at 10.5 volts or greater.

CCA ratings are based on two 12-VDC batteries in series.

Minimum Recommended Battery Capacity for ISB/QSB engines

System Voltage	Ambient Temperature			
	−18°C [0°F]		−29°C [−20°F]	
	Cold Cranking Amps	Reserve Capacity (minutes)[1]	Cold Cranking Amps	Reserve Capacity (minutes)[1]
12 VDC	800	260	950	260
24 VDC[2]	400	130	475	130

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.

Cold cranking amp ratings are based on two 12-VDC batteries in series.

Batteries (Specific Gravity)

Specific Gravity at 27°C [80°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

Maximum Starting Circuit Resistance12-VDC System..0.00075 ohms
24-VDC System..0.00200 ohms

Compressed Air System

Specifications

Cummins 18.7 CFM Model

Cylinders....1
Compressor Swept Volume @ 1250 RPM....6.6 l/sec. [14.0 cfm]
Piston Displacement....31 cc [19.405 C.I.D.
Bore....85 mm [3.346 in]
Stroke....56 mm [2.204 in]
Speed....Engine speed
Cooling....Engine coolant
Lubrication....Engine lubricating oil

Plumbing Line Sizes

Coolant Inlet and Outlet....3/4 x 116 STOR
Air Inlet....25.4 mm [1 in] Nominal
Air Outlet....M27 x 2 STOR
Unloader Port....M10 x 1 STOR
Governor Mounting Direct....M8 x 1.25
Height, Overall (Approximate)....217.4 mm [8.56 in]
Width, Overall (Approximate)....142 mm [5.59 in]
Length, Overall (Approximate)....216 mm [8.50 in]
Weight (Approximate)....15 kg [35.0 lb]

Engine Testing

Specifications

Engine Blowby Specifications..30.5 cm H_2O [12.0 in H_2O]

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.

Capscrew Markings and Torque Values

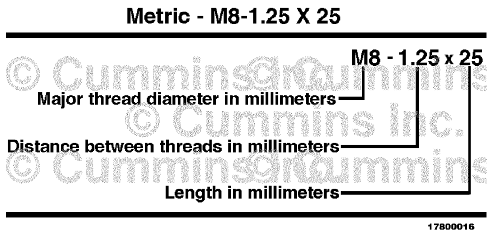
General Information

CAUTION

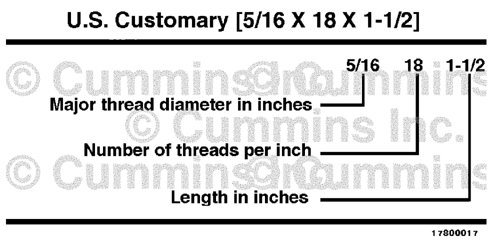
When replacing capscrews, always use a capscrew of the same measurement and strength as the capscrew being replaced. Using the wrong capscrews can result in engine damage.

Metric capscrews and nuts are identified by the grade number stamped on the head of the capscrew or on the surface of the nuts. U.S. Customary capscrews are identified by radial lines stamped on the head of the capscrew.

The following examples indicate how capscrews are identified:

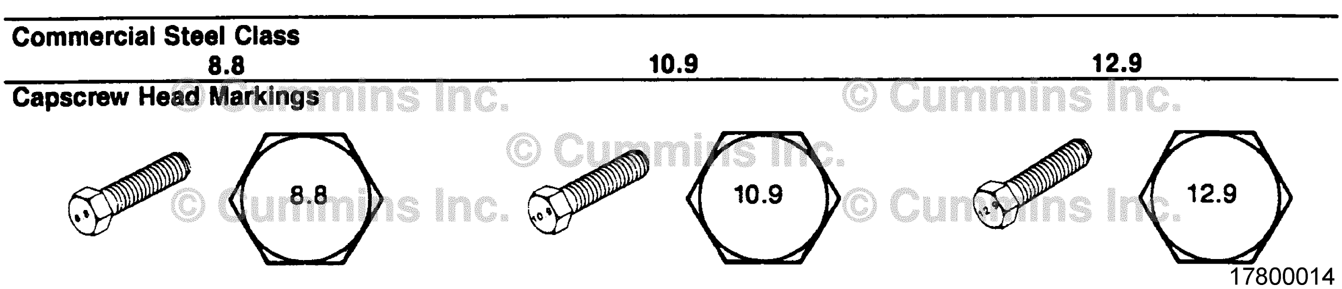


- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the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



- **Always** use the torque values listed in the following tables when specific torque values are **not** available.
- Do **not** use the torque values in place of those specified in other sections of this manual.
- The torque values in the table are based on the use of lubricated threads.
- When the ft-lb value is less than 10, convert the ft-lb value to in-lb to obtain a better torque with an in-lb torque wrench. Example: 6 ft-lb equals 72 in-lb.

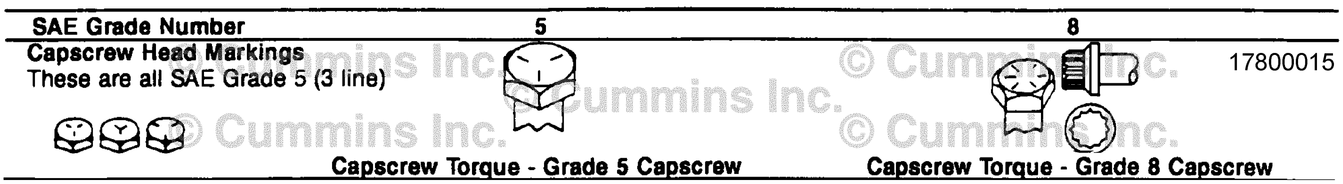
Capscrew Markings and Torque Values - Metric



Body Size	Torque				Torque				Torque			
Diameter	Cast Iron		Aluminium		Cast Iron		Aluminium		Cast Iron		Aluminium	
mm	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
6	9	5	7	4	13	10	7	4	14	9	7	4
7	14	9	11	7	18	14	11	7	23	18	11	7

Body Size	Torque				Torque				Torque			
Diameter	Cast Iron		Aluminium		Cast Iron		Aluminium		Cast Iron		Aluminium	
mm	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
8	23	17	18	14	33	25	18	14	40	29	18	14
10	45	33	30	25	65	50	30	25	70	50	30	25
12	80	60	55	40	115	85	55	40	125	95	55	40
14	125	90	90	65	180	133	90	65	195	145	90	65
16	195	140	140	100	280	200	140	100	290	210	140	100
18	280	200	180	135	390	285	180	135	400	290	180	135
20	400	290	—	—	550	400	—	—	—	—	—	—

Capscrew Markings and Torque Values - U.S. Customary



Capscrew Body Size	Cast Iron		Aluminium		Cast Iron		Aluminium	
	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1/4 - 20	9	7	8	6	15	11	8	6
1/4 - 28	12	9	9	7	18	13	9	7
5/16 - 18	20	15	16	12	30	22	16	12
5/16 - 24	23	17	19	14	33	24	19	14
3/8 - 16	40	30	25	20	55	40	25	20
3/8 - 24	40	30	35	25	60	45	35	25
7/16 - 14	60	45	45	35	90	65	45	35
7/16 - 20	65	50	55	40	95	70	55	40
1/2 - 13	95	70	75	55	130	95	75	55
1/2 - 20	100	75	80	60	150	110	80	60
9/16 - 12	135	100	110	80	190	140	110	80
9/16 - 18	150	110	115	85	210	155	115	85
5/8 - 11	180	135	150	110	255	190	150	110
5/8 - 18	210	155	160	120	290	215	160	120
3/4 - 10	325	240	255	190	460	340	255	190
3/4 - 16	365	270	285	210	515	380	285	210
7/8 - 9	490	360	380	280	745	550	380	280
7/8 - 14	530	390	420	310	825	610	420	310
1 - 8	720	530	570	420	1100	820	570	420
1 - 14	800	590	650	480	1200	890	650	480

Fraction, Decimal, Millimeter Conversions

Conversion Chart

Fraction	inch	mm	Fraction	inch	mm
1/64	0.0156	0.397	33/64	0.5156	13.097
1/32	0.0313	0.794	17/32	0.5313	13.494
3/64	0.0469	1.191	35/64	0.5469	13.891
1/16	0.0625	1.588	9/16	0.5625	14.288
5/64	0.0781	1.984	37/64	0.5781	14.684
3/32	0.0938	2.381	19/32	0.5938	15.081
7/64	0.1094	2.778	39/64	0.6094	15.478
1/8	0.1250	3.175	5/8	0.6250	15.875
9/64	0.1406	3.572	41/64	0.6406	16.272
5/32	0.1563	3.969	21/32	0.6563	16.669
11/64	0.1719	4.366	43/64	0.6719	17.066
3/16	0.1875	4.763	11/16	0.6875	17.463
13/64	0.2031	5.159	45/64	0.7031	17.859
7/32	0.2188	5.556	23/32	0.7188	18.256
15/64	0.2344	5.953	47/64	0.7344	18.653
1/4	0.2500	6.350	3/4	0.7500	19.050
17/64	0.2656	6.747	49/64	0.7656	19.447
9/32	0.2813	7.144	25/32	0.7813	19.844
19/64	0.2969	7.541	51/64	0.7969	20.241
5/16	0.3125	7.938	13/16	0.8125	20.638
21/64	0.3281	8.334	53/64	0.8281	21.034
11/32	0.3438	8.731	27/32	0.8438	21.431
23/64	0.3594	9.128	55/64	0.8594	21.828
3/8	0.3750	9.525	7/8	0.8750	22.225
25/64	0.3906	9.922	57/64	0.8906	22.622
13/32	0.4063	10.319	29/32	0.9063	23.019
27/64	0.4219	10.716	59/64	0.9219	23.416
7/16	0.4375	11.113	15/16	0.9375	23.813
29/64	0.4531	11.509	61/64	0.9531	24.209
15/32	0.4688	11.906	31/32	0.9688	24.606
31/64	0.4844	12.303	63/64	0.9844	25.003
1/2	0.5000	12.700	1	1.0000	25.400

Conversion Factor: 1 inch = 25.4 mm

Newton-Meter to Foot-Pound Conversions

Conversion Chart

N•m	ft-lb	N•m	ft-lb	N•m	ft-lb
1	9 in-lb	55	41	155	114
5	44 in-lb	60	44	160	118
6	53 in-lb	65	48	165	122
7	62 in-lb	70	52	170	125
8	71 in-lb	75	55	175	129
9	80 in-lb	80	59	180	133
10	89 in-lb	85	63	185	136
11	97 in-lb	90	66	190	140
12	106 in-lb	95	70	195	144
14	124 in-lb	100	74	200	148
15	133 in-lb	105	77	205	151
16	142 in-lb	110	81	210	155
18	159 in-lb	115	85	215	159
20	15 ft-lb	120	89	220	162
25	18	125	92	225	165
30	22	130	96	230	170
35	26	135	100	235	173
40	30	140	103	240	177
45	33	145	107	245	180
50	37	150	111	250	184
NOTE: To convert from Newton-Meters to Kilogram-Meters divide Newton-Meters by 9.803.					

Pipe Plug Torque Values

Torque Table

Size		Torque		Torque	
Thread	Actual Thread O.D.	In Aluminum Components		In Cast Iron or Steel Components	
in	**in**	**N•m**	**ft-lb**	**N•m**	**ft-lb**
1/16	0.32	5	45 in-lb	15	10
1/8	0.41	15	10	20	15
1/4	0.54	20	15	25	20
3/8	0.68	25	20	35	25
1/2	0.85	35	25	55	40
3/4	1.05	45	35	75	55
1	1.32	60	45	95	70
1-1/4	1.66	75	55	115	85
1-1/2	1.90	85	65	135	100

Tap-Drill Chart - U.S. Customary and Metric

General Information

NOTE ON SELECTING TAP-DRILL SIZES: The tap drill sizes shown on this card give the theoretical tap drill size for approximately 60% and 75% of full thread depth. Generally, it is recommended that drill sizes be selected in the 60% range as these sizes will provide about 90% of the potential holding power. Drill sizes in the 75% range are recommended for shallow hole tapping (less than 1 1/2 times the hole diameter) in soft metals and mild steel.

Tap Size		Drill Size
60%	75%	
		48
		1.95mm
		5/64
	3-48	47
		2.00mm
	M2.5x.45	2.05mm
		46
3-48	3056	45
		2.10mm
M2.5x.45	M2.6x.45	2.15mm
3-56	4-36	44
		2.20mm
M2.6x.45		2.25mm
4-36	4-40	43
		2.30mm
		2.35mm
4-40	4-48	42
		3/32
	M3x.6	2.40mm
4-48		41
		2.45mm
		40
M3x.6	M3x.5	2.50mm
		39
	5-40	38
M3x.5		2.60mm
5-40	5-44	37
		2.70mm
5-44	6-32	36
		2.75mm
		7/64
		35
		2.80mm
		34
6-32	6-40	33
	M3.5x6	2.90mm
		32
M3.5x6		3.00mm
6-40		31
		3.10mm
		1/8
		3.20mm
	M4x.75	3.25mm
		30
	M4x.7	3.30mm
M4x.75		3.40mm
M4x.7	8-32	29
		3.50mm
	8-36	28
8-32		9/64
		3.60mm
8-36		27
		3.70mm
		26
	M4.5x.75	3.75mm
	10-24	25
		3.80mm
		24
M4.5x.75		3.90mm
		23
		5/32
10-24		22
	M5x1	4.00mm
	10-32	21
		20
	M5x.9	4.10mm
M5x1	M5x.8	4.20mm
10-32		19
M5x.9		4.25mm
M5x.8		4.30mm
		18
		11/64
		17

Tap Size		Drill Size
60%	75%	
		4.40mm
	12-24	16
		4.50mm
		15
	M5.5x.9	4.60mm
12-24	12-28	14
		13
		4.70mm
M5.5x.9		4.75mm
12-28		3/16
		12
		4.80mm
		11
		4.90mm
		10
		9
	M6x1	5.00mm
		8
		5.10mm
	1/4-20	7
		13/64
		6
M6x1		5.20mm
		5
	M6x.75	5.25mm
		5.30mm
1/4-20		4
M6x.75		5.40mm
	1/4-28	3
		5.50mm
		7/32
		5.60mm
1/4-28		2
		5.70mm
		5.75mm
		1
		5.80mm
		5.90mm
		A
		15/64
	M7x1	6.00mm
		B
		6.10mm
		C
M7x1		6.20mm
		D
	M7x.75	6.25mm
		6.30mm
		E
		1/4
M7x.75		6.40mm
		6.50mm
	5/16-18	F
		6.60mm
		G
		6.70mm
		17/64
	M8x1.25	6.75mm
5/16-18		H
		6.80mm
		6.90mm
	5.16-24	I
M8x1.25	M8x1	7.00mm
		J
		7.10mm
5/16-24		K
		9/32
M8x1		7.20mm
		7.25mm
		7.30mm
		L
		7.40mm
		M

Tap Size		Drill Size
60%	75%	
		7.50mm
		19/64
		7.60mm
		N
		7.70mm
	M9x1.25	7.75mm
		7.80mm
		7.90mm
	3/8-16	5/16
M9x1.25	M9x1	8.00mm
		O
		8.10mm
M9x1		8.20mm
		P
		8.25mm
		8.30mm
3/8-16	1/8-27NPT	21/64
		8.40mm
	3/8-24	Q
	M10x1.5	8.50mm
		8.60mm
		R
3/8-24		8.70mm
1/8-27NPT		11/32
	M10x1.25	8.75mm
M10x1.5		8.80mm
		S
		8.90mm
M10x1.25	M10x1	9.00mm
		T
		9.10mm
		23/64
M10x1		9.20mm
		9.30mm
	7/16-14	U
		9.40mm
	M11x1.5	9.50mm
		3/8
		V
		9.60mm
		9.70mm
		9.75mm
M11x1.5		9.80mm
7/16-14		W
		9.90mm
	7/16-20	25/64
		10.00mm
7/16-20		X
	M12x1.75	10.20mm
		Y
		13/32
		Z
M12x1.75	M12x1.5	10.50mm
	1/2-13	27/64
M12x1.5	M12x1.25	10.75mm
M12x1.25		11.00mm
1/2-13		7/16
1/4-18NPT		
		11.25mm
		11.50mm
		29/64
		11.75mm
		11.50mm
	1/2-20	29/64
	9/16-12	15/32
	M14x2	12.00m
		12.25mm
9/16-12		31/64
M14x2	M14x1.5	12.50mm
	9/16-18	1/2
M14x1.5	M14x1.25	12.75mm
M14x1.25		13.00mm
9/16-18		33/64

Tap Size		Drill Size
60%	75%	
		13.25mm
	5/8-11	17/32
	M15x1.5	13.50mm
M15x1.5		13.75mm
5/8-11		35/64
	M16x2	14.00mm
		14.25mm
	5/8-18	9/16
M16x2	M16x1.5	14.50mm
5/8-18		37/64
		14.75mm
M16x1.5		15.00mm
		19.32
		15.25mm
		39/64
	M17x1.5	15.50mm
M17x1.5	M18x2.5	15.75mm
		5/8
M18x2.5	M18x2	16.00mm
M18x2		16.25mm
	3/4-10	41/64
	M18x1.5	16.50mm
3/4-10	M19x2.5	21/32
M18x1.5		16.75mm
M19x2.5		17.00mm
		43/64
		17.25mm
3/4-16	3/4-16	11/16
	M20x2.5	17.50mm
		17.75mm
		45/64
M20x2.5	M20x2	18.00mm
M20x2		18.25mm
		23/32
	M20x1.5	18.50mm
		47/64
M20x1.5		18.75mm
		19.00mm
		3/4
		19.25mm
	7/8-9	49/64
	M22x2.5	19.50mm
7/8-9		25/32
		19.75mm
M22x2.5	M22x2	20.00mm
	7/8-14	51/64
M22x2		20.25mm
	M22x1.5	20.50mm
7/8-14		13/16
		20.75mm
M22x1.5	M24x3	21.00mm
		53/64
		21/25mm
		27/32
M24x3		21.50mm
		21.75mm
		55/64
	M24x2	22.00mm
	1"-8	7/8
M24x2		22.25mm
	M24x1.5	22.50mm
1"-8		57/64
M24x1.5		22.75mm
	M25x2	23.00mm
	1"-12	29/32
M25x2		23.25mm
1"x12	1"-14	59/64
	M25x1.5	23.50mm
M20x1.5		23.75mm
1"-14		15/16

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Weights and Measures - Conversion Factors

Conversion Chart

Quantity	U.S. Customary		Metric		From U.S. Customary To Metric Multiply By	From Metric To U.S. Customary Multiply By
	Unit Name	Abbreviation	Unit Name	Abbreviation		
Area	sq. inch	in^2	sq. millimeters	mm^2	645.16	0.001550
			sq. centimeters	cm^2	6.452	0.155
	sq. foot	ft^2	sq. meter	m^2	0.0929	10.764
Fuel Consumption	pounds per horsepower hour	lb/hp-hr	grams per kilowatt hour	g/kW-hr	608.277	0.001645
Fuel Performance	miles per gallon	mpg	kilometers per liter	km/l	0.4251	2.352
	gallons per mile	gpm	liters per kilometer	l/km	2.352	0.4251
Force	pounds force	lbf	Newton	N	4.4482	0.224809
Length	inch	in	millimeters	mm	25.40	0.039370
	foot	ft	millimeters	mm	304.801	0.00328
Power	horsepower	hp	kilowatt	kW	0.746	1.341
Pressure	pounds force per sq. inch	psi	kilopascal	kPa	6.8948	0.145037
	inches of mercury	in Hg	kilopascal	kPa	3.3769	0.29613
	inches of water	in H_2O	kilopascal	kPa	0.2488	4.019299
	inches of mercury	in Hg	millimeters of mercury	mm Hg	25.40	0.039370
	inches of water	in H_2O	millimeters of water	mm H_2O	25.40	0.039370
	bars	bars	kilopascals	kPa	100.001	0.00999
	bars	bars	millimeters of mercury	mm Hg	750.06	0.001333
Temperature	fahrenheit	°F	centigrade	°C	(°F-32) ÷1.8	(1.8 x °C) +32
Torque	pound force per foot	ft-lb	Newton-meter	N•m	1.35582	0.737562
	pound force per inch	in-lb	Newton-meter	N•m	0.113	8.850756
Velocity	miles/hour	mph	kilometers/hour	kph	1.6093	0.6214
Volume: liquid displacement	gallon (U.S.)	gal.	liter	l	3.7853	0.264179
	gallon (Imp*)	gal.	liter	l	4.546	0.219976
	cubic inch	in^3	liter	l	0.01639	61.02545
	cubic inch	in^3	cubic centimeter	cm^3	16.387	0.06102
Weight (mass)	pounds (avoir.)	lb	kilograms	kg	0.4536	2.204623
Work	British Thermal Unit	BTU	joules	J	1054.5	0.000948
	British Thermal Unit	BTU	kilowatt-hour	kW-hr	0.000293	3414
	horsepower hours	hp-hr	kilowatt-hour	kW-hr	0.746	1.341

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

Notes

Fault Codes

Index

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