ENGINE OWNER'S MANUAL

QSX15L ENGINE

CUMMINS BULLETIN # 4332669

Doosan Infracore Portable Power
1293 Glenway Drive
Statesville, N.C. 28625
DoosanPortablePower.com

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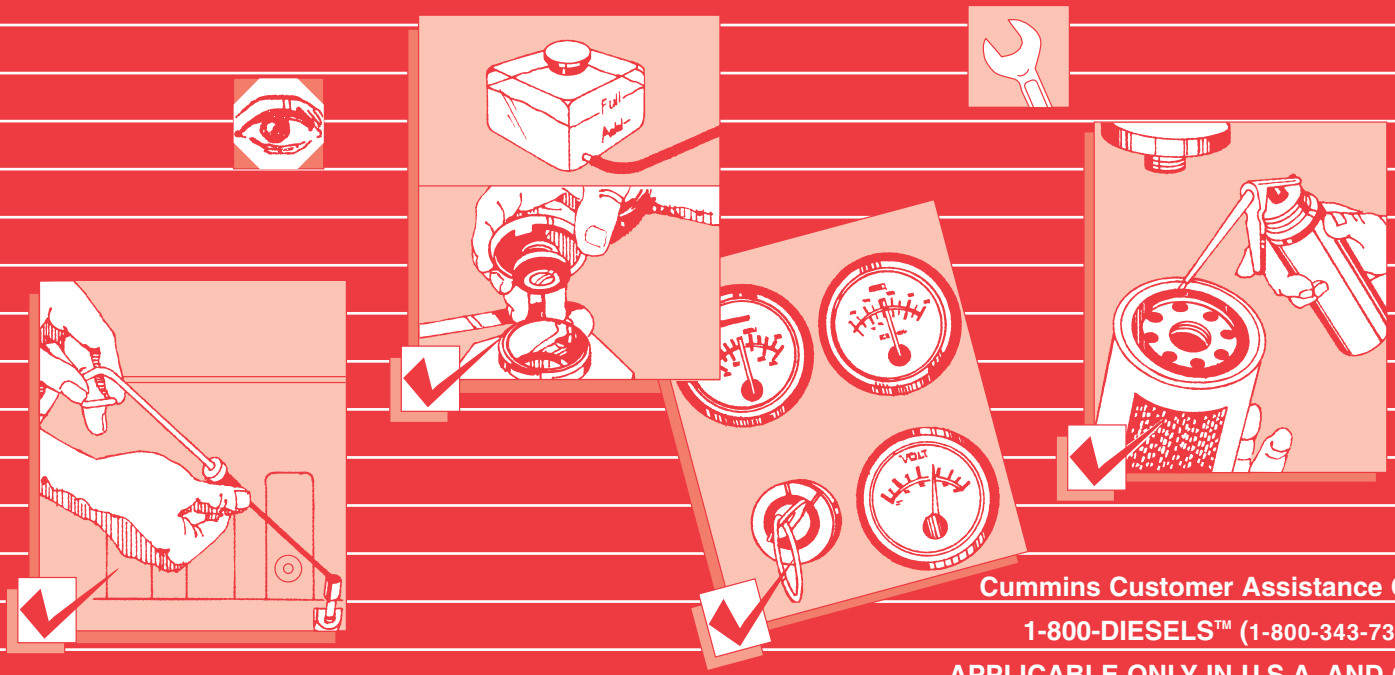
Owners Manual
QSX15 CM2350 X105



Cummins Customer Assistance Center

1-800-DIESELS™ (1-800-343-7357)

APPLICABLE ONLY IN U.S.A. AND CANADA

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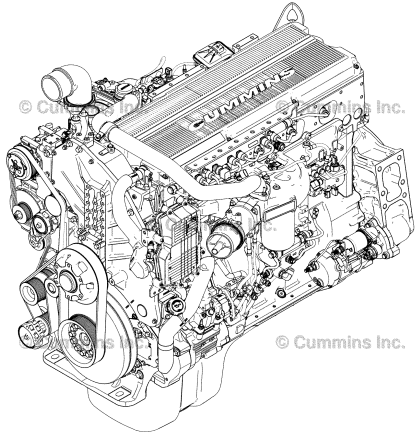
QSX15 CM2350 X105



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Foreword

This manual contains information for the correct operation and maintenance of your Cummins engine.

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

Keep this manual with the equipment. If the equipment is traded or sold, give the manual to the new owner.

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

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

NOTE: Warranty information is located in Section W. Make sure you are familiar with the warranty or warranties applicable to your engine.

Table of Contents

Important Reference Numbers

Fill in the part name and number in the blank spaces provided below. This will give you a reference whenever service or maintenance is required.

Name	Number	Number
Engine Model		
Engine Serial Number (ESN)		
Control Parts List (CPL)		
Fuel Pump Part Number		
Electronic Control Module (ECM)		
Electronic Control Module Serial Numbers (ECM)		
Filter Part Numbers:		
• Air Cleaner Element		
• Lubricating Oil		
• Fuel		
• Fuel-Water Separator		
• Coolant		
• Crankcase Ventilation		
• Cummins Particulate Filter		
Governor Control Module (GCM) (if applicable)		
Belt Part Numbers:		

•		
•		
•		
Clutch or Marine Gear (if applicable):		
• Model		
• Serial Number		
• Part Number		
• Oil Type		
• Sea Water Pump		
- Model		
- Part Number		

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Section i - Introduction

Section Contents

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Symbols

General Information

The following symbols have been used in this manual to help communicate the intent of the instructions. When one of the symbols appears, it conveys the meaning defined below:

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

CAUTION - Minor personal injury can result or a part, an assembly, or the engine can be damaged if the caution instructions are **not** followed.

Indicates a **REMOVAL or DISASSEMBLY** step.

Indicates an **INSTALLATION or ASSEMBLY** step.

INSPECTION is required.

CLEAN the part or assembly.

PERFORM a mechanical or time **MEASUREMENT**.

LUBRICATE the part or assembly.

Indicates that a **WRENCH or TOOL SIZE** will be given.

TIGHTEN to a specific torque.

PERFORM an electrical **MEASUREMENT**.

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

The component weighs 23 kg [50 lb] or more. To avoid personal injury, use a hoist or get assistance to lift the component.

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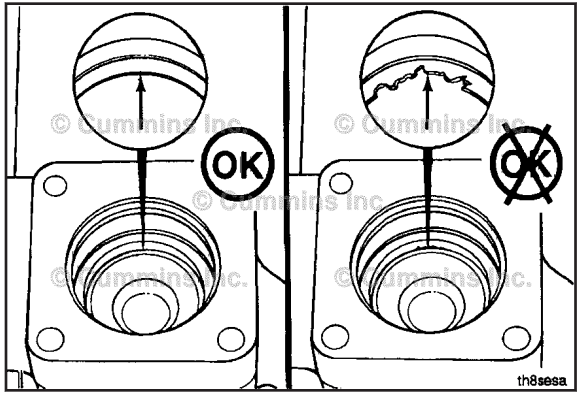

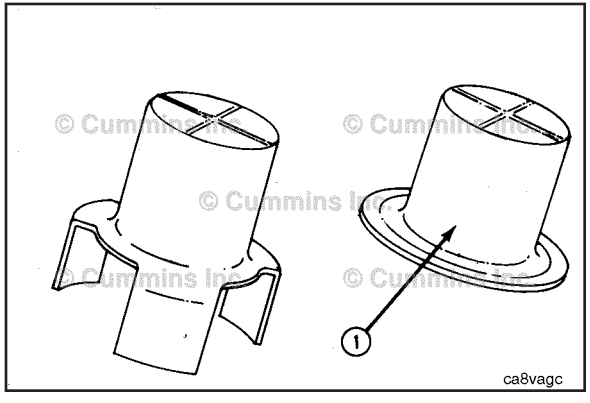

Illustrations

General Information

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

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

General Safety Instructions

Important Safety Notice

⚠ WARNING ⚠

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

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

- Work in an area surrounding the product that is dry, well lit, ventilated, free from clutter, loose tools, parts, ignition sources and hazardous substances. Be aware of hazardous conditions that can exist.
- **Always** wear protective glasses and protective shoes when working.
- Rotating parts can cause cuts, mutilation or strangulation.
- Do **not** wear loose-fitting or torn clothing. Remove all jewelry when working.
- Disconnect the battery (negative [-] cable first) and discharge any capacitors before beginning any repair work. Disconnect the air starting motor if equipped to prevent accidental engine starting. Put a "Do **Not** Operate" tag in the operator's compartment or on the controls.
- Use ONLY the proper engine barring techniques for manually rotating the engine. Do **not** attempt to rotate the crankshaft by pulling or prying on the fan. This practice can cause serious personal injury, property damage, or damage to the fan blade(s) causing premature fan failure.
- If an engine has been operating and the coolant is hot, allow the engine to cool before slowly loosening the filler cap to relieve the pressure from the cooling system.

- **Always** use blocks or proper stands to support the product before performing any service work. Do **not** work on anything that is supported ONLY by lifting jacks or a hoist.
- Relieve all pressure in the air, oil, fuel, and cooling systems before any lines, fittings, or related items are removed or disconnected. Be alert for possible pressure when disconnecting any device from a system that utilizes pressure. Do **not** check for pressure leaks with your hand. High pressure oil or fuel can cause personal injury.
- To reduce the possibility of suffocation and frostbite, wear protective clothing and ONLY disconnect liquid refrigerant (Freon) lines in a well ventilated area. To protect the environment, liquid refrigerant systems **must** be properly emptied and filled using equipment that prevents the release of refrigerant gas (fluorocarbons) into the atmosphere. Federal law requires capturing and recycling refrigerant.
- To reduce the possibility of personal injury, use a hoist or get assistance when lifting components that weigh 23 kg [50 lb] or more. Make sure all lifting devices such as chains, hooks, or slings are in good condition and are of the correct capacity. Make sure hooks are positioned correctly. **Always** use a spreader bar when necessary. The lifting hooks **must not** be side-loaded.
- Corrosion inhibitor, a component of SCA and lubricating oil, contains alkali. Do **not** get the substance in eyes. Avoid prolonged or repeated contact with skin. Do **not** swallow internally. In case of contact, immediately wash skin with soap and water. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. IMMEDIATELY CALL A PHYSICIAN. KEEP OUT OF REACH OF CHILDREN.
- Naptha and Methyl Ethyl Ketone (MEK) are flammable materials and **must** be used with caution. Follow the manufacturer's instructions to provide complete safety when using these materials. KEEP OUT OF REACH OF CHILDREN.
- To reduce the possibility of burns, be alert for hot parts on products that have just been turned off, exhaust gas flow, and hot fluids in lines, tubes, and compartments.
- **Always** use tools that are in good condition. Make sure you understand how to use the tools before performing any service work. Use ONLY genuine Cummins® or Cummins ReCon® replacement parts.

- **Always** use the same fastener part number (or equivalent) when replacing fasteners. Do **not** use a fastener of lesser quality if replacements are necessary.
- When necessary, the removal and replacement of any guards covering rotating components, drives, and/or belts should only be carried out be a trained technician. Before removing any guards the engine **must** be turned off and any starting mechanisms **must** be isolated. All fasteners **must** be replaced on re-fitting the guards.
- Do **not** perform any repair when fatigued or after consuming alcohol or drugs that can impair your functioning.
- Some state and federal agencies in the United States of America have determined that used engine oil can be carcinogenic and can cause reproductive toxicity. Avoid inhalation of vapors, ingestion, and prolonged contact with used engine oil.
- Do **not** connect the jumper starting or battery charging cables to any ignition or governor control wiring. This can cause electrical damage to the ignition or governor.
- **Always** torque fasteners and fuel connections to the required specifications. Overtightening or undertightening can allow leakage. This is critical to the natural gas and liquefied petroleum gas fuel and air systems.
- **Always** test for fuel leaks as instructed, as odorant can fade.
- Close the manual fuel valves prior to performing maintenance and repairs, and when storing the vehicle inside.
- Coolant is toxic. If **not** reused, dispose of in accordance with local environmental regulations.
- The catalyst reagent contains urea. Do **not** get the substance in your eyes. In case of contact, immediately flood eyes with large amounts of water for a minimum of 15 minutes. Avoid prolonged contact with skin. In case of contact, immediately wash skin with soap and water. Do **not** swallow internally. In the event the catalyst reagent is ingested, contact a physician immediately.
- The catalyst substrate contains Vanadium Pentoxide. Vanadium Pentoxide has been determined by the State of California to cause cancer. Always wear protective gloves and eye protection when handling the catalyst assembly. Do not get the catalyst material in your eyes. In Case of contact, immediately flood eyes with large amounts of

water for a minimum of 15 minutes. Avoid prolonged contact with skin. In case of contact, immediately wash skin with soap and water.

- The Catalyst substrate contains Vanadium Pentoxide. Vanadium Pentoxide has been determined by the State of California to cause cancer. In the event the catalyst is being replaced, dispose of in accordance with local regulations.
- California Proposition 65 Warning - Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

Acronyms and Abbreviations

General Information

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

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society of Testing and Materials
ATDC	After Top Dead Center
BTU	British Thermal Unit
BTDC	Before Top Dead Center
°C	Celsius
CAN	Controller Area Network
CO	Carbon Monoxide
CCA	Cold Cranking Amperes
CARB	California Air Resources Board
C.I.B.	Customer Interface Box
C.I.D.	Cubic Inch Displacement
CNG	Compressed Natural Gas
CPL	Control Parts List
cSt	Centistokes
DEF	Diesel Exhaust Fluid

DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
ECM	Engine Control Module
EFC	Electronic Fuel Control
EGR	Exhaust Gas Recirculation
EPA	Environmental Protection Agency
°F	Fahrenheit
ft-lb	Foot-Pound Force
FMI	Failure Mode Indentifier
GVW	Gross Vehicle Weight
Hg	Mercury
hp	Horsepower
H_2O	Water
inHg	Inches of Mercury
in H_20	Inches of Water
ICM	Ignition Control Module
IEC	International Electrotechnical Commission
km/l	Kilometers per Liter
kPa	Kilopascal
LNG	Liquid Natural Gas
LPG	Liquified Petroleum Gas

LTA	Low Temperature Aftercooling
MCRS	Modular Common Rail System
MIL	Malfunction Indicator Lamp
MPa	Megapascal
mph	Miles Per Hour
mpq	Miles Per Quart
N•m	Newton-meter
NOx	Mono-Nitrogen Oxides
NG	Natural Gas
O2	Oxygen
OBD	On-Board Diagnostics
OEM	Original Equipment Manufacturer
OSHA	Occupational Safety and Health Administration
PID	Parameter Identification Descriptions
ppm	Parts Per Million
psi	Pounds Per Square Inch
PTO	Power Takeoff
REPTO	Rear Power Take Off
RGT	Rear Gear Train
rpm	Revolutions Per Minute
SAE	Society of Automotive Engineers

SCA	Supplemental Coolant Additive
SCR	Selective Catalytic Reduction
STC	Step Timing Control
SID	Subsystem Identification Descriptions
TDC	Top Dead Center
VDC	Volts of Direct Current
VGT	Variable Geometry Turbocharger
VS	Variable Speed
VSS	Vehicle Speed Sensor

Section E - Engine and System Identification

Section Contents

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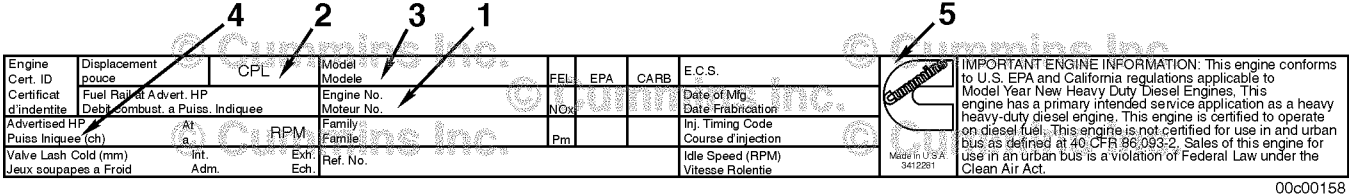
Engine Identification

Engine Dataplate



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The engine dataplate, located on top of the rocker lever cover, provides the model identification and other important data about the engine.

Have the following engine data available when communicating with a Cummins® Authorized Repair Location. The information on the dataplate is **mandatory** when sourcing service parts:

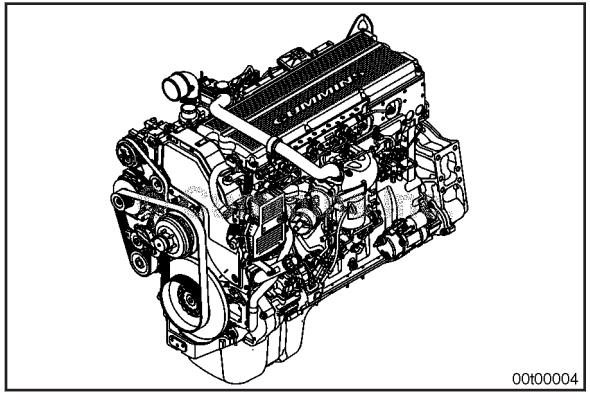
1 Engine serial number (ESN)

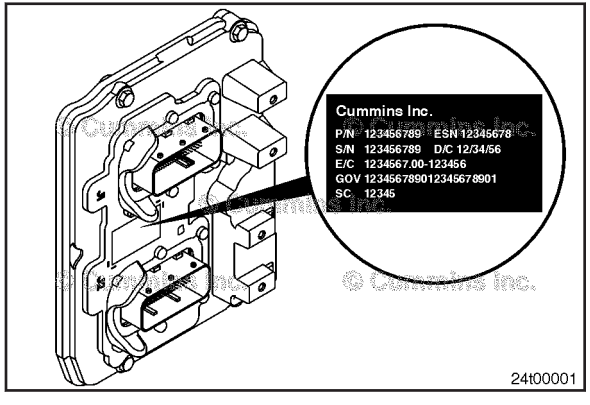
2 Control parts list (CPL)

3 Model

4 Advertised horsepower and rpm

5 Indicates the Emmisions Control Systems.





Cummins® Engine Nomenclature

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

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

Engine Control Module Dataplate

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

The abbreviations on the dataplate are explained as follows:

- P/N = part number
- ESN = engine serial number
- S/N = serial number
- D/C = date code
- E/C = engine calibration.

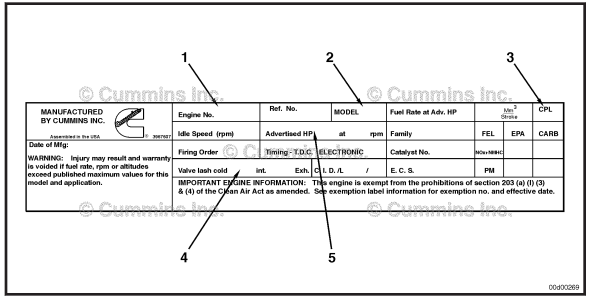
Cummins® Service Engine Model Identification

General Information

The Cummins® Service Engine Model Identification procedure describes:

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

This includes 2013 and later products.



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

Marketing Engine Model Name	Service Model Name
ISX15	ISX15 CM2350 X101

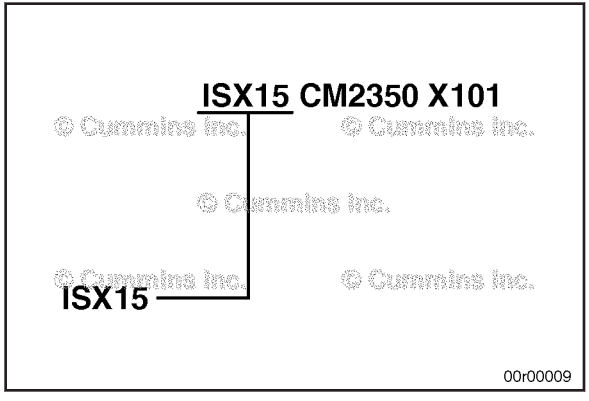
Marketing engine model names (2) can be found on the engine dataplate, Cummins® brochures, and Cummins® promotional literature.

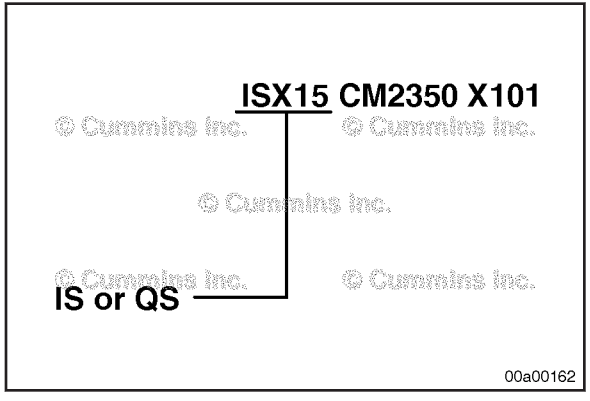
Examples of Cummins® service information and products that use service model names:

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

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

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





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

“IS” prefix designates and On-Highway automotive engine.

“QS” prefix designates an Off-Highway industrial engine.

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

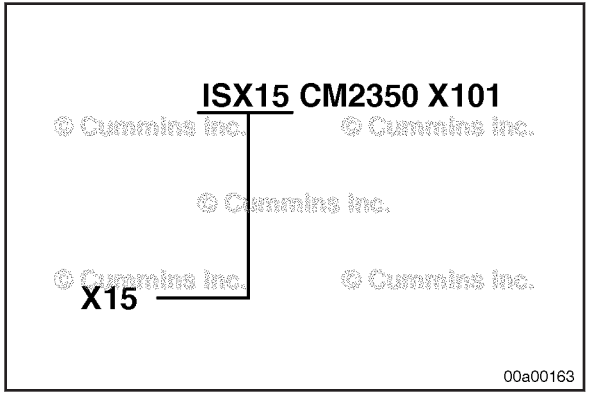
Non-electronic engines do not have an “IS” or “QS” prefix and do not have an electronic control system listed in the service model name.

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

X Series engine

15 Liters in Displacement

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

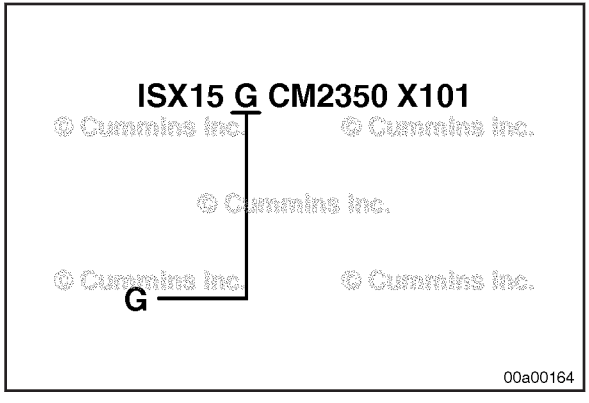


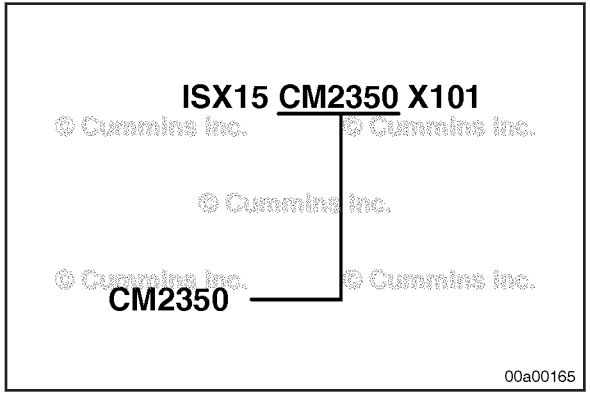
If a “G” indicator is located after the liter displacement, the engine is fueled by natural gas.

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

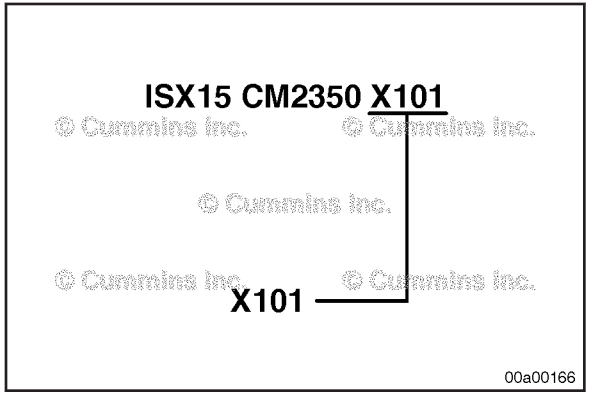
If a “M” is located after the liter displacement, the engine is in a marine application.

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





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



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

The letter is the engine platform designation.

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

Cummins® Product Technology

General Information

The service model name for this product is **QSX15 CM2350 X105**.

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

United States and Canada

- Tier 4 (EPA Final)

European Union

- Stage IV (Euro)

Korea (South)

EPA Product

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

- Charge-Air Cooler (CAC)
- Direct Diesel Injection (DDI)
- Engine Control Module (ECM)
- Exhaust Gas Recirculation (EGR)
- Oxidation Catalyst (OC)
- Periodic Trap Oxidizer (PTOX)

- Selective Catalytic Reduction - Urea (SCR-U)
- Turbocharger (TC).

This engine uses the following product technology:

Engine

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

Electronic Control System

- Engine Control Module (ECM): CM2350
- Electrical System Voltage:
- 12-VDC
- 24-VDC
- Engine Coolant Level Sensor
- Engine Coolant Temperature Sensor
- Engine Oil Pressure Sensor

- Engine Oil Temperature Sensor
- Fuel Rail Pressure Sensor
- Water-in-Fuel Sensor
- Camshaft Position Sensor
- Crankshaft Position Sensor
- EGR Differential Pressure Sensor
- Exhaust Gas Pressure Sensor
- EGR Temperature Sensor
- Turbocharger Speed Sensor
- Turbocharger Compressor Intake Pressure/Temperature Sensor
- Ambient Air Pressure Sensor
- Aftertreatment Diesel Particulate Filter Differential Pressure Sensor
- Crankcase Pressure Sensor
- Aftertreatment Exhaust Gas Temperature Sensor
- Diesel Exhaust Fluid Quality Sensor
- Aftertreatment Intake NOx Sensor
- Aftertreatment Outlet NOx Sensor

Air Handling

- Turbocharger (Single)

- Variable Geometry
- Charge-Air Cooler
- Air Shut Off Valve.

Fuel System

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

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

Industrial

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

- Track Maintenance

Notes

Section 1 - Operating Instructions

Section Contents

Operating Instructions - Overview

General Information

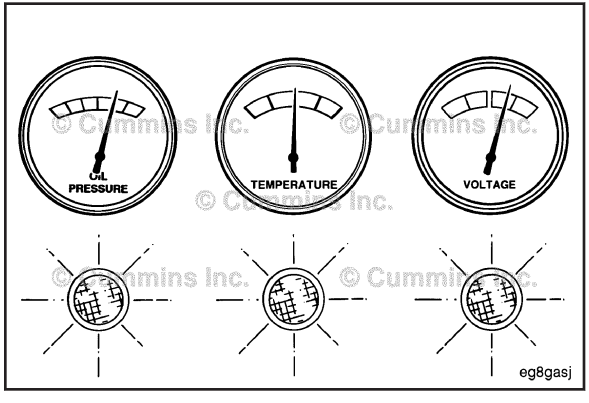
Correct care of your engine will result in longer life, better performance, and more economical operation.

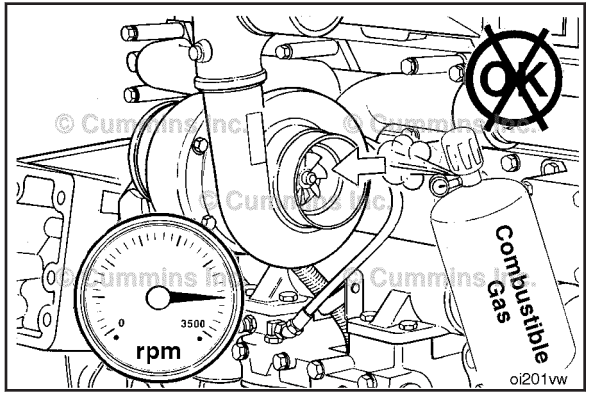
Follow the daily maintenance checks listed in Maintenance Guidelines (Section 2).

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

Check the oil pressure indicators, temperature indicators, warning lights, and other gauges daily to make sure they are operational.

Check the oil pressure, coolant temperatures DEF level, and other engine parameters daily via the OEM front panel to make sure they are operational. Check the panel regularly for any alarm messages. Take appropriate action to rectify the alarm condition or contact your nearest Authorized Cummins® Distributor.





⚠WARNING⚠

Do not operate a diesel engine where there are or can BE COMBUSTIBLE vapors. These vapors can be sucked through the air intake system and cause engine acceleration and over speeding that can result in a fire, an explosion, and extensive property damage. Numerous safety devices are available, such as air intake shutoff devices, to minimize the risk of over speeding where an engine, due to its application, is operating in a combustible environment, such as due to a fuel spill or gas leak. Remember, Cummins Inc. has no way of knowing the use you have for your engine. The equipment owner and operator ARE responsible for safe operation in a hostile environment. Consult A Cummins® Authorized Repair Location for further information.

△CAUTION△

Do not expose the engine to corrosive chemicals. Corrosive chemicals can damage the engine.

Cummins recommends the installation of an air intake shutoff device or a similar safety device to minimize the risk of overspeeding when an engine is operating in a combustible environment, such as due to a fuel spill or gas leak.

Normal Starting Procedure

General Information

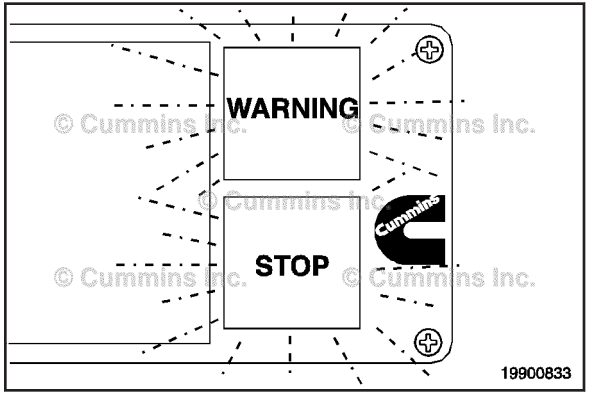
The STOP or STOP ENGINE lamp is red and indicates the need to stop the engine as soon as it can be safely done. The engine **must** then remain shut down until it can be repaired.

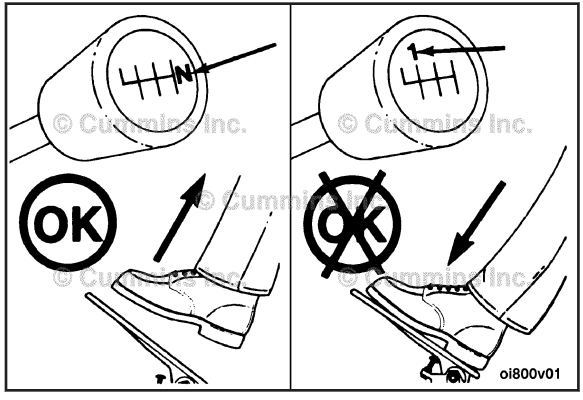
The WARNING or CHECK ENGINE lamp is yellow. When it illuminates, the engine is in need of repair at the first available opportunity.

The yellow lamp will flash for 30 seconds at keyswitch ON when one of the following occurs:

- Maintenance required (if Maintenance Monitor is enabled)
- Water-in-fuel is detected
- Low coolant level.

If the warning light flashes for 30 seconds at keyswitch ON and water is drained from the suction side water-separating fuel filter, the pressure side fuel filter **must** be replaced.





⚠ WARNING ⚠

Do not depress the accelerator pedal or move the accelerator lever from the idle position while cranking the engine. This can result in engine overspeed and severe damage to the engine.

△ CAUTION △

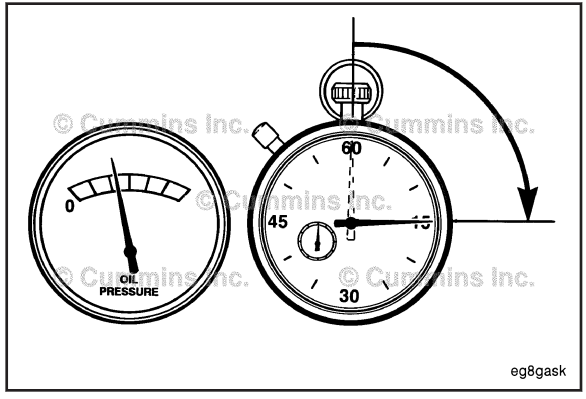
To prevent damage to the starting motor, do not engage the starting motor for more than 30 seconds. Wait 2 minutes between each attempt to start (electrical starting motors only).

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

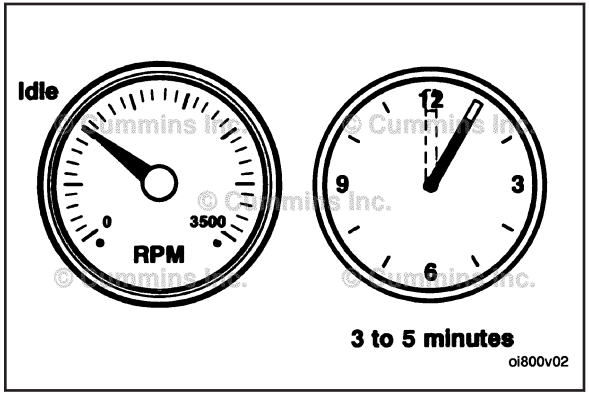
- Disengage the driven unit, or if equipped, put the transmission in neutral.
- With the accelerator pedal or lever in the idle position, turn the keyswitch to the ON position, then turn the keyswitch to the START position.
- If the engine does **not** start after three attempts, check the fuel supply system. Absence of blue or white exhaust smoke during cranking indicates no fuel is being delivered.

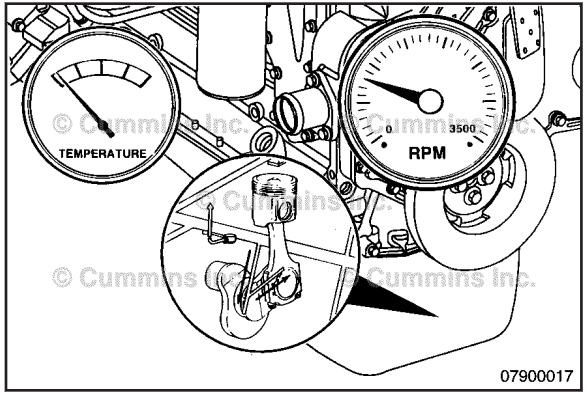
⚠CAUTION⚠

The engine must have adequate oil pressure within 15 seconds after starting. If the warning lamp indicating low oil pressure has not gone out or there is no oil pressure indicated on a gauge within 15 seconds, shut OFF the engine immediately to reduce the possibility of engine damage. The low oil pressure troubleshooting procedure is located in Troubleshooting Symptoms (Section TS).

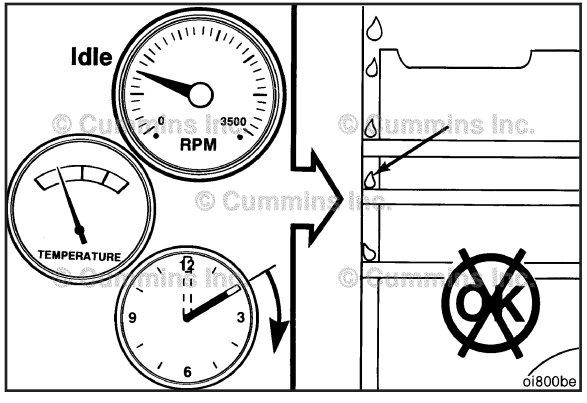


Idle the engine 3 to 5 minutes before operating with a load.





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



⚠CAUTION⚠

Do not operate engine at low idle for long periods with engine coolant temperature below the minimum specification in Coolant Recommendations and Specifications (Section V). Low coolant temperature can result in:

- Fuel dilution of the lubricating oil
- Carbon buildup in the cylinder
- Cylinder head valve sticking
- Reduced performance.

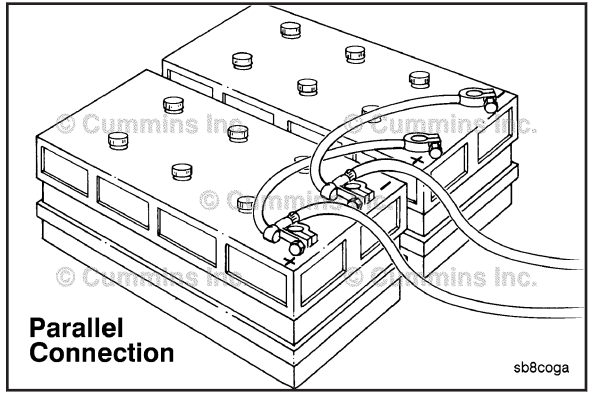
Jump Starting

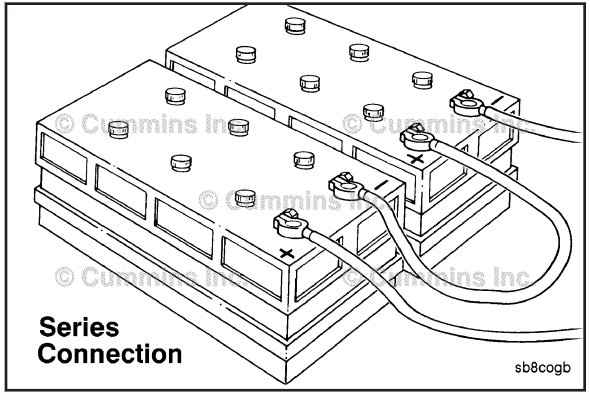
⚠WARNING⚠
Batteries can emit explosive gases. To reduce the possibility of personal injury, always ventilate the compartment before servicing the batteries. To reduce the possibility of arcing, remove the negative (-) battery cable first and attach the negative (-) battery cable last.

△CAUTION△
When using jumper cables to start the engine, make sure to connect the cables in parallel: Positive (+) to positive (+) and negative (-) to negative (-). When using an external electrical source to start the engine, turn the disconnect switch to the OFF position. Remove the key before attaching the jumper cables.

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

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





This illustration shows a typical series battery connection. This arrangement, positive (+) to negative (-), doubles the voltage.

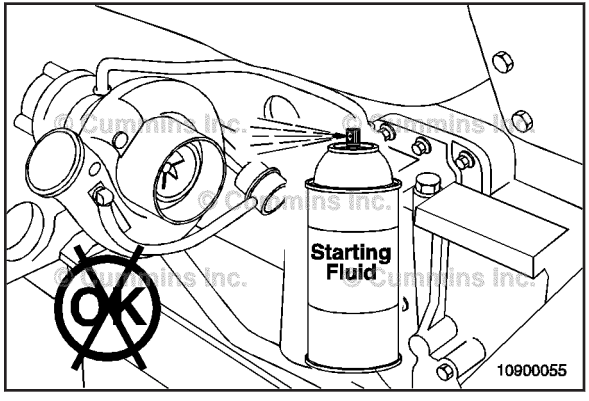
Cold Weather Starting

General Information

Follow the Normal Starting Procedure in this section. In cold weather, the engine can run longer at idle but **only** until the minimum specified oil pressure is detected by the engine control module (ECM).

Using Starting Aids

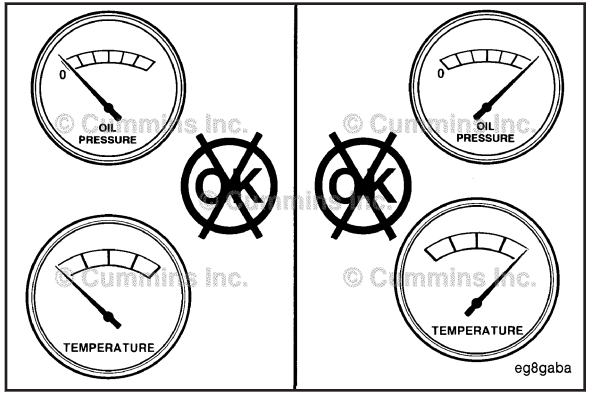
Cold weather starting aids are available for the engine. Contact a Cummins® Authorized Repair Location for more information.



Starting Procedure After Extended Shutdown or Oil Change

General Information

Follow the Normal Starting Procedure in this section. The engine will run at idle **only** until the minimum specified oil pressure is detected by the engine control module (ECM).



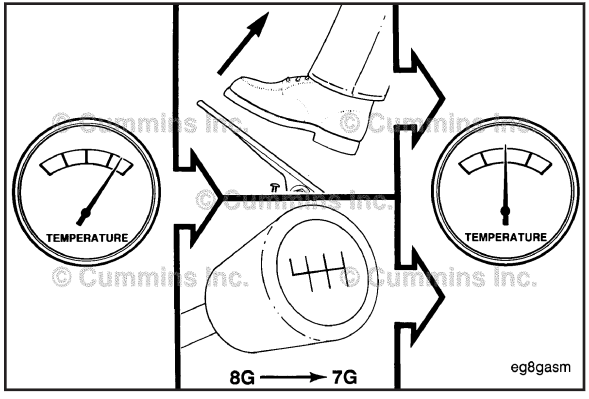
Operating the Engine

Normal

If equipped, monitor the oil pressure and coolant temperature gauges frequently. Refer to Lubricating Oil System specifications and Cooling System specifications, in Maintenance Specifications (Section V) for recommended operating pressures and temperatures. Shut off the engine if any pressure or temperature does **not** meet the specifications.

Continuous operation with engine coolant temperature above or below the engine coolant temperature specifications listed in Maintenance Specifications (Section V) can damage the engine.

If an overheating condition starts to occur, reduce the power output of the engine by releasing the accelerator pedal or lever or shifting the transmission to a lower gear, or both, until the temperature returns to the normal operating range. If the engine temperature does **not** return to normal, shut off the engine, and refer to Troubleshooting Symptoms (Section TS), or contact a Cummins® Authorized Repair Location.



⚠CAUTION⚠

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

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

Ambient Temperature

0 to -32°C [32 to -25°F]

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

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

-32 to -54°C [-25 to -65°F]

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

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

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

Winterfronts and Shutters

Winterfronts and shutters can be used on a vehicle or equipment to reduce air flow through the radiator core into the engine compartment. This can reduce the time required to warm the engine and help maintain the engine coolant temperature. The engine coolant temperature specifications are in the Maintenance Specification (Section V).

Unique Operating Characteristics of an Engine with EGR

Variable Geometry Turbocharger

The variable geometry turbocharger is used to create back pressure in the exhaust system to aid in the exhaust gas recirculation (EGR) flow. Non-EGR engines typically utilize wastegated turbochargers that minimize the amount of exhaust manifold back pressure in the exhaust manifold, but do **not** use all of the exhaust gas flowing through the turbocharger. The design of the variable geometry turbocharger helps create the back pressure needed for EGR flow and still control boost pressure, since there is no exhaust gas being wastegated around the turbine wheel.

What to expect with variable geometry turbocharged engines:

1 Turbocharger boost can fluctuate depending on speed, load, and desired EGR flow.

- Boost will peak briefly at a snap throttle and return to a lower boost setting at the same throttle position and engine load. The control system aids in throttle response and by design, will overshoot its boost needs rather than undershoot.
- Boost can also increase when you let off the throttle, as the control system closes down the variable geometry in anticipation of the next on throttle event.
- When the engine is at a constant speed and experiences no load change, boost can still fluctuate as EGR flow demand is changed by the control system.

2 Boost pressure can vary day to day.

- Boost pressures can vary depending on power requirements, EGR flow requirements, and ambient conditions. Because the control system can closely control the turbocharger the engine **only** gets the boost pressure it needs. For example: The driver can notice boost pressures of around 172 kPa [25 psi] while pulling a hill at 72 kph [45 mph] during the summer with a certain EGR flow. However, in winter conditions the boost pressure can be 138 kPa [20 psi] as EGR demands can change and boost pressure needs **not** be as great.

3 Turbocharger may whistle loudly in certain normal engine operating conditions.

- The turbocharger may whistle loudly periodically when the engine control module (ECM) requests more exhaust heat for aftertreatment regeneration purposes. This turbo whistle has been described as sounding like a boost leak. Read the following procedure for further information regarding variable geometry turbocharger and aftertreatment system interactions. Refer to Procedure 101-047 in Section 1.

Engine Cooling

Because of changes to the cooling system as required by the addition of the EGR system, the engine cooling system characteristics will be different from that of a non-EGR engine.

1 The engine can run cooler at cold ambient air temperatures.

- Due to more coolant flow from the water pump and more capable cooling packages provided by the original equipment manufacturer (OEM), there will be more coolant flow going through the engine. Due to the design changes, when operating in colder ambient temperatures, the engine coolant can average 83°C [180°F]. The engine is designed to run efficiently at lower coolant temperatures. Thermostats **must not** be replaced because the engine will **not** run constantly at 82°C [180°F]. Additional control of coolant temperatures can still be accomplished by using winter fronts, same as today's engines.
- Engines can run hotter at hot ambient air temperatures. Due to added heat rejection from cooling the EGR valve, EGR cooler, and variable geometry turbocharger, the engine has been designed to operate at higher coolant temperatures. It is **not** abnormal to see coolant temperatures between 82°C to 107°C [180°F to 225°F] while operating in hotter ambient temperatures. Coolant fans will engage when the coolant temperature reaches 99°C [210°F]. Engine protection for coolant temperature will begin at 107°C [225°F].
- Thermostat opening is **not** noticeable when monitoring coolant temperatures. Due to decreasing the number of coolant thermostats from two to one on the EGR engine, it is no longer noticeable when the thermostat opens. A gradual climb in coolant temperature occurs as the thermostat opens, compared to the slight decrease and eventual stabilization of temperature seen on engines when the dual thermostats are utilized.

- With the addition of the cooled EGR system, the under hood temperature has increased by approximately 7°C [20°F] compared to an non-EGR engine.

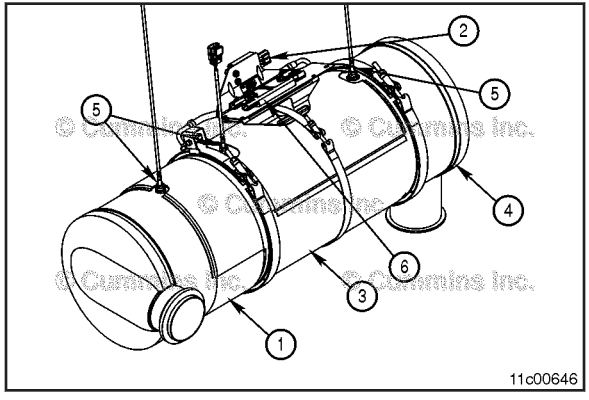
Performance/Driveability

With the addition of the EGR system to the engine, some of the characteristics of the engine are different from that of a non-EGR engine.

- It is normal to see boost pressure fluctuate while the engine brakes are activated. To take full advantage of the increased braking power provided by the addition of the variable geometry turbocharger, the engine brake selector switch level chosen will **not** necessarily activate the same number of engine brakes as a non-EGR engine. The engine control module (ECM) controls the number of engine cylinders that are activated for braking and the variable geometry turbocharger will be positioned to meet the desired braking horsepower. The variable geometry turbocharger will adjust in order to meet the power requirements depending on the engine brake position switch. More braking power correlates to a more closed variable geometry turbocharger position, more cylinders braking, or both.

Shifting Techniques

Drivers have experienced a change in shifting techniques with EGR engines. With the variable geometry turbocharger improving boost response, the engine speed will decelerate and accelerate quicker than a non-EGR. The additional back pressure on the engine during out of gear, no throttle conditions causes the engine speed to drop quickly. The ability of the variable geometry turbocharger to spool up quickly causes quicker engine speed acceleration during out of gear, no throttle conditions. Drivers have characterized this as a more sensitive throttle pedal, meaning small pedal movements create large engine speed changes.



Unique Operating Characteristics of an Engine with Aftertreatment Diesel Particulate Filter

General Information

The aftertreatment system is used to reduce particulate emissions and is composed of six main components:

1 Aftertreatment inlet and aftertreatment diesel oxidation catalyst (DOC)

2 Aftertreatment diesel particulate filter (DPF) differential/outlet pressure sensor

3 Aftertreatment DPF

4 Aftertreatment outlet

5 Aftertreatment exhaust gas temperature sensors

6 Aftertreatment DPF temperature sensor interface module.

The components of the aftertreatment system perform the following functions:

The aftertreatment inlet and outlet adapt the equipment exhaust piping to the aftertreatment system.

The aftertreatment DPF differential/outlet pressure sensor measures:

1 The restriction across the aftertreatment DPF.

2 The pressure on the outlet of the aftertreatment DPF.

The aftertreatment DPF captures the soot and ash from the engine exhaust.

The aftertreatment DOC is used to oxidize fuel in the exhaust in order to create heat for the regeneration process.

The aftertreatment exhaust gas temperature sensors are used to measure the exhaust gas temperatures at various points in the aftertreatment system.

Soot is composed of the partially burned particles of fuel that occur during normal engine operation (black smoke).

Ash is composed of the partially burned particles of engine oil that occur during normal engine operation.

Over time, both soot and ash accumulate in the aftertreatment DPF and **must** be removed. Soot is removed by a process called regeneration. Ash is removed by removing the aftertreatment DPF and cleaning it at specified intervals.

Equipment with an aftertreatment system has three additional indicator lamps on the dashboard. Two of the additional lamps, along with the CHECK ENGINE lamp, alert the operator of the status of the aftertreatment DPF. The third additional indicator lamp indicates the position of the Regeneration Permit switch.

Equipment with an aftertreatment system has three additional indicator lamps. Two of the additional lamps, along with the CHECK ENGINE lamp, alert the operator of the status of the aftertreatment DPF. The third additional indicator lamp indicates the position of the Regeneration Permit switch.

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

Ultra low sulfur diesel fuel is required for an engine equipped with an aftertreatment DPF. If ultra low sulfur diesel is **not** used, the aftertreatment DPF or aftertreatment DOC can be damaged.

NOTE: The blending of fuel with new or used engine lubricating oil or other oils is **not** permitted on equipment using an aftertreatment DPF.

NOTE: Use the following procedure for additional information about the fuel recommendations and specifications required for use in the engine being serviced. Refer to Procedure 018-002 in Section V.

To maximize the maintenance intervals of the aftertreatment DPF, Cummins Inc. requires the use of a lubricating engine oil meeting Cummins® Engineering Standard 20081. The use of oil meeting CES 20081 also requires the use of ultra low sulfur diesel fuel to maintain the specified oil drain interval without risk of engine damage.

NOTE: Use the following procedure for additional information about the lubricating oil recommendations and specifications recommended for use in the engine being serviced. Refer to Procedure 018-003 in Section V.

NOTE: Use the following procedure for information on the Maintenance Schedule, which provides the aftertreatment DPF cleaning intervals for the engine being serviced. Refer to Procedure 102-002 in Section 2.

Regeneration

Regeneration is the process of converting the soot collected in the aftertreatment DPF into carbon dioxide.

The regeneration process requires heat to occur, and can be classified into two different types: passive regeneration and active regeneration.

Passive Regeneration

Passive regeneration occurs when the exhaust temperatures are naturally high enough to oxidize the soot collected in the aftertreatment DPF faster than the soot is collected.

Passive regeneration typically occurs when the equipment is operated under heavy loads.

Active Regeneration

Active regeneration occurs when the exhaust temperatures are **not** naturally high enough to oxidize the soot collected in the aftertreatment DPF faster than it is collected.

Active regeneration requires assistance from the engine in order to increase the exhaust temperature. This is typically accomplished by the engine injecting a small amount of diesel fuel into the exhaust stream, which is then oxidized by the aftertreatment DOC, which creates the heat needed to regenerate the aftertreatment DPF.

Active regeneration will occur more frequently in vehicles with low speed, low load, or stop and go duty cycles.

Active regeneration **only** occurs if the ECM has detected that the aftertreatment DPF restriction has reached a specified limit, and may **only** occur if the vehicle is moving above a speed threshold. The ECM will activate and de-activate active regeneration as needed.

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

During active regeneration, the exhaust temperature can be higher than when the engine is operating at full load. The exhaust temperature during a normal active regeneration event could reach 593°C [1100°F], and possibly 816°C [1500°F] under certain conditions.

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

⚠WARNING⚠

During regeneration, exhaust gas temperature could reach 816°C [1500°F], and exhaust system surface temperature could exceed 740°C [1300°F], which is hot enough to ignite or melt common materials, and to burn the skin. The exhaust and exhaust components can remain hot after the equipment has stopped moving. To avoid the risk of fire, property damage, burns or personal injury, allow the exhaust system to cool before beginning this procedure or repair and make sure that no combustible materials are located where they are likely to come in contact with hot exhaust or exhaust components.

Manual (Non-Mission) Regeneration

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

Manual (non-mission) regeneration is a form of active regeneration that is initiated by the equipment operator when **not** in operation.

Manual (non-mission) regeneration requires an engine speed of approximately 900 to 1200 rpm, depending on the application. The length of a manual (non-mission) regeneration will vary, depending on how full the aftertreatment DPF is, but will typically take anywhere from 45 minutes to 1.5 hours to complete.

A manual (non-mission) regeneration can be initiated in one of two ways:

1 An equipment-mounted manual (non-mission) regeneration switch. Use the owners manual for the location and operation of this switch (this switch may also be called a "parked regeneration" switch or "start" switch). The mounted manual (non-mission) regeneration switch will only initiate a manual (non-mission) regeneration when the aftertreatment DPF lamp is illuminated.

2 INSITE™ electronic service tool can initiate a manual (non-mission) regeneration by starting the Aftertreatment Diesel Particulate Filter Regeneration Test.

⚠ WARNING ⚠

During regeneration, exhaust gas temperature could reach 816°C [1500°F], and exhaust system surface temperature could exceed 740°C [1300°F], which is hot enough to ignite or melt common materials, and to burn people. Depending on application, engine speed may increase and could possibly reach between 900 to 1200 rpm. Follow these instructions to avoid the risk of fire, properly damage, burns, or other serious personal injury.

To perform a manual (non-mission) regeneration, follow the steps listed:

- Select an appropriate location to park the equipment, preferably on a surface that will **not** burn or melt under high exhaust temperatures (such as clean concrete or gravel, **not** grass or asphalt).
- Make sure there are no items within 0.6 m [2 ft] of the exhaust outlet.
- Items that can burn, melt, or explode **must** be kept at least 1.5 m [5 ft] from the exhaust outlet (such as gasoline, paper, plastics, fabrics, compressed gas containers, and hydraulic lines).
- Make sure there are no gases or vapors nearby that can burn, explode, or contribute to a fire (such as liquid propane (LP) gas, gasoline vapors, oxygen, and nitrous oxide).
- Park the vehicle securely. Place the transmission in Park, if provided, otherwise in Neutral. Set wheel chocks at the front and the rear of at least one tire.
- Set up a safe exhaust area. If bystanders might enter the area, set up barriers to keep people at least 1.5 m [5 ft] from the exhaust outlet during the manual (non-mission) regeneration. When indoors, attach an exhaust discharge pipe rated for at least 816°C [1500°F].
- Keep a fire extinguisher nearby.
- Check the exhaust system surfaces. Confirm that nothing is on or near the exhaust system surfaces (such as tools, rags, grease, or debris).
- The clutch pedal is released.

- The brake pedal is released.
- The transmission is in neutral or park.
- PTO or Remote PTO is OFF.
- The vehicle speed is 0 kph [0 mph].
- The throttle pedal is released.
- Initiate the manual (non-mission) regeneration by toggling the equipment-mounted manual (non-mission) regeneration switch or by using INSITE™ electronic service tool.
- Once the manual (non-mission) regeneration is initiated, the engine speed may increase, the turbocharger noise will increase, the High Exhaust System Temperature lamp will illuminat, and the aftertreatment DPF lamp will flash.
- When the ECM detects that the aftertreatment DPF has been regenerated, the engine will automatically return to normal idle speed, if increased.
- Monitor the equipment and surrounding area during the manual (non-mission) regeneration. If any unsafe condition occurs, shut the engine OFF immediately.

To stop a manual (non-mission) regeneration before it has completed, depress the clutch, brake, or throttle pedal. Set the regeneration permit switch to the inhibit position, or turn off the engine.

After the manual (non-mission) regeneration is complete, exhaust gas and surface temperatures will remain elevated for 3 to 5 minutes.

NOTE: Applications that use PTO as the only method of throttle control can activate a manual (non-mission) regeneration in PTO mode.

NOTE: If a manual (non-mission) regeneration is attempted, and the High Exhaust System Temperature lamp does **not** illuminate, contact a Cummins® Authorized Repair Location for assistance.

NOTE: If the low idle engine speed is 900 rpm or greater, the engine speed will **not** increase when a manual (non-mission) regeneration is initiated. Some high idle applications may require an OEM switch to be pressed in order to lower the idle speed and allow a stationary regeneration to initiate. Refer to OEM service manual.

NOTE: If the Idle Ramp Down feature is in use and a manual regeneration is initiated, the engine speed will increase to low idle, then proceed to the regeneration speed. Depending on the idle ramp down settings, there can be a delay between the time the engine reaches low idle and when the engine speed begins to increase toward the regeneration speed.

Aftertreatment Switches

The equipment manufacturer may choose to equip the equipment with up to two switches that interact with the aftertreatment system:

- A manual (non-mission) regeneration switch (can also be called a START switch or PARKED REGENERATION switch).
- An active regeneration permit switch (can also be called an INHIBIT switch, DISABLE switch, or STOP switch)

Both of these switches are optional. Please reference the equipment owners manual for the location and presence of these switches.

The manual (non-mission) regeneration switch is used to initiate a manual (non-mission) regeneration. Reference the Manual (Non-Mission) Regeneration section of this procedure for further instructions.

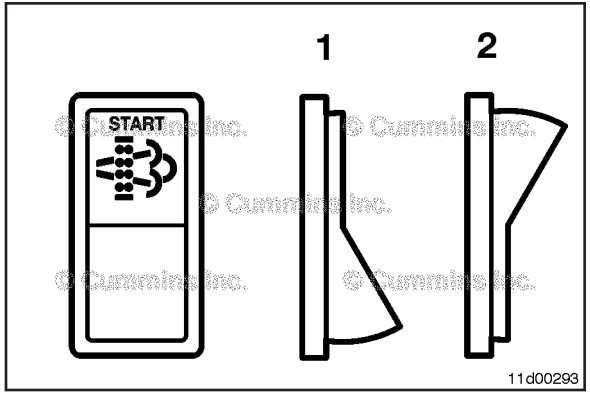
The active regeneration permit switch is used to disable active regeneration of the aftertreatment.

The permit switch **must only** be used for special circumstances where it is desirable to **not** allow an active regeneration event. Prolonged engine operation with this switch engaged may result in illumination of the aftertreatment diesel particulate lamp, as the aftertreatment DPF will continue to accumulate soot as the engine operates.

The aftertreatment switches are typically used in two configurations:

- A two-position switch that is used to activate manual (non-mission) regeneration.
- A three-position switch that is used to activate manual (non-mission) regeneration and also disable active regeneration.

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



A two-position switch (ON and OFF positions) will, when in the ON position (1), activate a manual (non-mission) regeneration.

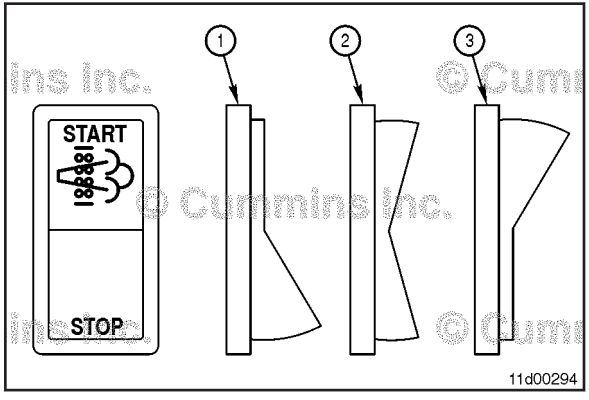
The switch should be left in the OFF position (2) when the switch is **not** being used.

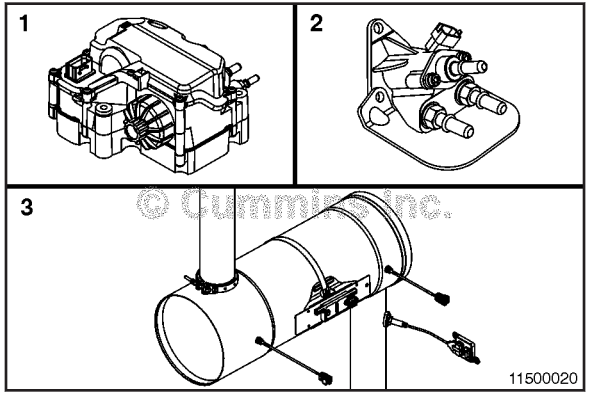
A three-position switch (ON, NEUTRAL, and OFF positions) will typically have both START and PERMIT functions.

In the ON position (1), the START switch is depressed, which will activate a manual (non-mission) regeneration.

In NEUTRAL position (2), neither the START switch or PERMIT switch is depressed as the switch is in the NEUTRAL position. This position is recommended for normal engine operation.

In OFF position (3), the PERMIT switch is depressed. When the switch is in this position, active regeneration of the aftertreatment system will **not** be allowed.





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

General Information

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

1 Aftertreatment diesel exhaust fluid (DEF) dosing unit

2 Aftertreatment DEF dosing valve

3 Aftertreatment SCR catalyst.

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

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

DEF:

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

Reference the DEF Recommendations and Specifications in Section V for DEF specifications. Refer to Procedure 018-026 in Section V.

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

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

NOTE: Reference the Maintenance Schedule for the aftertreatment DEF dosing unit filter maintenance interval. Refer to Procedure 102-002 in Section 2.

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

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

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

Equipment with SCR will be equipped with an additional lamp on the dashboard, the aftertreatment DEF lamp. This lamp, along with the check engine lamp and stop engine lamp, alert the operator to the level of DEF in the tank. As the DEF tank level approaches empty, the aftertreatment DEF lamp will illuminate and engine power will be reduced. Attempting to operate the vehicle with no DEF in the tank will result in the engine being limited to idle speed or automatically shut down.

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

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

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

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

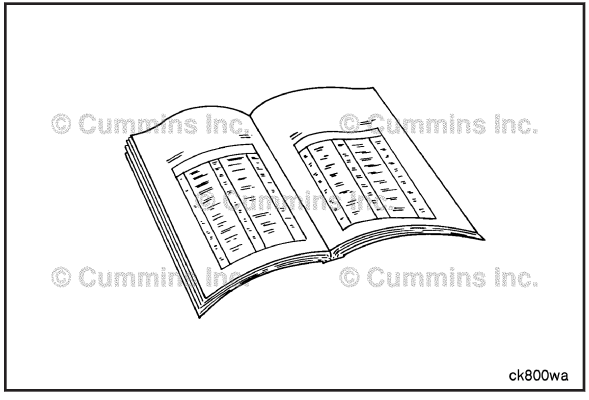
Under certain conditions (cold or very dry), water condensation, in the form of water vapor, can be seen coming from the vehicle tailpipe. This is normal operation and will clear within a few minutes of normal vehicle operation.

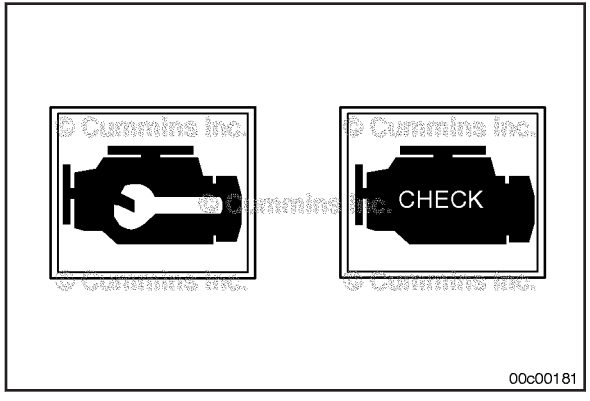
Engine Indicator Lamps

General Information

The following engine indicator lamps cover **only** the lamps controlled by the engine control module (ECM). The vehicle manufacturer can provide additional indicator lamps. Reference the vehicle owners manual for additional lamp information.

- Check engine
- Aftertreatment diesel particulate filter (DPF)
- Stop engine
- Aftertreatment diesel exhaust fluid (DEF)
- Exhaust high temperature





Check Engine Lamp

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

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

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

Another function of the CHECK ENGINE lamp is to flash for 30 seconds at key ON to indicate a maintenance condition. This flashing function is referred to as the MAINTENANCE lamp. The MAINTENANCE lamp could flash for the following reasons:

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

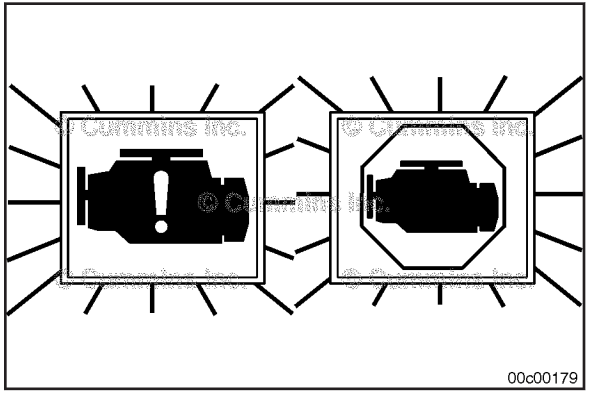
Stop Engine Lamp

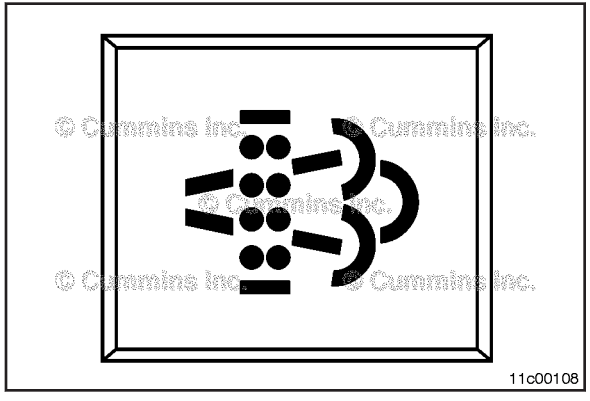
The STOP ENGINE lamp indicates, when illuminated, the need to stop the engine as soon as it can be safely done. The engine **must** remain shut down until the engine can be repaired.

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

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

- The words STOP or STOP ENGINE spelled out
- A symbol of an engine with an exclamation point in the center, similar to the illustration.
- A symbol of a stop sign with an engine outline in the center, similar to the illustration





Aftertreatment Diesel Particulate Filter Lamp

The AFTERTREATMENT DIESEL PARTICULATE FILTER lamp indicates, when illuminated or flashing, the status of the aftertreatment regeneration cleaing events.

An illuminated AFTERTREATMENT DIESEL PARTICULATE FILTER lamp indicates that the aftertreatment DPF needs to be regenerated at the next possible opportunity. This can be accomplished by:

- Changing to a more challenging duty cycle, for at least 20 minutes.
- Performing a stationary regeneration. Follow the instructions in Unique Operating Characteristics of an Engine with Aftertreatment, in Section 1.

NOTE: Stationary regeneration is considered a normal maintenance practice and is **not** covered by Cummins Inc. warranty.

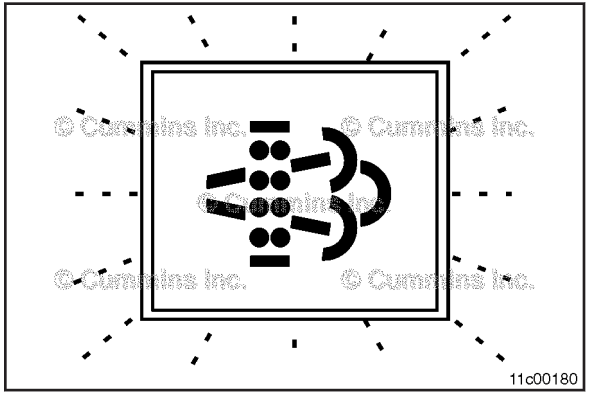
A flashing AFTERTREATMENT DIESEL PARTICULATE FILTER lamp indicates the status of a non-mission (stationary) regeneration when the manual (non-mission) regeneration switch has been activated. See the following procedure for more information on the manual (non-mission) regeneration switch. Refer to Procedure 101-050 in Section 1. When this lamp is flashing, the operator should:

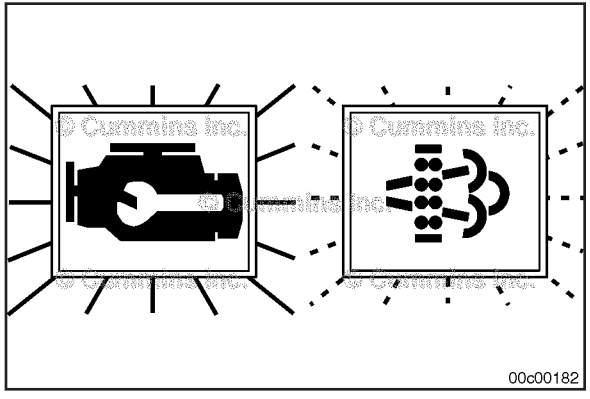
1 Keep the exhaust outlet away from people and anything that can burn, melt, or explode.

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

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

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





A solid AFTERTREATMENT DIESEL PARTICULATE FILTER lamp combined with an illuminated WARNING or CHECK ENGINE lamp indicates that the aftertreatment DPF needs be regenerated immediately. Engine power will be reduced automatically.

When these lamps are illuminated, a stationary regeneration is required.

- Follow the instructions in Unique Operating Characteristics of an Engine with Aftertreatment, in Section 1.

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

NOTE: Stationary regeneration is considered a normal maintenance practice and is **not** covered by Cummins Inc. warranty.

High Exhaust System Temperature Lamp

WARNING

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

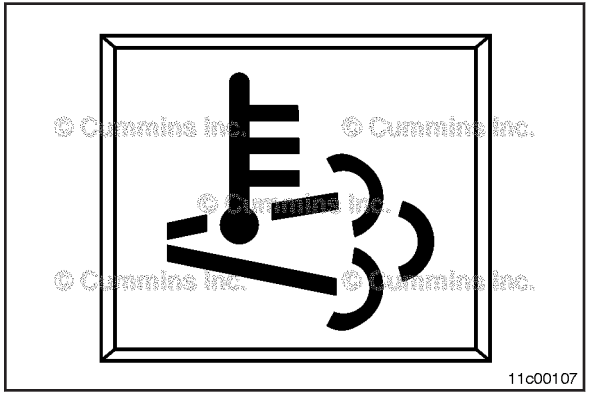
The HIGH EXHAUST SYSTEM TEMPERATURE lamp indicates, when illuminated, that exhaust temperatures are high due to regeneration of the aftertreatment DPF. This lamp can illuminate during normal engine operation or during stationary regeneration.

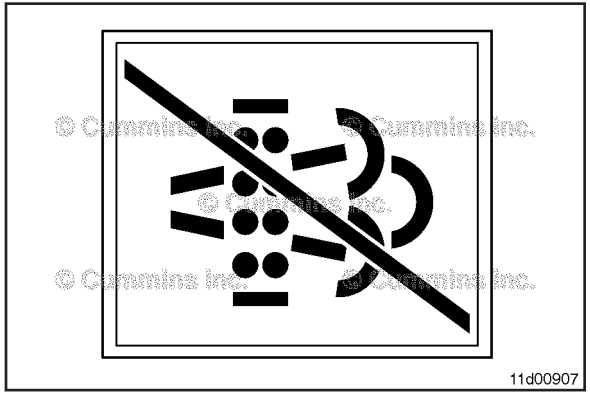
NOTE: The original equipment manufacturer (OEM) determines whether or **not** the HIGH EXHAUST SYSTEM TEMPERATURE lamp is installed on the vehicle. The OEM also specifies the temperatures, vehicle speeds, and other conditions at which the lamp illuminates. Refer to the OEM service manual for additional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

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

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

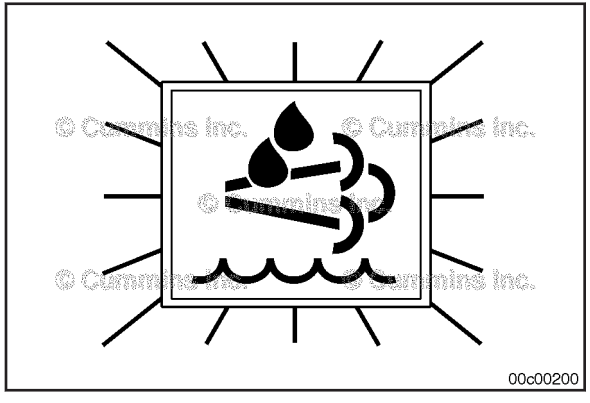
NOTE: The HIGH EXHAUST SYSTEM TEMPERATURE lamp does **not** signify the need for any kind of vehicle or engine service; it merely alerts the vehicle operator to high exhaust temperatures. It will be common for the HIGH EXHAUST SYSTEM TEMPERATURE lamp to illuminate on and off during normal vehicle operation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





Regeneration Disabled Lamp

The REGENERATION DISABLED lamp indicates, when illuminated, the Regeneration Disabled (Inhibit) Switch is active; therefore, automatic and manual (non-mission) regeneration can **not** occur.



Aftertreatment Diesel Exhaust Fluid Lamp

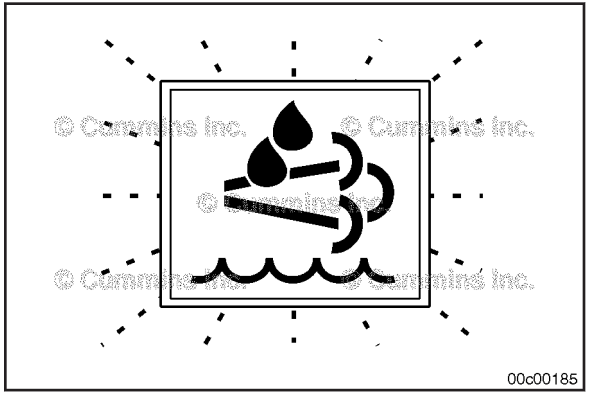
The DIESEL EXHAUST FLUID lamp indicates, when illuminated or flashing, that the DEF level is low.

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

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

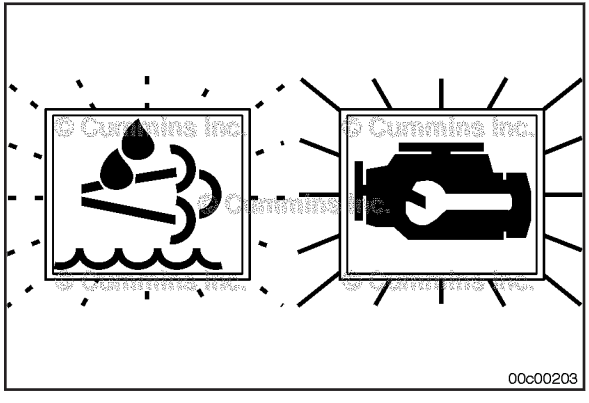
A flashing DIESEL EXHAUST FLUID lamp indicates that the DEF level has fallen below the critical warning level. This can be corrected by filling the DEF tank with DEF.

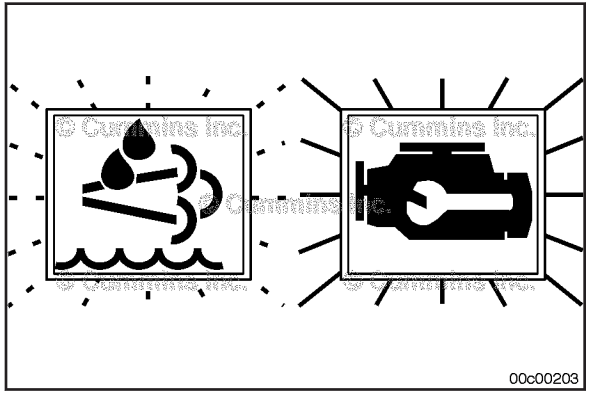
NOTE: It is recommended that the DEF tank be filled completely full of DEF in order to correct any fault conditions.



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

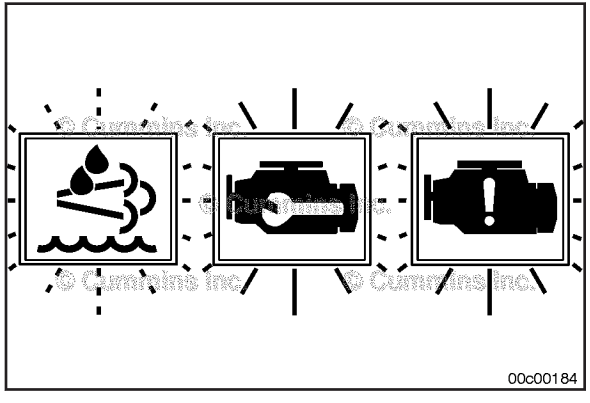
NOTE: It is recommended that the DEF tank be filled completely full of DEF in order to correct any fault conditions.





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

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



If the engine has been operated for 30 minutes after the tank has been emptied, the STOP ENGINE lamp will also be illuminated along with the flashing DIESEL EXHAUST FLUID lamp and illuminated CHECK ENGINE lamp. The engine will also either be limited to idle speed or shut down depending on OEM configuration.

NOTE: In order to remove the idle limitation or engine shutdown, the DEF tank **must** be filled to at least 10 percent volume of the tank.

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

Engine Operating Range

General Information

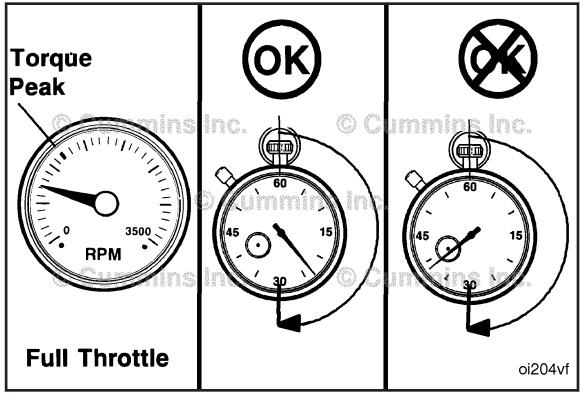
⚠CAUTION⚠

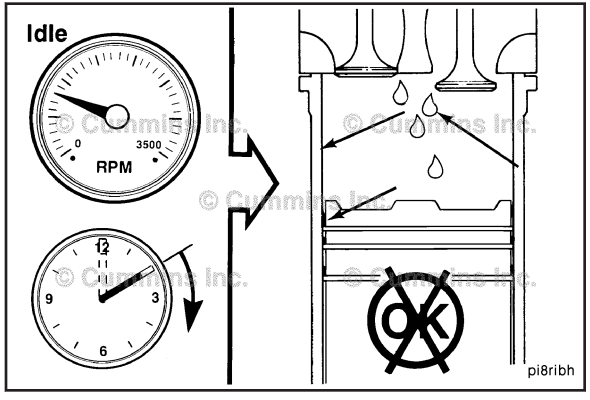
Do not operate the engine at full throttle below peak torque rpm (refer to engine dataplate for peak torque rpm) for more than 30 seconds. Operating the engine at full throttle below peak torque will shorten engine life to overhaul, can cause serious engine damage, and is considered engine abuse.

Cummins® engines are designed to operate successfully at full throttle under transient conditions down to peak torque engine speed. This is consistent with recommended operating practices.

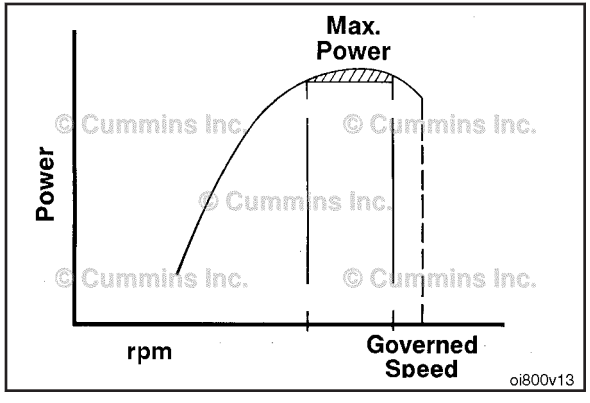
⚠CAUTION⚠

Do not operate the engine beyond the maximum engine speed. Operating the engine beyond the maximum engine speed can cause severe engine damage. Use proper operating techniques for the vehicle, vessel, or equipment to prevent engine overspeed. The maximum engine speed specification is listed in Maintenance Specifications (Section V).





⚠CAUTION⚠
Do not idle the engine for excessively long periods. Long periods of idling, more than 10 minutes, can cause poor engine performance.



Driving Techniques

General Information

The engine produces maximum power at an rpm less than governed engine speed.

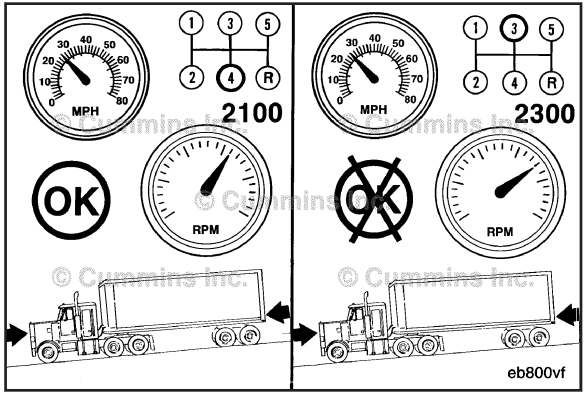
To obtain optimum engine performance on a grade, allow the engine speed to load down to near peak torque before shifting. This will result in an engine operating speed in the maximum power zone after the shift is completed.

Refer to the engine dataplate for peak torque rpm and governed speed rpm.

Engine Braking System

General Information

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

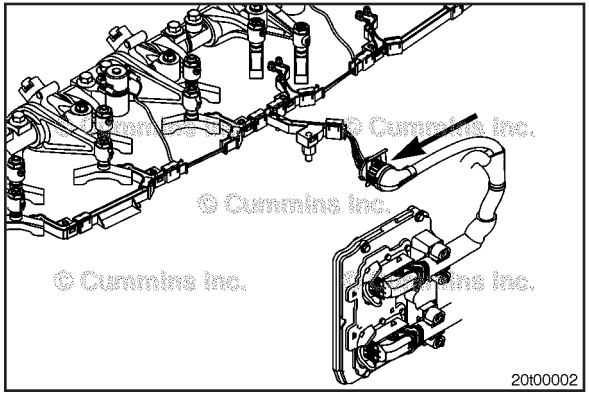


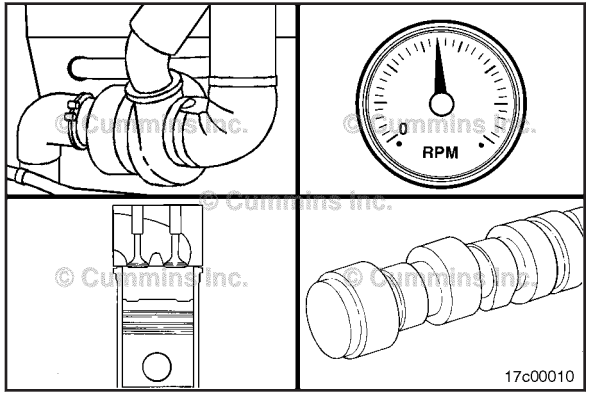
Engines in this family are equipped with engine brakes.

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

The engine brakes temporarily convert the engine to an energy-absorbing device to reduce vehicle speed. This is accomplished through the use of a hydraulic circuit that opens the exhaust valves near the end of the compression stroke.

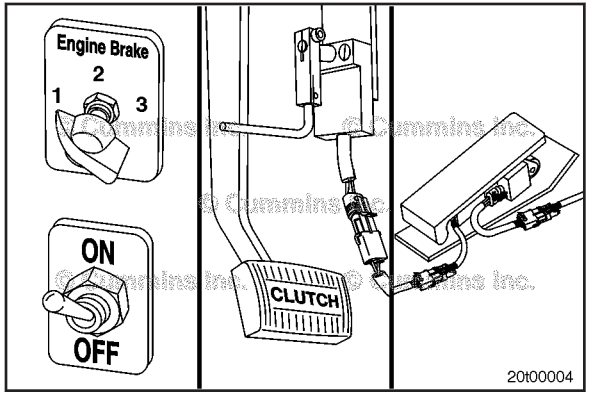
This engine family uses the added benefit of the variable geometry turbocharger to assist in engine braking.





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

This engine family uses the added benefit of the variable geometry turbocharger to assist in engine braking.



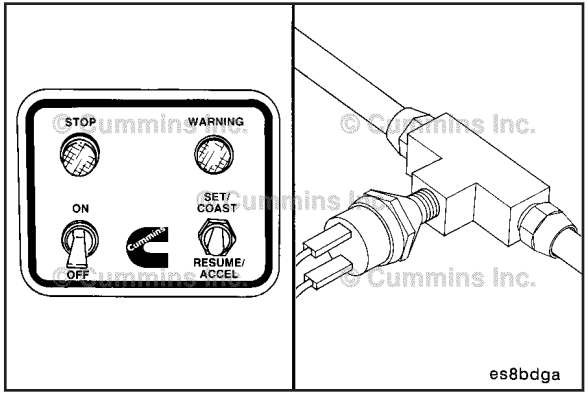
Engine brake controls consist of the following:

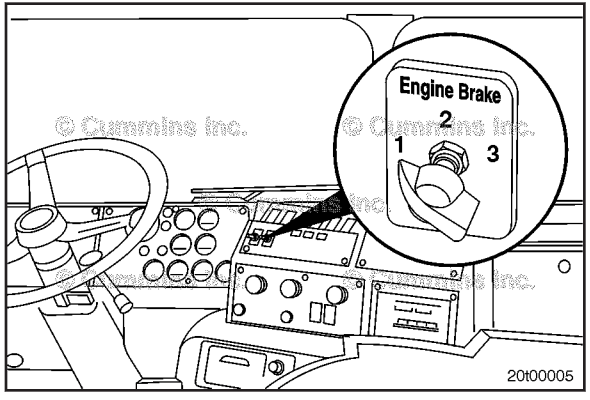
- A three-position selector switch
- An ON/OFF switch
- A clutch switch
- A throttle sensor
- A service brake pressure switch

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

- Cruise control ON/OFF and SET/RESUME switches, if the Engine Brake In Cruise Control feature is turned OFF
- Service brake air pressure switch.

Engine brakes can operate while cruise control is turned on. The electronic feature, Fan Control Engine Braking, can be enabled to turn the fan on during engine braking. This increases the parasitic load on the engine during braking. Reference the Programmable Features in this section.





The selector switch is located in the cab, and allows the selection of the retarding power.

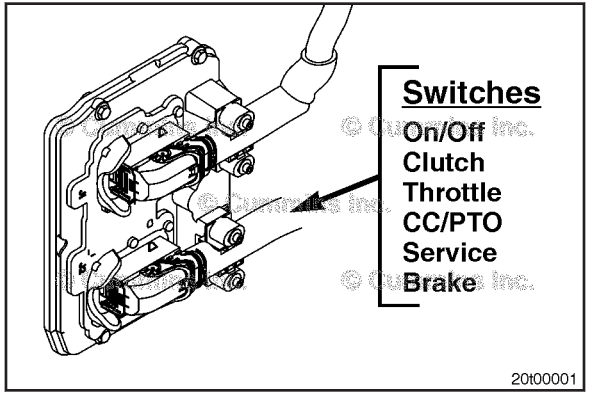
Engine Brake Level Specifications

- Position Number 1 = 33-percent engine braking power
- Position Number 2 = 67-percent engine braking power
- Position Number 3 = 100-percent engine braking power.

For engines in this family, the engine brake select switch does **not** always directly correlate to the number of engine brake solenoids that are activated. This is due to the added use of the variable geometry turbocharger to assist in engine braking, and the use of **only** two engine brake solenoids.

NOTE: Any one of these switches can deactivate the engine brakes.

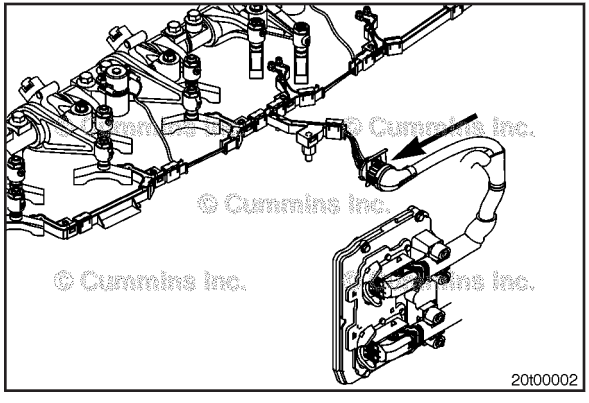
Signals from the ON/OFF switch, the clutch switch, the throttle sensor, the cruise control/PTO switches, or both, are fed into the engine control module.

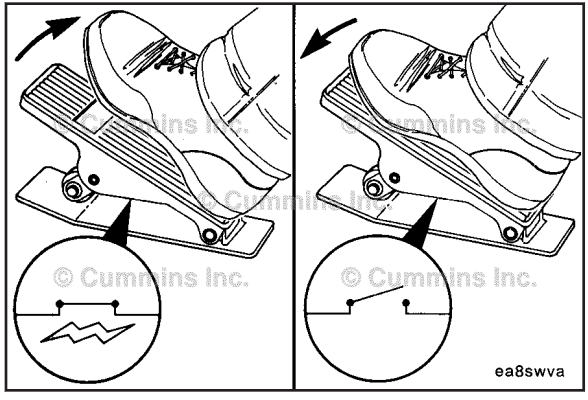


The ECM then electronically enables or disables the engine brakes.

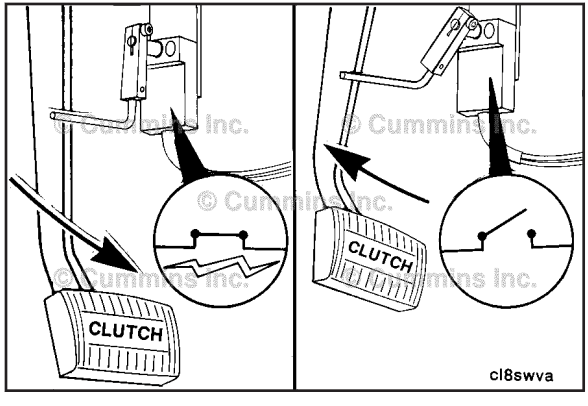
Engine brakes can **not** be enabled:

- When cruise control is active, if the Engine Brake In Cruise Control feature is turned OFF
- When engine speed goes below 850 rpm or below the engine brake control minimum vehicle speed parameter
- When an electronic fault code is active.





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

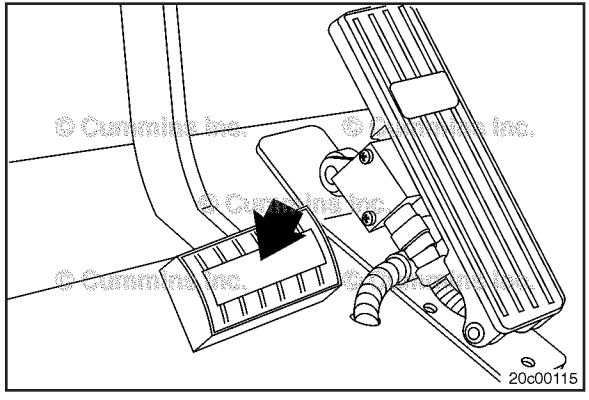


The clutch switch uses the motion of the clutch linkage to deactivate the engine brakes when the clutch pedal is depressed.

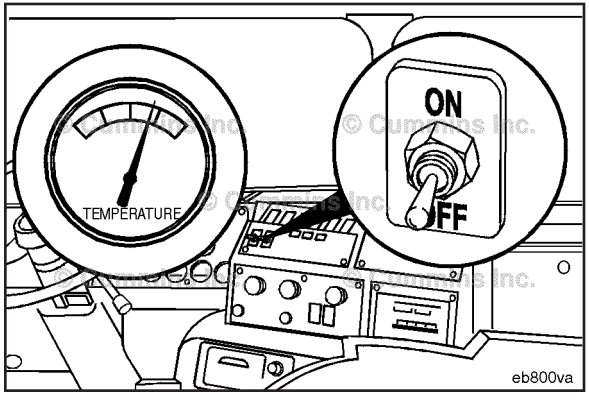
The service brake pressure switch is attached to the service brake air supply line.

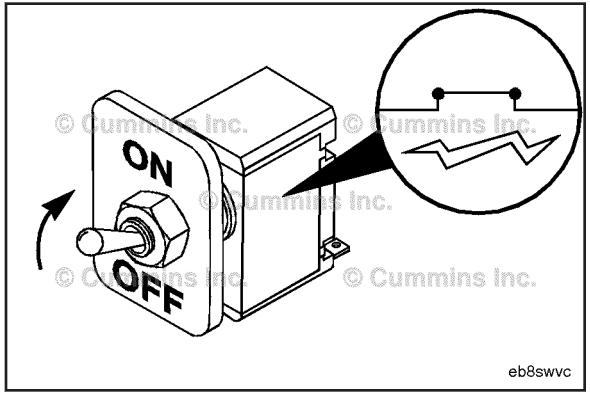
Applying the service brakes while in cruise control will disengage the cruise control and enable the engine brakes.

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



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

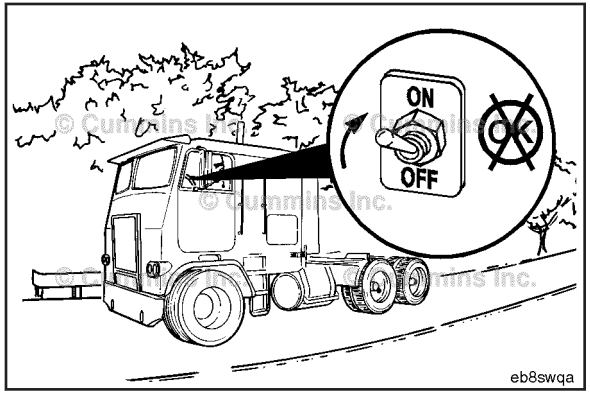




To activate the engine brakes, switch the ON/OFF switch to the ON position. Once activated, the operation of the engine brake is fully automatic.

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

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



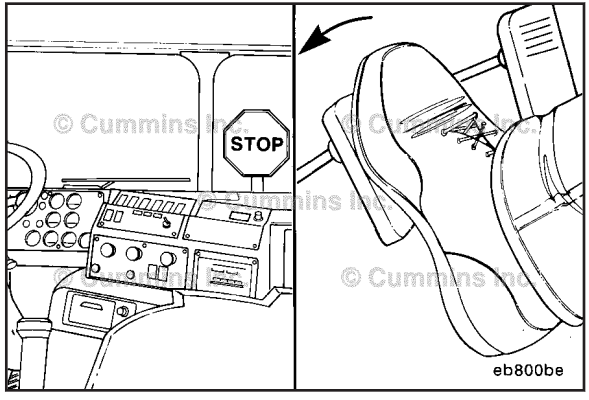
⚠ WARNING ⚠

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

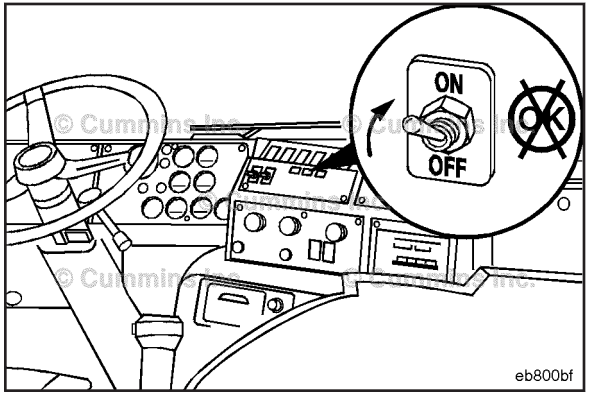
Make sure the engine brakes are switched to the OFF position when bobtailing or pulling an empty trailer.

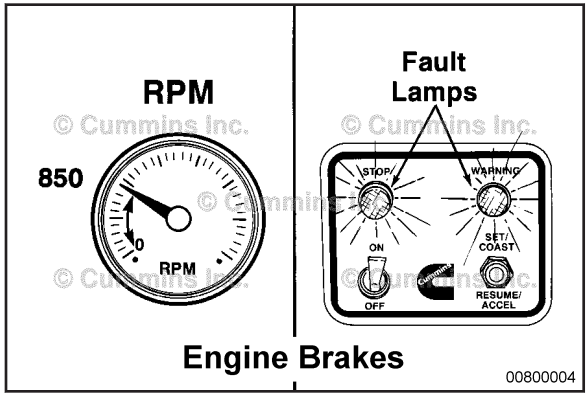
⚠CAUTION⚠
The engine brakes are designed to assist the vehicle's service brakes in slowing the vehicle to a stop.

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

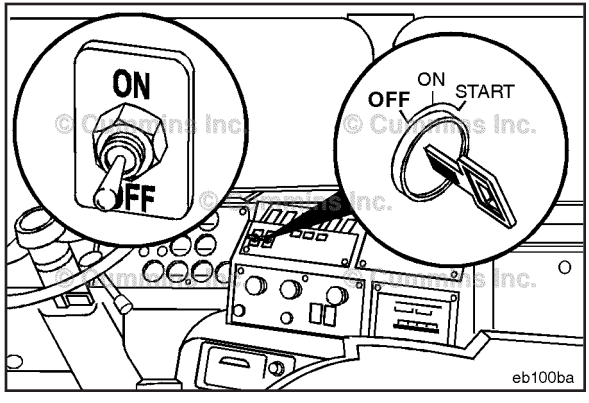


⚠CAUTION⚠
Do not use the engine brakes to aid clutchless gear shifting. This can cause the engine to stall or lead to engine damage.





The ECM will disable the engine brakes when the engine rpm is below 850 rpm or below the Engine Brake Control Minimum Vehicle Speed parameter when an electronic fault code is active.



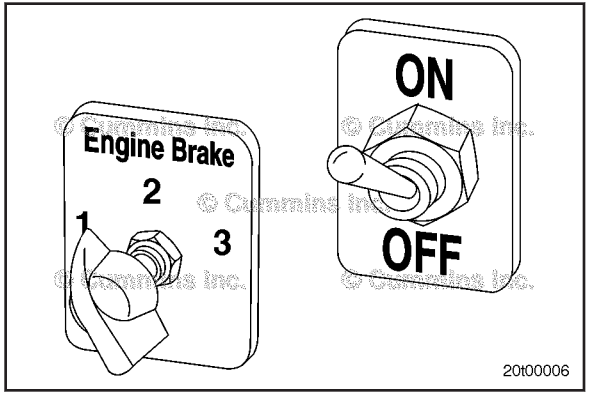
⚠CAUTION⚠

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

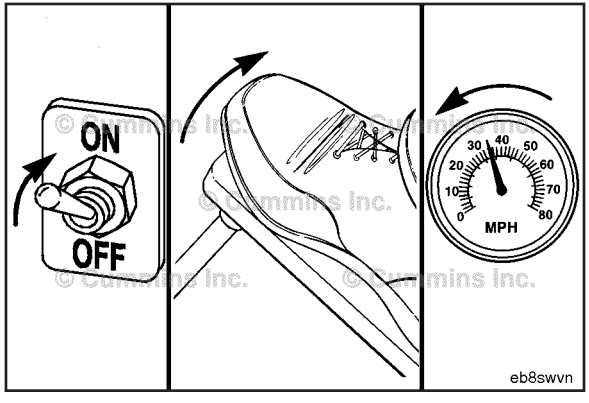
If the engine brakes will **not** shut off, immediately shut off the engine and contact a Cummins® Authorized Repair Location.

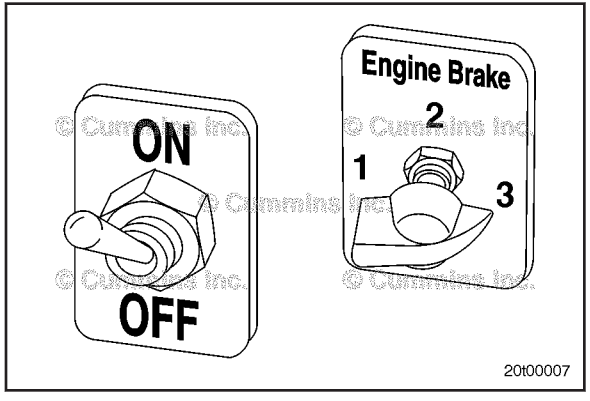
Tips for Operation on Level and Dry Pavement

For operating on dry and relatively flat surfaces when greater retarding power is **not** required, put the position selector switch in a lower position



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





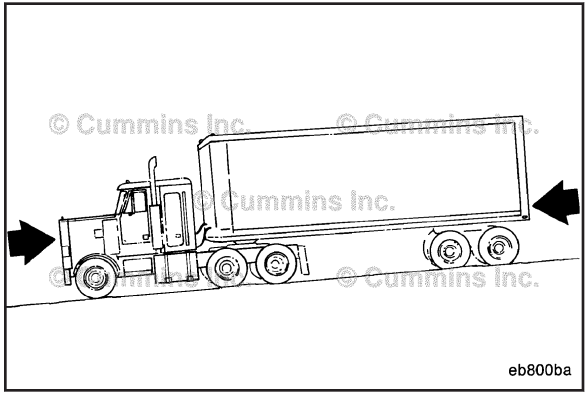
For operation on dry pavement when maximum retarding power is required, put the position selector switch in the highest position.

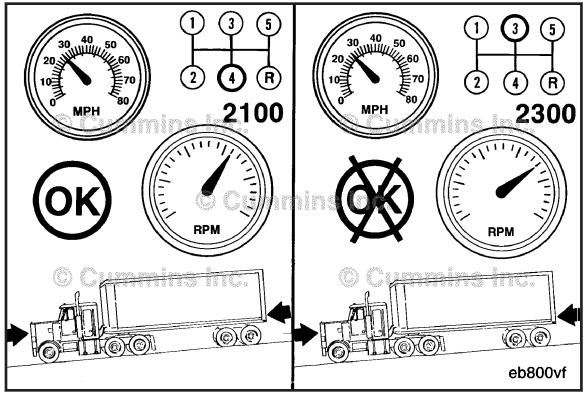
Tips for Operation on Grades with Dry Pavement

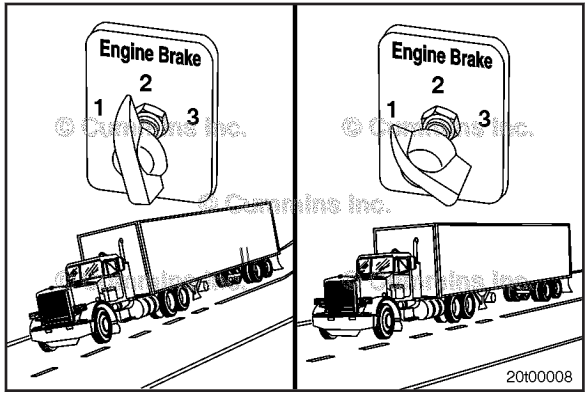
⚠WARNING⚠
To reduce the possibility of personal injury or property damage, always be prepared to use the vehicle service brakes for emergency stopping. The safe control speed of a vehicle will vary with the size of the load, the type of load, the grade, and the road conditions.

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

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







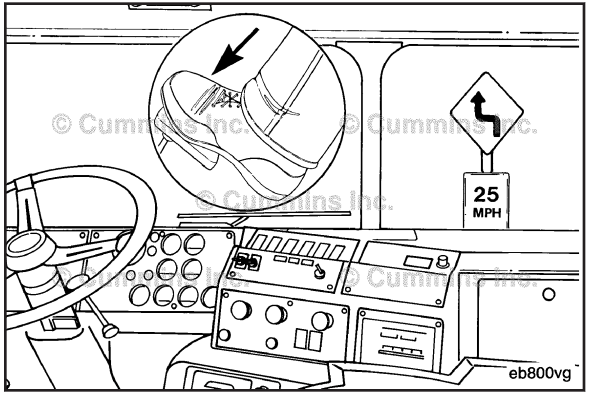
⚠CAUTION⚠
Never exceed governed engine speed as engine damage can occur.

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

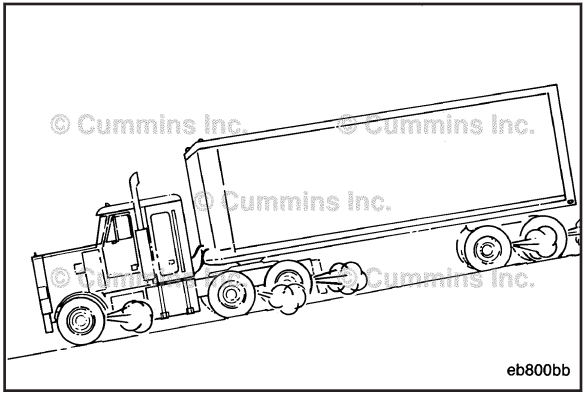
Once you have determined the safe speed for your vehicle, operate the engine brakes with the transmission in the lowest gear that will **not** cause the engine speed to exceed the rated engine speed.

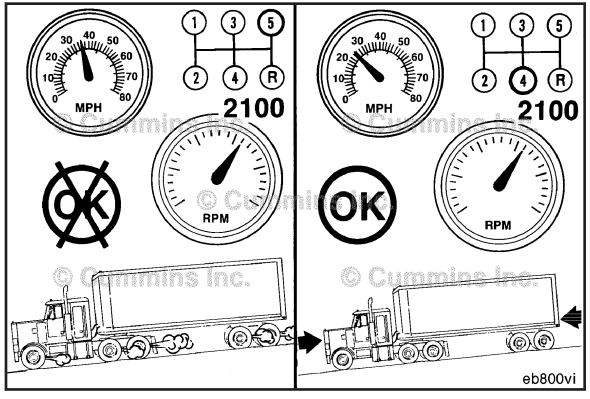
The position selector switch can be used to vary braking power as road conditions change.

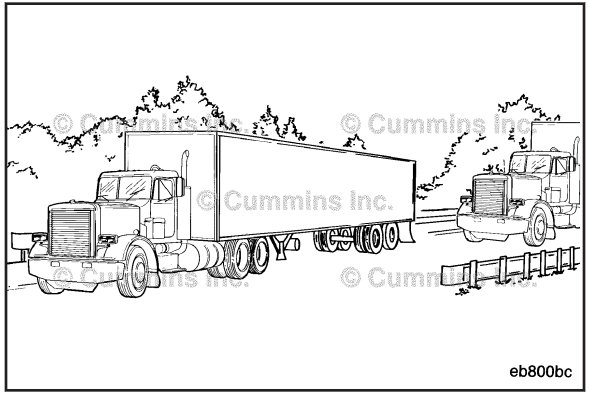
Vehicle service brakes **must** be used when additional braking power is required.



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







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

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

Tips for Operation on Slick Roads

⚠ WARNING ⚠

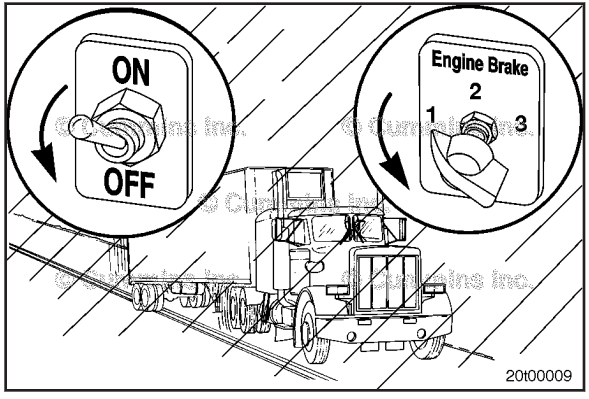
To reduce the possibility of personal injury or property damage, always allow for extra distance between your vehicle and other objects when using the service brakes or engine brakes on slick roads

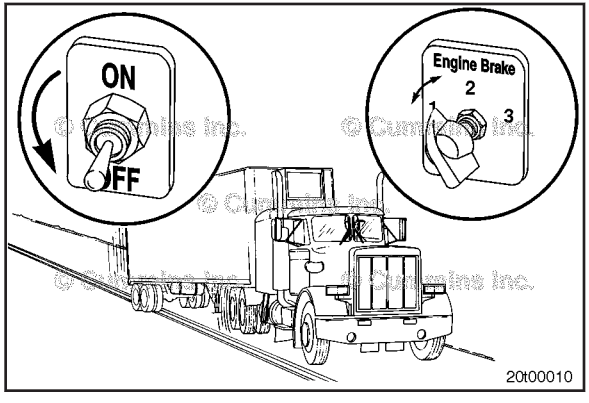
The operation of any vehicle is difficult to predict on slick roads. The first 10 to 15 minutes of rainfall are the most dangerous, as road dirt and oil mixed with rain create a very slippery surface.

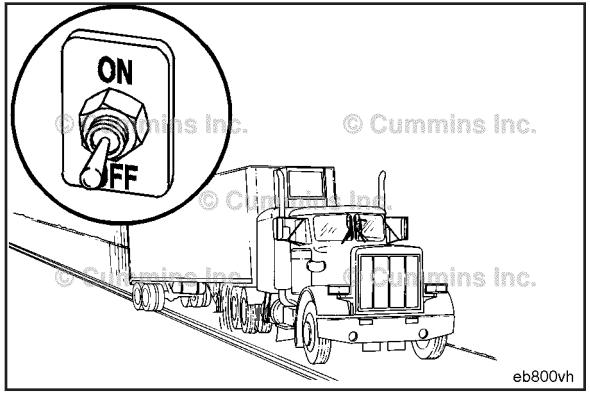
⚠WARNING⚠
To reduce the possibility of personal injury or property damage, reduce the retarding power or turn "OFF" the engine brakes on slick roads. Using engine brakes on wet or slippery roads can cause overbraking, especially on vehicles with light loads or single-drive axles. Stopping distance can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

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

If the tractor is equipped with a twin-screw rear axle, use the power divider in the UNLOCKED position.

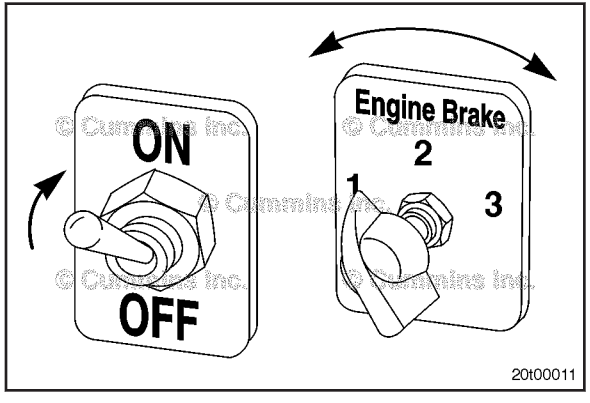






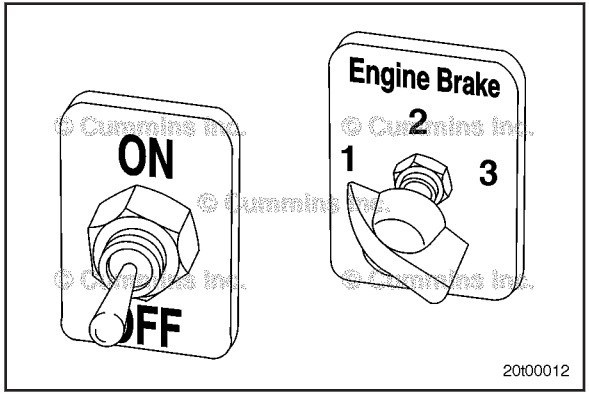
Remove your foot from the accelerator pedal to make sure that the vehicle will maintain traction with the retarding power of the engine alone.

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

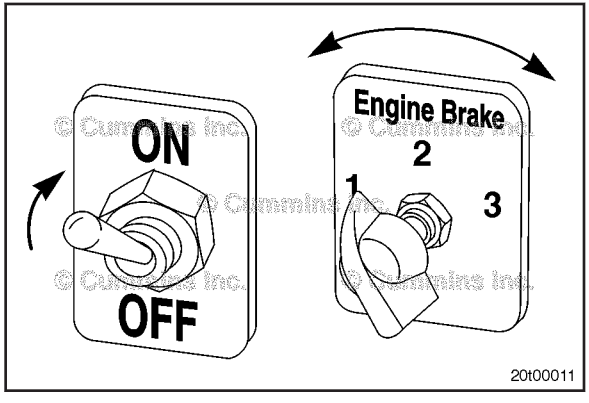


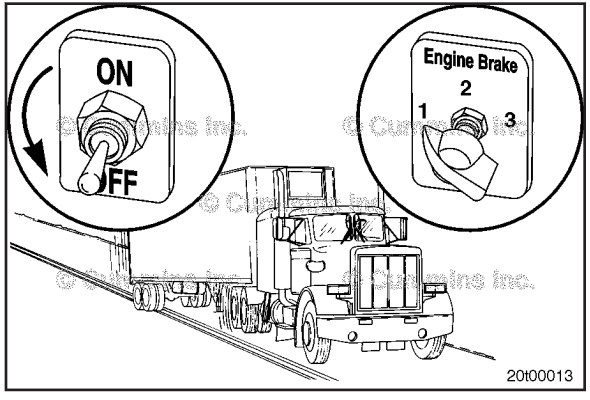
If traction is maintained using the retarding power of the engine alone, and more braking power is required, switch the position selector switch to the lowest position and activate the engine brakes by switching the on/off switch to the ON position.

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



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





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

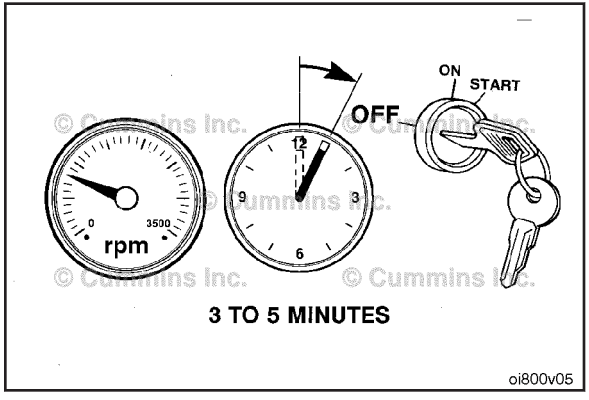
Engine Shutdown

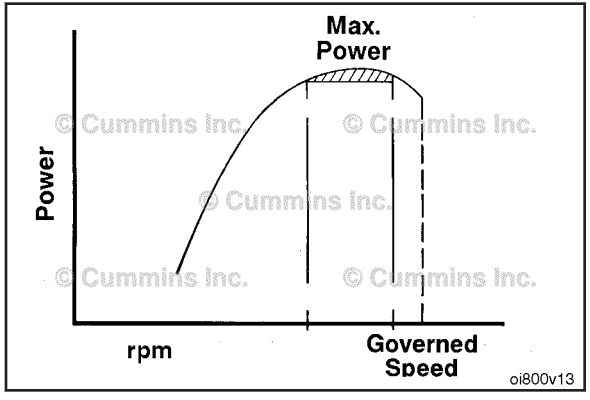
General Information

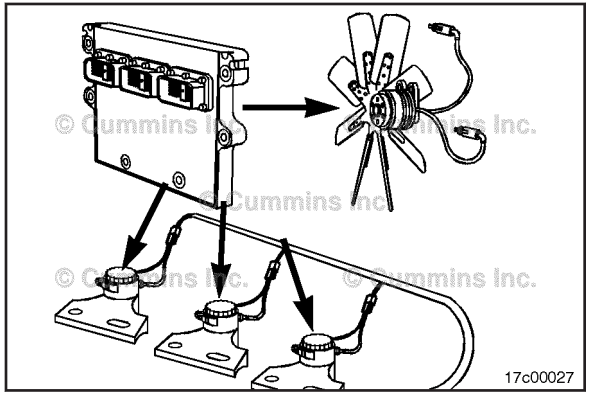
NOTE: For engines equipped with an electronic control module (ECM) ensure the keyswitch is turned off for a minimum of 70 seconds prior to disconnecting the continuous (unswitched) battery power supply. If the unswitched battery power supply is disconnected in less than 70 seconds after the keyswitch is turned off active fault codes and incorrect ECM information can occur.

Turn the ignition switch to the OFF position. If the engine does **not** shut down, refer to Troubleshooting Symptom (Section TS) in appropriate Operation and Maintenance manual.

⚠CAUTION⚠
Failure to follow the correct shutdown procedure may result in damage to the turbocharger and shorten the turbocharger life.







Electronic Controlled Fuel System

General Information

The QSX15 CM2350 X105 fuel system is an electronically controlled fuel injection system that optimizes fuel economy. It does this by controlling the torque and horsepower curve, engine high speed, low idle, and road speed.

QSX15 CM2350 X105 has the capability of controlling the fan clutch actuator if an electronically controlled fan clutch is used.

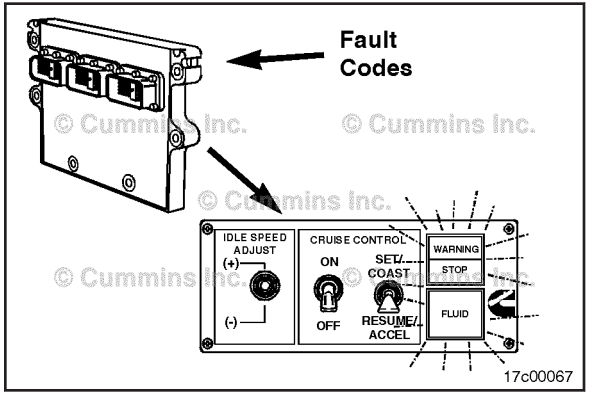
QSX15 CM2350 X105 also allows the engine brakes to be activated by controlling the engine brake solenoids.

The electronic feature Fan Control Engine Braking can be enabled to activate the fan clutch during engine braking. This increases the load on the engine during engine braking.

Diagnostic Fault Codes

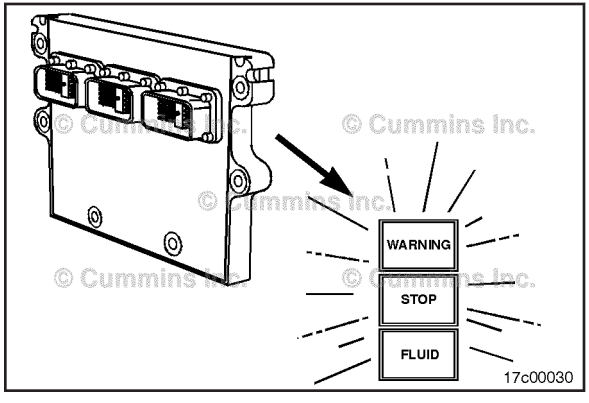
The electronically controlled fuel system can show and record certain engine faults. The faults are shown as fault codes. These fault codes will make troubleshooting easier. The fault codes are recorded in the engine control module (ECM).

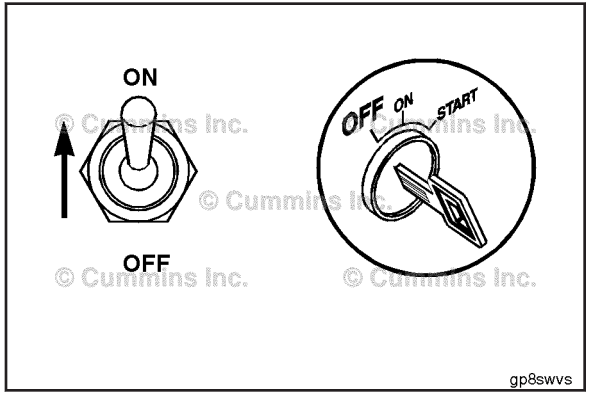
NOTE: Not all engine irregularities are shown as fault codes.



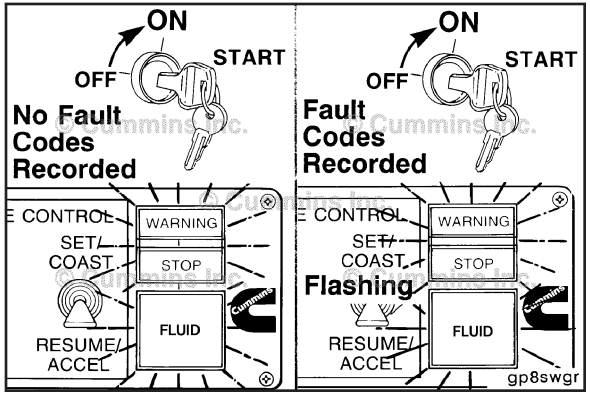
The engine electronic fuel system fault codes can be seen on the WARNING and STOP lights in the cab panel.

NOTE: Inactive fault codes can **not** be flashed out. An electronic service tool **must** be used to read inactive fault codes in the ECM. Contact a Cummins® Authorized Repair Location.





If the equipment is equipped with a diagnostic switch, turn the switch OFF. Turn the equipment OFF. To check for engine electronic fuel system and engine protection system fault codes, move the diagnostic switch to the ON position, or connect the shorting plug into the diagnostic connector.



Turn the equipment keyswitch ON. If any fault codes were active during system power down, the lights will begin to flash the code of the recorded faults. If no fault codes are recorded, the lamps will **not** flash, but will be illuminated.

The fault code will flash in the following sequence:

1 A WARNING (amber) light will flash.

2 There will be a short 1 or 2 second pause.

3 The recorded fault code number will flash STOP (red) light.

4 There will be a 1 or 2 second pause between each number.

5 When the number has finished flashing in red, a yellow light will appear again.

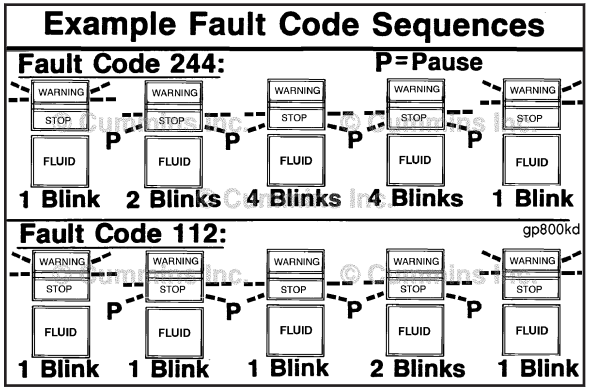
The code will repeat in the same sequence.

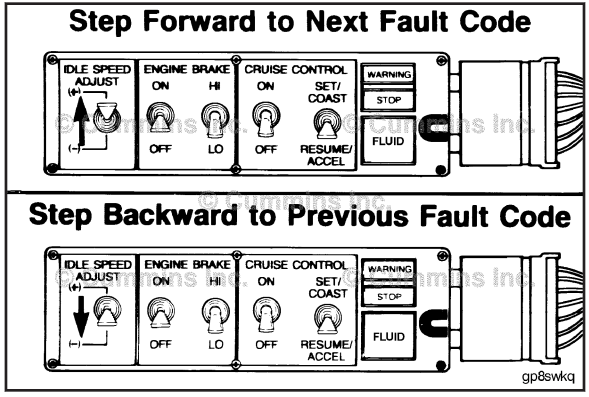
The lights will continue to flash the same code until the system is told to do something else.

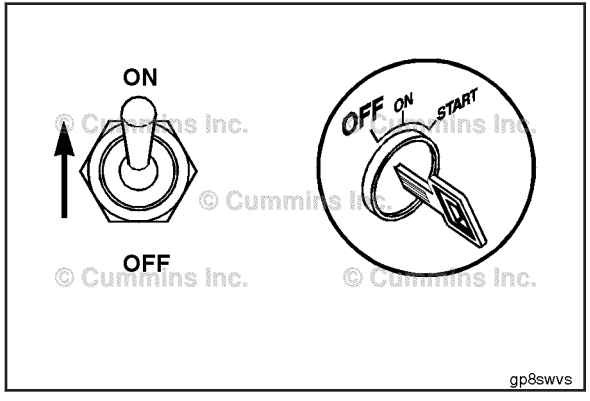
To go to the next fault code, move the CRUISE CONTROL/PTO switch momentarily to the RESUME/ ACCEL position.

To go back to the previous fault code momentarily, move the CRUISE CONTROL/PTO switch to the SET/COAST position.

If **only** one active fault is recorded, the system will continuously display the same fault code when either RESUME/ACCEL or SET/COAST switch is depressed.







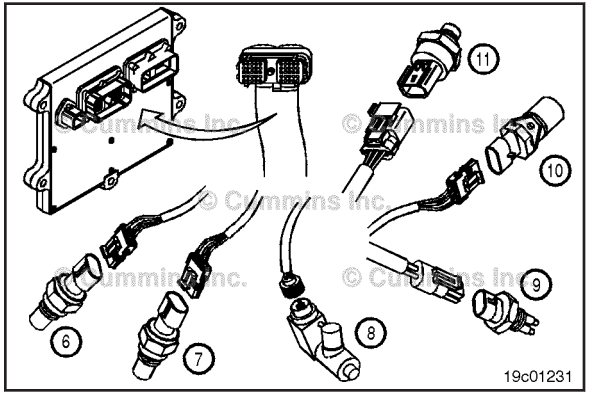
When **not** using the diagnostic system, turn the diagnostic switch OFF, or remove the shorting plug. If the diagnostic switch is left ON or the shorting plug left in, the ECM will **not** log some faults and the maintenance monitor will **not** function correctly.

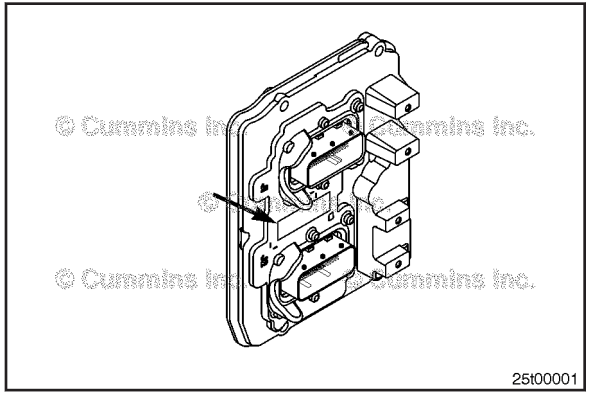
To stop the diagnostic system, move the diagnostic switch to the OFF position, or remove the shorting plug. Turn the equipment switch OFF.

Engine Protection System

The QSX15 CM2350 X105 engines are equipped with an engine protection system. The system monitors critical engine temperatures and pressures, and logs diagnostic faults when an over or under normal condition occurs. If an out-of-range condition exists and engine derate action is to be initiated, the operator is alerted by an in-cab WARNING lamp. The STOP lamp blinks or flashes when out-of-range conditions continue to worsen. The operator **must** stop when it is safe to do so, to reduce the possibility of engine damage.

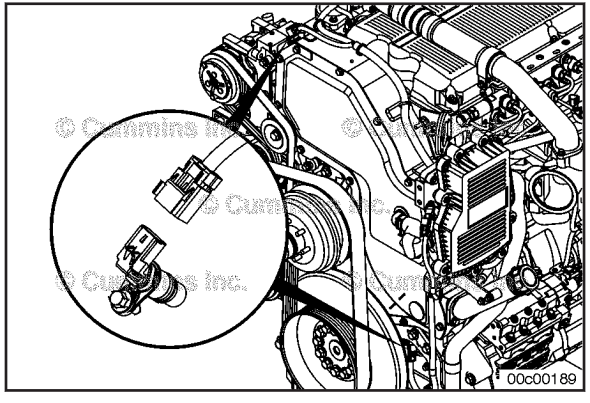
NOTE: Engine power and speed will gradually be reduced, depending on the level of severity of the observed condition. The engine protection system will **not** shut down the engine unless the Engine Protection Shutdown feature has been selected. If the feature has been selected and the engine does shut down, the engine can be started again by turning the keyswitch OFF and then turning it back ON.





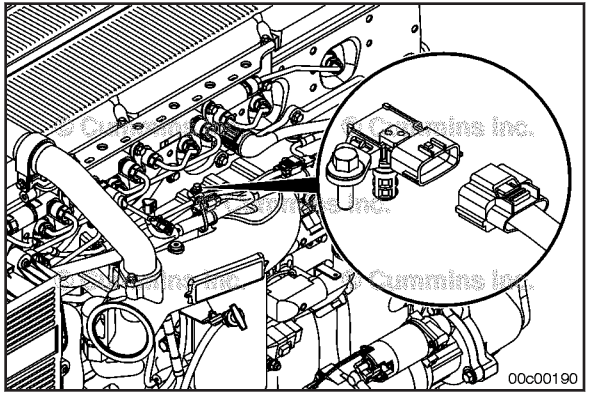
Fuel System Description

The one data tag for the ECM is located on the front of the module housing.

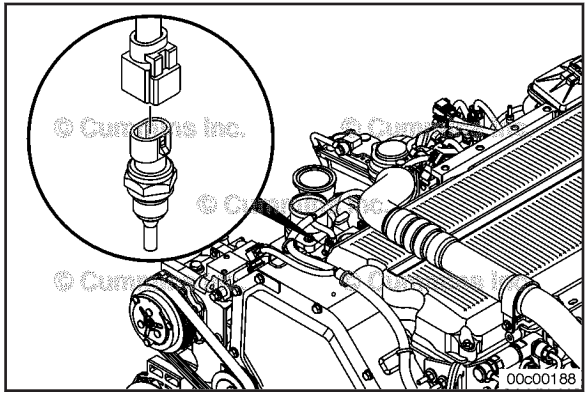


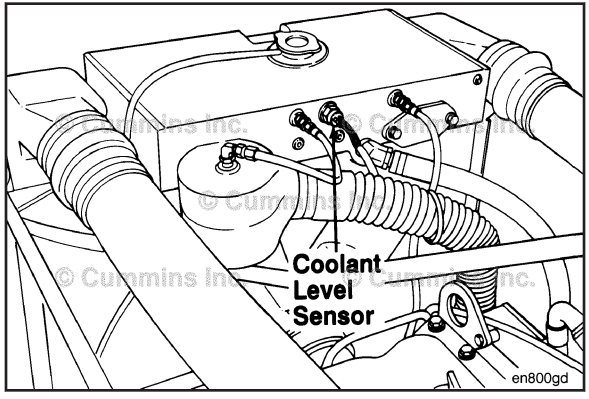
The camshaft position sensor is located on the top right side of the gear housing. The crankshaft position sensor is located behind the vibration damper.

The intake air pressure/temperature sensor, located in the front of the intake air connection, monitors positive manifold pressure and turbocharged intake air temperature. Both are used in the fuel control function. The intake air pressure/temperature sensor is also used in the engine protection system.

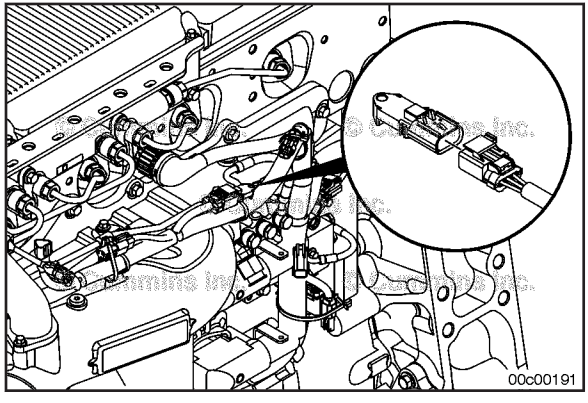


The engine coolant temperature sensor, located in the thermostat housing, monitors engine coolant temperature which is used in the fuel control function and engine protection system.





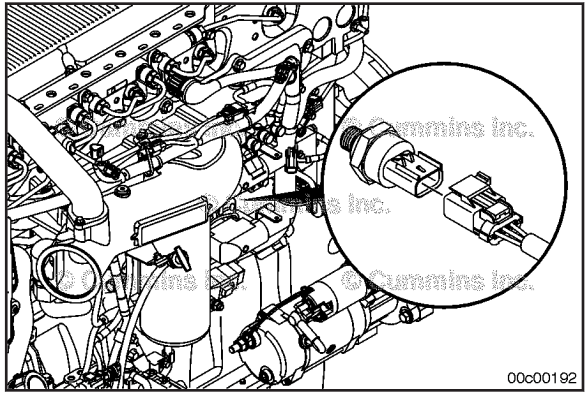
The coolant level sensor is mounted in the radiator top tank or surge tank, depending on the OEM. It is a fluid-level-actuated switch required for the engine protection system.



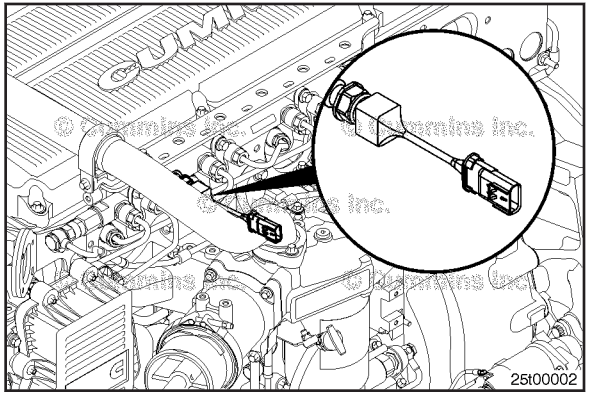
The barometric pressure sensor is located on the engine harness, on top of the air intake manifold. It is used to control fueling.

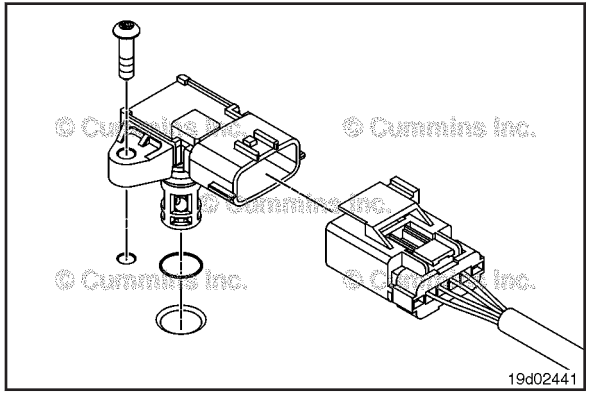
The oil pressure sensor is located on the left side of the engine and monitors lubricating oil pressure for the engine protection system.

The oil temperature sensor is located on the left side of the engine and monitors lubricating oil pressure for the engine protection system.

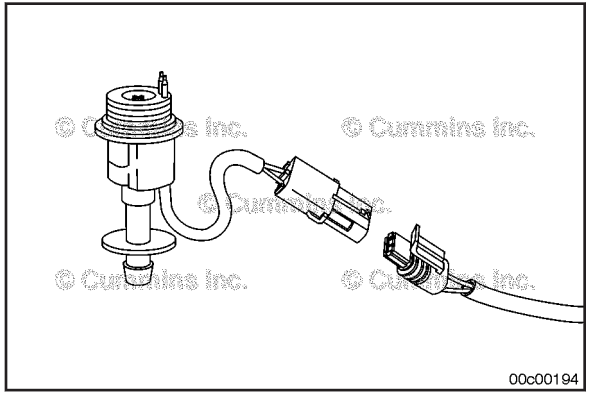


The fuel rail pressure sensor is located on the fuel rail and monitors rail pressure.





The turbocharger compressor intake pressure/ temperature sensor is located in the air intake piping between the air cleaner and the turbocharger.



The water-in-fuel sensor is located on the OEM-supplied filter housing.

Electromagnetic Interference (EMI)

General Information

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

System EMI Susceptibility

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

System EMI Radiation Levels

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

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

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

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

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

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

Section 2 - Maintenance Guidelines

Section Contents

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Maintenance Guidelines - Overview

General Information

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

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

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

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

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

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

Maintenance Schedule

General Information

Perform maintenance at whichever interval occurs first. At each scheduled maintenance interval, perform all previous maintenance checks that are due for scheduled maintenance.

Maintenance Procedures at Daily Interval [(1)(7)]

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

Maintenance Procedures at 250 Hours or 6 Months [(7)(9)]

- Pressure Fuel Filter - Change
- Fuel Filter Suction - Change

Maintenance Procedures at 500 Hours or 6 Months (1) (3)

- Lubricating Oil and Filters - Change
- Radiator Pressure Cap - Test
- Supplemental Coolant Additive (SCA) and Antifreeze Concentration - Check
- Charge-Air Cooler - Check

Maintenance Procedures at 1500 Hours or 1 Year (2)(8)

- Coolant Filter - Change
- Cooling Fan Belt Tensioner - Inspect for Reuse
- Air Cleaner Element (primary and secondary) - Change
- Air Leaks, Air Intake and Exhaust Systems - Check
- Air Compressor Air Cleaner Element - Check
- Air Compressor Discharge Lines - Check
- Engine Wiring Harness - Check

Maintenance Procedures at 1500 Hours

- Aftertreatment Fuel Injector - Clean

Maintenance Procedures at 3000 Hours (4)

- Crankcase Breather Element - Change

Maintenance Procedures at 4500 Hours[5]

- Aftertreatment Diesel Particulate Filter - Check

Maintenance Procedures at 4500 Hours or 3 Years

- Aftertreatment Diesel Exhaust Fluid Dosing Unit Filter - Change

Maintenance Procedures at 6000 Hours or 2 Years

- Engine Mounting Bolts - Check
- Engine Steam Cleaning - Clean
- Vibration Damper, Viscous - Check
- Overhead Set - Adjust
- Cooling System - Check
- Cooling System - Flush
- Radiator Hoses - Check
- Radiator Shutter Assembly - Check
- Cold Weather Starting Aids - Check
- Engine Brake Assembly - Test
- Engine Mounts - Inspect for Reuse

Maintenance Procedures at 10000 Hours or 5 Years[6]

- Overhead Set - Adjust
- Fan Hub, Belt Driven - Check

- Engine Brake Assembly - Test

1 The lubricating oil and lubricating oil filter intervals are based on Cummins® Engineering Standard 20081 and a normal duty cycle. Oil change intervals can be adjusted based on fuel consumption and whether or **not** the oil meets Cummins® Engineering Standard 20081. See the Oil Drain and Fuel Filter Change Intervals in Table 2 for Severe Duty and Light Duty drain intervals.

2 Follow the manufacturer's recommended maintenance procedures for the starter, alternator, generator, batteries, electrical components, engine brakes, exhaust brake, charge-air cooler, air compressor, air conditioner compressor, and fan clutch.

3 Test the SCA concentration level every 6 months unless the concentration is over three units; then check at every oil drain interval until the concentration is below three units. Use the following procedure for coolant condemnation limits. Refer to Procedure 018-004 in Section V.

4 The crankcase breather element intervals can be adjusted based on engine blowby. See the Crankcase Breather Element Change Intervals table below.

5 While air cleaning is allowed, the Cummins Inc. preferred method would be to exchange the DPF at the recommended maintenance interval.

6 The components of the engine brake that are subjected to wear during normal operation of the engine are available as a kit through Cummins® Inc. Distributors/Dealers. It is recommended to do this maintenance at 10,000 hours, or 5 years.

7 Suction fuel filters are original engine manufacturer (OEM) installed. It is important to always use clean, high quality fuel. Failure to use clean, high quality fuel will negatively affect engine life and maintenance intervals. Use the following procedure for fuel requirements. Refer to Procedure 018-002 in Section V.

8 The air cleaner (filter) element change interval is based on restriction, but the elements should be changed at least every 1500 hours or 1 year. It is important to check the restriction daily and change the air cleaners (filters) once they become restricted (635 mm H2O [25 in H2O]). The secondary air cleaner (filter) elements should be changed

every other time the primary elements are changed. Proper inspection of the secondary air filter elements should be performed and the secondary elements changed, if necessary. Refer to Procedure 010-014 in Section A.

9 The fuel filter change intervals can be increased and the engine fuel system can be better protected depending on the suction-side fuel filters used. If a suction side fuel filter is used that has NanoNet™ media with Beta Ratio (filtration efficiency) rating of ß5(C)=75 is used (such as Short Industrial Pro® FH2390000 Series and filter part number FS53015), recommended service interval can be increased to 500 hours or 6 months for the pressure fuel filter. This will also provide additional protection to the engine fuel system from debris in fuel

All EPA 07, EPA 10, EPA Tier 4 Interim/European Union Stage IIIB 2011(174 -751 hp), EPA Tier 4 Final/European Union Stage IV (174-751 hp) engine systems equipped with exhaust aftertreatment **must** operate on ultra-low sulfur diesel (ULSD) with a maximum sulfur content of 15 ppm in the United States and 10 ppm in the European Union. Failure to do so can permanently damage engine and aftertreatment systems within a short period of time. This damage could cause the engine to become inoperable and affect the warranty coverage on the engine system.

Aftertreatment Cleaning Intervals	
Oil Classification	**Interval (Hours)**
CES20081	4500

Crankcase Breather Element Change Intervals	
Engine Blowby	**Interval (Hours)**
Less than 305 mm H_2O [12 in H_2O]	3000
Greater than or equal to 305 mm H_2O [12 in H_2O]	1500

Oil Drain Intervals

For industrial engines, the oil drain intervals are based on the duty cycle (as reflected by fuel consumption) and lubricating oil quality. The table below specifies the maximum oil drain interval for the listed lubricating oil classifications, based on the three different duty cycles: Heavy, Medium, and Light.

- Follow oil drain interval Heavy Duty if the equipment uses more than 57 liter [15 gal] of fuel per hour.
- Follow oil drain interval Medium Duty if the equipment uses between 42 to 57 liter [11 to 15 gal] of fuel per hour.
- Follow oil drain interval Light Duty if the equipment uses less than 42 liter [11 gal] of fuel per hour.

NOTE: Extending the oil and filter change interval beyond the recommendation will decrease engine life due to factors such as corrosion, deposits, and wear.

	Duty Cycle (Fuel Consumption)		
Oil Classification	**Heavy >57 liters/hour [15 gallons/hour]**	**Medium 42 to 57 liters/ hour [11 to 15 gallons/ hour]**	**Light < 42 liters/hour] [11 gallons/hour]**
CES 20081/CJ-4/ACEA E9/ JAMA DH-2	500	625	750

1 The oil classifications CD, CE, CF, and CG have been obsoleted by American Petroleum Institute (API) and **must not** be used, as their specifications are no longer controlled.

2 Use the following procedure for the lubricating oil filter specification table. Refer to Procedure 018-003 in Section V.

The table below lists typical duty cycles by application.

NOTE: The actual duty cycle can vary from the chart below. In those cases, it is necessary to change the lubricating oil as a function of average fuel consumption. Therefore, select a column based on the representative fuel consumption range.

Typical Duty Cycles by Applications		
Heavy	**Medium**	**Light**
Air Compressor	Articulated Dump Truck	Crane
Combine	Irrigation Equipment	Rear Dump Truck
Dozer	Scraper	
Dragline	Skidder	
Excavator		
Farm Tractors		
Forage Harvester		
Rock Drill		
Tub Grinder		

The QSX15 CM2350 X105 Generator Drive engines require the use of premium grade oils; CES 20081, CJ-4, ACEA E9, JAMA DH-2. The oil grades CD, CE, CF, and CG have been obsoleted by API and **must not** be used because their specifications are no longer controlled.

- Utilize the fixed hour method, based on fixed hours of operation or months inservice, whichever occurs first.

Oil Drain Interval		
Application	**Sump Size**	**Change Interval**
Standby Power	95 liters [25 gal]	250 Hours or 12 Months
All Other Applications	95 liters [25 gal]	500 Hours or 12 Months

Maintenance Record Form

Maintenance Data

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

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

A	B	C	D	E	F

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
4332667	QSX15 CM2350 X105 Service Manual
4332666	QSX15 CM2350 X105 Fault Code Troubleshooting Manual
4332665	QSX15 CM2350 X105 Wiring Diagram
4332668	QSX15 CM2350 X105 Operation and Maintenance Manual
4332669	QSX15 CM2350 X105 Owners Manual
3379000	Air for Your Engines
3379001	Fuels for Cummins® Engines
3379009	Operation of Diesel Engines in Cold Climates
3387266	Cold Weather Operation
3666132	Cummins® Coolant Requirements and Maintenance
3666209	Extended Service Interval, Cooling System Maintenance
3810340	Cummins® Engine Oil and Oil Analysis Recommendations

Service Literature Ordering Location

Contact Information

Region	Ordering Location
United States and Canada	Cummins Distributors or Credit Cards at https://store.cummins.com
All Other Countries	Cummins Distributors or Dealers

Cummins Customized Parts Catalog

General Information

Cummins is pleased to announce the availability of a parts catalog compiled specifically for you. Unlike the generic versions of parts catalogs that support general high volume parts content; Cummins Customized catalogs contain only the new factory parts that were used to build your engine.

The catalog cover, as well as the content, is customized with you in mind. You can use it in your shop, at your worksite, or as a coffee table book in your RV or boat. The cover contains your name, company name, address, and telephone number.

This new catalog was designed to provide you with the exact information you need to order parts for your engine. This will be valuable for customers that do not have easy access to Cummins QuickServe Online.

Additional Features of the Customized Catalog include:

- Engine Configuration Data
- Table of Contents
- Separate Option and Parts Indexes
- Service Kits (when applicable)
- ReCon Part Numbers (when applicable)

Ordering the Customized Parts Catalog

Ordering by Telephone

- 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 - Maintenance Specifications

Section Contents

General Engine

Specifications

General Engine Specifications

Horsepower	Refer to the engine dataplate
Displacement	15 liters [912 C.I.D.]
Bore and Stroke	137 mm [5.40 in] x 169 mm [6.65 in]
Firing Order	1-5-3-6-2-4
Crankshaft Rotation (viewed from front of engine)	**Clockwise**
Engine Speed	
400 to 500 hp	Refer to the engine dataplate
500 to 600 hp	Refer to the engine dataplate
Engine Weight	
Dry Engine	1344 kg [2964 lb]
Wet Engine	1416 kg [3122 lb]
Overhead Adjustment	
Intake Valve	0.36 mm [0.014 in]
Exhaust Valve	0.69 mm [0.027 in]
Engine Brake	7.00 mm [0.276 in]

Lubricating Oil System

Specifications

Oil Pressure
- At Idle (minimum allowable at 93°C [200°F] oil temperature).....103 kPa [15 psi]
- At No-Load Governed Speed.....241 to 276 kPa [35 to 40 psi]

Pressure Drop Across Oil Filter
- Maximum Allowable (with 15W-40 and 10W-30 oil at operating temperature).....172 kPa [25 psi]

Oil Filter Capacity of Standard Engine
- Combination Full-Flow/Bypass Filter.....2.2 liters [0.58 gal]

Oil Pan Capacity of Standard Engine

Stamped Steel
- High.....45.4 liters [12 gal]
- Low.....37.9 liters [10 gal]

Oil Pan Capacity of Standard Engine

Aluminum
- High - Center Sump.....43.5 liters [11.5 gal]
- Low - Center Sump.....36 liters [9.5 gal]
- High - Shallow Full Sump.....56.8 liters [15 gal]
- Low - Shallow Full Sump.....49.2 liters [13 gal]
- High - Deep Full Sump.....83.3 liters [22 gal]
- Low - Deep Full Sump.....75.7 liters [20 gal]
- High - Wedge Sump.....47.3 liters [12.5 gal]
- Low - Wedge Sump.....43.5 liters [11.5 gal]

Oil Capacity of Standard Engine

Oil Change Capacity (oil pan and filter filled to capacity)
- Stamped Steel.....47.7 liters [12.6 gal]

Aluminum - Center Sump.....45.8 liters [12.1 gal]
Aluminum - Shallow Full Sump.....59.1 liters [15.6 gal]
Aluminum - Deep Full Sump.....85.6 liters [22.6 gal]
Aluminum - Wedge Sump.....49.6 liters [13.1 gal]

Total Lubricating Oil System Capacity Including Filter and Residual

Stamped Steel.....47.7 liters [13 gal]
Aluminum - Center Sump.....49.2 liters [13 gal]
Aluminum - Shallow Full Sump.....60.6 liters [16 gal]
Aluminum - Deep Full Sump.....87.1 liters [23 gal]
Aluminum - Wedge Sump.....51.1 liters [13.5 gal]

Oil Pressure Range

Cold Engine.....Up to 1034 kPa [150 psi]
Warm Engine.....241 to 276 kPa [35 to 40 psi]
Oil Drain Fitting Size.....M27x2 STOR

Cooling System

General Information

Cummins Inc. recommends the use of fully-formulated antifreeze or coolant containing a precharge of supplemental coolant additive (SCA) for this engine. The antifreeze or coolant **must** meet the specifications outlined in the Technology and Maintenance Council (TMC) Recommended Practice (RP) 329 (ethylene glycol) or Recommended Practice (RP) 330 (propylene glycol). The use of fully-formulated antifreeze or coolant significantly simplifies cooling system maintenance.

Copies of Technology and Maintenance Council (TMC) specifications can be obtained through Cummins Inc., or by contacting:

Technology and Maintenance Council

American Trucking Association

2200 Mill Road

Alexandria, VA 33314-5388

Phone: (703) 838-1763

Fax (703) 836-6070

Fully-formulated antifreeze contains balanced amounts of antifreeze, SCA, and buffering compounds, but does **not** contain 50 percent water. Fully-formulated coolant contains balanced amounts of antifreeze, SCA, and buffering compounds already premixed 50/50 with deionized water.

Alternative maintenance practices for cooling systems can be found in Cummins® Coolant Requirements and Maintenance, Bulletin 3666132.

Specifications

Coolant Capacity
Engine **Only** .....33.1 liters [35 qt]
Standard Modulating Thermostat
Temperature Range.....82 to 93°C [180 to 200°F]
Maximum Coolant Pressure
Exclusive of Pressure Cap, Closed Thermostat @ Maximum No-load Governed Speed.....434 kPa [63psi]
Maximum Temperature.....107°C [225°F]
Minimum Temperature.....70°C [160°F]
Minimum Allowable Draw Down.....11 Percent
Minimum Recommended Pressure Cap.....103 kPa [15 psi]
Minimum Fill Rate
Without Low-Level Alarm.....19 liters/min [5 gpm]
Maximum Deaeration Time
Maximum Time.....25 minutes
Fan-on Coolant Temperature.....99°C [210°F]
Fan-on Intake Air Temperature.....93°C [200°F]
Shutter Opening Temperature
Coolant.....96°C [205°F]
Winterfronts
Air Passage Area.....774 cm ^{2} [120 in ^{2}]

Cummins®/Fleetguard® Filter Specifications

Specifications

Fleetguard® filters are manufactured by Cummins Filtration Inc., which is a subsidiary of Cummins Inc. Fleetguard® filters are developed through joint testing at Cummins Inc. and at Cummins Filtration Inc. Fleetguard® filters are standard on new Cummins® engines. Cummins Inc. recommends their use.

Fleetguard® products meet all Cummins Inc. Source Approval Test standards to provide the quality filtration necessary to achieve the engine's design life. If other brands are substituted, the purchaser **must** insist on products that the supplier has tested to meet Cummins Inc. high-quality standards.

Cummins Inc. can **not** be responsible for problems caused by non-genuine filters that do **not** meet Cummins Inc. performance or durability requirements.

Filter Type	
QSX15 CM2350 X105	
Lubricating Oil Filter	
Cummins® Part Number	2882673 or 2882674
Fleetguard® Part Number	LF9070 or LF9080
Suction Fuel Filter	
Fleetguard® Part NumberFS53015(1) (Short Industrial Pro, NanoNet™ media)	FS19763(1) (Industrial Pro, StratoPore™ media) FS53015(1) (Short Industrial Pro, NanoNet™ media)
Spin-On Pressure Fuel Filter	
Cummins® Part Number	3689131(2)

Filter Type	
QSX15 CM2350 X105	
Lubricating Oil Filter	
Fleetguard® Part Number	FF63010(2)
Coolant Filter	
Fleetguard® Part Number	WF2126(3)
	WF2127(4)
Coalescing Filter	
Cummins® Part Number	4312013
Fleetguard® Part Number	CV50634
Air Filter (Primary)	
Cummins® Part Number	3688918
Fleetguard® Part Number	AF55024
Air Filter (Secondary)	
Cummins® Part Number	3688919
Fleetguard® Part Number	AF55318
Diesel Exhaust Fluid Filter	
Cummins® Part Number	2888182

1 An equivalent suction fuel filter can be used, but it **must** meet or exceed the following characteristics:

- Remove a minimum of 95 percent of free and emulsified water

- NanoNet™ media or equivalent with Beta Ratio (filtration efficiency) rating of ß4(C)=75, or equivalent, is recommended in order to extend fuel filter service intervals, but a minimum of 7-micron rating at 98.7 percent efficiency is required
- Water-in-fuel sensor with shunt resistor
- Water-in-fuel drain valve
- Refer to the original equipment manufacturer (OEM) service manual for more information on the suction side fuel filter.

2 An equivalent pressure fuel filter can be used, but it **must** meet or exceed the following characteristics:

- Beta Ratio (filtration efficiency) rating of $ß_{4(C)}$=200
- This filter is designed for extended service intervals up to 1 year or 1500 hours when using TMC RP329/RP330 or ASTM D6210 coolants that meet Cummins® Engineering Standard CES 14603. The filter is designed for cooling systems up to 49 liters [13 gal]. Refer to Cummins® Coolant Requirements and Maintenance, Bulletin 3666132
- This filter has been designed for extended service intervals of 1 year or 4000 hours. It has no chemical additives, as it contains zero units of DCA4 and can be used in the following systems
- Cooling systems of any capacity
- See maintenance chart below.

When using WF2127 filter, the following volumes of liquid treatment **must** be added at the designated distances/ intervals.

Cooling System Capacity	1 Year or 1500 Hours Service Interval with RP329/330 Coolant or Treated Water (DCA2 or DCA4)	1 Year or 4000 Hours Service Interval with ES Compleat™ Coolant (ES Extender Liquid)
0 to 57 liters [0 to 15 gal]	0.95 liters [1 qt] (10 units)	0.95 liters [1 qt] (15 units)

Cooling System Capacity	1 Year or 1500 Hours Service Interval with RP329/330 Coolant or Treated Water (DCA2 or DCA4)	1 Year or 4000 Hours Service Interval with ES Compleat™ Coolant (ES Extender Liquid)
58 to 114 liters [16 to 30 gal]	1.89 liters [2 qt] (20 units)	1.89 liters [2 qt] (30 units)
115 to 170 liters [31 to 45 gal]	2.84 liters [3 qt] (30 units)	2.84 liters [3 qt] (45 units)
171 to 227 liters [46 to 60 gal]	3.79 liters [4 qt] (40 units)	3.79 liters [4 qt] (60 units)
228 to 284 liters [61 to 75 gal]	4.74 liters [5 qt] (50 units)	4.74 liters [5 qt] (75 units)
285 to 341 liters [76 to 90 gal]	5.69 liters [6 qt] (60 units)	5.69 liters [6 qt] (90 units)
342 to 397 liters [91 to 105 gal]	6.63 liters [7 qt] (70 units)	6.63 liters [7 qt] (105 units)

NOTE: Filters **must** meet Cummins Inc. SAM 10,769. Fleetguard® filters meet Cummins Inc. SAM 10,769. The standard filter for the QSX15 CM2350 X105 engine is Fleetguard® WF2126. For systems larger than 379 liters [100 gal], use 0.94 liters [1 qt] per 57 liters [15 gal]. Consult the vehicle manufacturer for total cooling system capacity information.

Diesel Exhaust Fluid Recommendations and Specifications

General Information

⚠WARNING⚠

It is unlawful to tamper with or remove any component of the aftertreatment system. It is also unlawful to use a Diesel Exhaust Fluid (DEF) that does not meet the specifications provided or to operate the vehicle/ equipment with no Diesel Exhaust Fluid (DEF).

⚠WARNING⚠

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

⚠CAUTION⚠

Never attempt to create Diesel Exhaust Fluid by mixing agricultural grade urea with water. Agricultural grade urea does not meet the necessary specifications required and the aftertreatment system may be damaged.

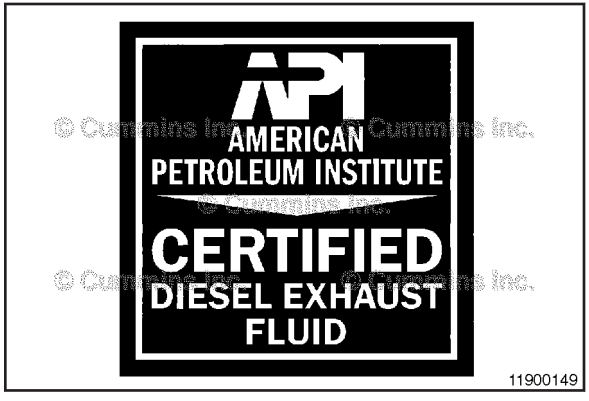
Cummins Inc. requires the use of Diesel Exhaust Fluid meeting ISO 22241-1. There is NO acceptable substitute.

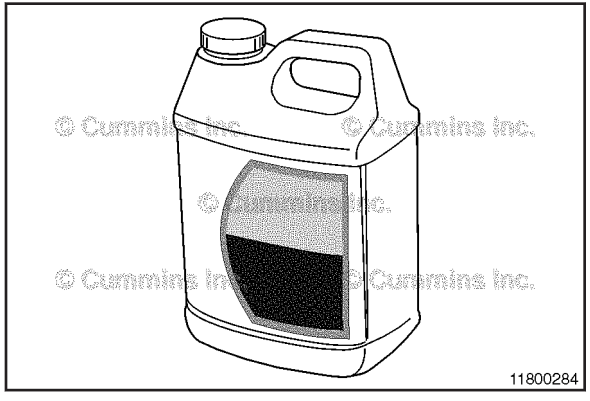
NOTE: Some locations may reference the DIN 70070 standard. Diesel Exhaust Fluid specification limits of this standard are identical to ISO 22241-1.

Cummins Inc. is not responsible for failures or damage resulting from what Cummins Inc. determines to be abuse or neglect, including but not limited to: operation without correctly specified Diesel Exhaust Fluid; lack of maintenance of aftertreatment; improper storage, or shutdown practices; unauthorized modifications of the engine and aftertreatment. Cummins is also not responsible for failures caused by incorrect Diesel Exhaust Fluid or by water, dirt or other contaminants in the Diesel Exhaust Fluid

For further details and discussion of Diesel Exhaust Fluid (DEF) for Cummins® engines. Refer to the Diesel Exhaust Fluid Specifications for Cummins® Selective Catalytic Reduction Systems, Service Bulletin Number 4021566.

For engines using SCR operating in the United States and Canada, it is also strongly recommended that the Diesel Exhaust Fluid (DEF) used be certified by the American Petroleum Institute (API). This would be indicated by a symbol on the container/dispensing system as shown.





To ensure the correct Diesel Exhaust Fluid (DEF) is used, Cummins Inc. recommends the use of Fleetguard® Diesel Exhaust Fluid. Fleetguard® carries different quantity options from small to bulk containers.

For customers located in the United States and Canada, for assistance locating Diesel Exhaust Fluid (DEF), contact the Cummins Customer Assistance Center: 1-800 DIESELS (1-800-343-7357).

For customers outside of the United States and Canada, contact you local Cummins authorized repair location for assistance in locating Diesel Exhaust Fluid (DEF).

The following are other common names used for Diesel Exhaust Fluid (DEF):

- Urea
- AUS 32 (Aqueous Urea Solution 32)
- AdBlue
- NOx Reduction Agent
- Catalyst Solution
- DEF

Regardless of what the Diesel Exhaust Fluid is called, the Diesel Exhaust Fluid must meet the specifications as outlined in the General Information section of this procedure.

Storage

NOTE: The following information is for reference and is to be used as a guideline only. There are many factors that determine Diesel Exhaust Fluid (DEF) shelf life, with temperature and duration being two of the major determining contributors. If in doubt, check the concentration of the Diesel Exhaust Fluid (DEF), refer to the Test step of this procedure, or replace the fluid with known quality Diesel Exhaust Fluid.

Diesel Exhaust Fluid has a limited shelf life, both in the vehicle's diesel exhaust fluid tank and in storage/bulk/transportation containers.

The following conditions are ideal for maintaining DEF quality and shelf life during prolonged transportation and storage:

- Storage temperature between 23°F and 77°F (-5°C and 25°C)
- Store in sealed containers to avoid contamination

- Avoid direct sunlight

In these conditions, DEF has a minimum expected shelf life of 18 months. If stored at higher temperatures for extended periods of time, the shelf life will be reduced by approximately 6 months for every 5°C [9°F] above the highest storage temperature listed above.

Long term storage in a vehicle (in excess of 6 months) is not recommended. If long term storage is necessary, periodic testing of the Diesel Exhaust Fluid is recommended to be performed to ensure the concentration does not fall out of specification. Follow the Test step of this procedure.

NOTE: To assist in preventing Diesel Exhaust Fluid from deteriorating when stored in the vehicles DEF tank, locate and plug the tanks venting to seal the tank exposure to the atmosphere.

Handling

Diesel Exhaust Fluid is not harmful to handle, but can be corrosive to certain materials over time. Such as carbon steels, iron, zinc, nickel, copper, aluminum and magnesium.

- Make sure to only use approved containers to transport and store Diesel Exhaust Fluid. Containers made of polyethylene and polypropylene are recommended.
- If Diesel Exhaust Fluid is spilled, rinse and clean immediately with water.
- Avoid prolonged contact with skin. In case of contact, wash with immediately with soap and water. If not washed immediately, when the diesel exhaust fluid dries, a white film will be left that can be more difficult to wash off.

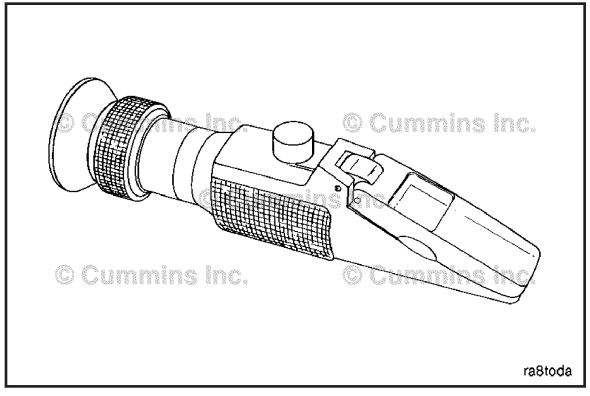
NOTE: Spilled Diesel Exhaust Fluid if left to dry or wiped away with a cloth only will leave a white residue. Failure to clean the spilled Diesel Exhaust Fluid may result in an incorrectly diagnosed leak of the Diesel Exhaust Fluid Dosing system.

Before using containers, funnels, etc. that will be used to dispense, handle or store Diesel Exhaust Fluid, make sure to wash thoroughly to remove any contaminants and then rinse with distilled water.

NOTE: Do not use tap water to rinse components that will be used to deliver diesel exhaust fluid. Tap water will contaminate the Diesel Exhaust Fluid. If distilled water is not available, rinse with tap water and then rinse with Diesel Exhaust Fluid.

Disposal

If disposing of Diesel Exhaust Fluid (DEF), always check with the local authority regulations on proper disposing process and requirements.



Test

Having the correct concentration of Diesel Exhaust Fluid is critical to the engine and aftertreatment system performing correctly.

To test the concentration of the Diesel Exhaust Fluid, use the Cummins Diesel Exhaust Fluid Refractometer, service tool part number 4919554. Follow the instructions provided with the service tool.

Percent Urea Concentration: 32.5 +/- 1.5%

The specification listed above takes into consideration the refractometer tool tolerances, varibility, and calibration when measuring Diesel Exhaust Fluid concentration.

If the Diesel Exhaust Fluid concentration is found to be outside of this specification, drain the Diesel Exhaust Fluid tank, flush with distilled water and fill with new and/or known good Diesel Exhaust Fluid. Recheck the Diesel Exhaust Fluid concentration.

Concentration of the Diesel Exhaust Fluid should be checked when:

- The vehicle has been stored for an extended period of time.
- It is suspected that water has been added to the Diesel Exhaust Fluid tank

Contamination/Incorrect Fluid

⚠CAUTION⚠

Never add water or any other fluid besides what is specified to the Diesel Exhaust Fluid (DEF) tank. The aftertreatment system may be damaged.

In the event that the incorrect fluid is added to the Diesel Exhaust Fluid tank, such as, but not limited to:

- Water
- Diesel Fuel
- Hydraulic Fluid
- Coolant
- Windshield Washer Fluid

Contact a local Cummins Authorized Repair location to determine the appropriate repair direction.

If only water has been added to the Diesel Exhaust Fluid (DEF) tank, drain the Diesel Exhaust Fluid (DEF) tank, flush with distilled water and refill with new and/or known good Diesel Exhaust Fluid (DEF). Check the Diesel Exhaust Fluid (DEF) concentration after completing the refill, follow to the Test step of this procedure.

Freezing

⚠CAUTION⚠

Do NOT add any chemicals/additives to the Diesel Exhaust Fluid in an effort to prevent freezing. If chemicals/additives are added to the Diesel Exhaust Fluid, the aftertreatment system may be damaged.

Diesel Exhaust Fluid will freeze around -11°C [12°F]. The diesel exhaust fluid system on the vehicle is designed to accommodate this and does not require any intervention by the vehicle operator.

The Operating the Engine (101-015) procedure in Section 1 of the Owners and Operation and Maintenance Manual will provide information on proper cold weather set up for your engine/vehicle.

Fuel Recommendations and Specifications

Fuel Recommendations

WARNING

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

WARNING

Do not mix gasoline, alcohol, or gasohol with diesel fuel. This mixture can cause an explosion.

CAUTION

Due to the precise tolerances of diesel injection systems, it is extremely important that the fuel be kept clean and free of dirt or water. Dirt or water in the system can cause severe damage to both the fuel pump and the fuel injectors.

CAUTION

Do not use diesel fuel blended with lubricating oil in engines equipped with an aftertreatment device. Service intervals for aftertreatment devices will be reduced.

CAUTION

Lighter fuels can reduce fuel economy or possibly damage fuel system components.

CAUTION

Ultra-low sulfur diesel fuel is required for correct operation of the aftertreatment system.

Cummins Inc. recommends the use of American Society of Testing and Materials (ASTM) number 2D fuel. The use of number 2D diesel fuel will result in optimum engine performance.

The engine has been optimized for use with an exhaust aftertreatment to meet the Tier 4 Final/Stage IV off-highway emissions regulations. It **must** operate on ultra-low sulfur diesel (ULSD) with a maximum sulfur content of 15 ppm in the United States and 10 ppm in the European Union. Failure to do so can permanently damage engine and aftertreatment systems within a short period of time. This damage could cause the engine to become inoperable and affect the warranty coverage on the engine.

Ultra-low sulfur diesel fuel, also defined by ASTM S-15, is defined as diesel fuel **not** exceeding 0.0015 (15 ppm) mass percent sulfur content. There is no acceptable substitute.

At operating temperatures below 0°C [32°F], acceptable performance can be obtained by using blends of number 2D and number 1D.

The following chart lists acceptable types of fuels for this engine.

Acceptable Types of Fuels									
Number 1D Diesel(1) (2)	**Number 2D Diesel(2)**	**Number 1K Kerosene**	**Jet-A**	**Jet-A1**	**JP-5**	**JP-8**	**Jet-B**	**JP-4**	**CITE**
OK	OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK	NOT OK
48-34(3)	40-24(3)	50-35(3)	51-37(3)	51-37(3)	48-36(3)	51-37(3)	57-45(3)	57-45(3)	57-45(3)

1 Any adjustment to compensate for reduced performance with a fuel system using alternate fuel is **not** warrantable.

2 Winter blend fuels, such as found at commercial fuel dispensing outlets, are combinations of number 1D and number 2D diesel fuel and are acceptable.

3 BTU Content/Degree API Gravity - Low American Petroleum Institute (API) gravity fuels have a higher thermal energy content (BTU). As a general rule, there is a 3 to 5 percent decrease in BTU content for every 10 degree

increase in API gravity, there is also a 0.7 degree API gravity increase with an increase in fuel temperature. This decrease in energy content equates roughly to the same percentage of power loss. Use of fuels with higher API gravity will cause higher than normal fuel consumption.

NOTE: Cummins Inc. recommends that the cetane number of diesel fuel be a minimum of 45 for engines that are expected to operate at temperatures below 0°C [32°F] and a minimum of 42 for engines that are operated at temperatures above 0°C [32°F].

NOTE: Using diesel fuel with a lower than recommended cetane number can cause hard starting, instability, and excessive white smoke. To maintain satisfactory operation at low ambient temperatures, it is important to specify diesel fuel of the correct cetane number.

NOTE: Cummins Inc. requires all permissible fuels to have adequate fuel lubricity. Lubricity can be measured by ASTM, specification D6079, ISO 12156, High Frequency Reciprocating Rig (HFRR) in which the fuel **must** have a wear scar diameter of 0.52 mm [0.02 in] or less.

The equipment original equipment manufacturer (OEM) is required to display readily visible labels on the dashboard (or instrument panel) and near all fuel fill inlets that state "Use Ultra Low-Sulfur Diesel Fuel **Only**" or "Ultra Low-Sulfur Diesel Fuel **Only**".

ULSD/Biodiesel blends up to B20 (20 percent biodiesel) supplied by a BQ9000 certified supplier are acceptable.

For information on alternative fuels, such as biodiesel, and additional information for fuel recommendations and specifications, refer to the latest revision of Fuels for Cummins® Engines Service Bulletin, Bulletin 3379001. See ordering information in Section L.

Fuel Recommended Properties	
Cummins Inc. recommends the use of fuels that meet the following specifications:	
Property	Recommended Specifications
Viscosity (ASTM D445)	1.3 to 4.1 centistokes [1.3 to 4.1 mm per second] at 40°C [104°F].

Fuel Recommended Properties	
Cetane Number (ASTM D613)	40 minimum above 0°C [32°F]. 45 minimum below 0°C [32°F].
Sulfur Content (ASTM D129 or D1552)	**Not** to exceed 0.05 mass percent for engines without aftertreatment devices. For engines with aftertreatment devices, sulfur content can **not** exceed 0.0015 (15 ppm) mass percent.
Active Sulfur (ASTM D130)	Copper strip corrosion **not** to exceed number 3 rating after three hours at 50°C [122°F].
Water and Sediment (ASTM D1796)	**Not** to exceed 0.05 volume percent.
Carbon Residue (Rams bottom, ASTM D524 or Conradson, ASTM D189)	**Not** to exceed 0.35 mass percent on 10 volume percent residuum.
Density (ASTM D287)	42 to 30° API gravity at 0.816 to 0.876 g/cc at 15°C [60°F].
Cloud Point (ASTM D97)	6°C [10°F] below lowest ambient temperature at which the fuel is expected to operate.
Ash (ASTM D482)	**Not** to exceed 0.02 mass percent (0.05 mass percent with lubricating oil blending). Oil blending is prohibited on engines with aftertreatment devices.
Distillation (ASTM D86)	The distillation curve **must** be smooth and continuous.
Acid Number (ASTM D664)	**Not** to exceed 0.1 mg KOA per 100 ml.

1 In addition to the requirements in the Fuel Recommended Properties table, Cummins Inc. strongly recommends the use of fuel with particle counts less than the ISO 4406 code of 18/16/13. Refer to the "Fuel Cleanliness" section of the Fuels For Cummins® Engines, Bulletin 3379001 for more details.

2 For additional information on fuel recommendations and specifications, refer to Fuels for Cummins® Engines, Bulletin 3379001,. See ordering information in Section L.

Fuel Cleanliness

This section explains the importance of fuel cleanliness to the successful operation of Cummins® Engines.

Modern fuel systems have been developed to improve combustion performance and fuel consumption, and improve engine performance. These high-pressure fuel systems operate at pressures approaching 2600 bar [37,700 psi], and with component match clearances typically from 2- to 5-microns for injectors. At these pressures, very small, hard particles are potential sources of a fuel system malfunction.

Excessive contamination of diesel fuel can cause premature clogging of diesel fuel filters and/or premature wear of critical fuel injection system parts. Depending on the size and nature of the particles, this can lead to:

- reduced component life
- component malfunction
- fuel system and/or engine malfunction.

Determining fuel cleanliness requires measuring both the size and number of particles per size class in the fuel, i.e. the particle size distribution. The International Standards Organization (ISO) has developed a protocol for expressing the level of contamination by coding the size distribution called ISO 4406. ISO 4406 cleanliness codes are expressed as a series of three numbers (x/x/x), which correspond respectively to the number of particles greater than 4-, 6-, and 14-microns. For example, the numbers in the ISO 4406 rating of 18/16/13 translate to:

- 18 - Up to 2500 particles larger than 4µm (per mL of fuel)
- 16 - Up to 640 particles larger than 6µm (per mL of fuel)
- 13 - Up to 80 particles larger than 14µm (per mL of fuel).

ISO 4406		
ISO Code	Number of Particles per mL	
	More Than	Up to and Including
24	80,000	160,000
23	40,000	80,000
22	20,000	40,000
21	10,000	20,000
20	5000	10,000
19	2500	5000
18	1300	2500
17	640	1300
16	320	640
15	160	320
14	80	160
13	40	80
12	20	40
11	10	20
10	5	10
9	2.5	5
8	1.3	2.5
7	0.64	1.3

ISO 4406		
ISO Code	Number of Particles per mL	
	More Than	Up to and Including
6	0.32	0.64
5	0.16	0.32
4	0.08	0.16
3	0.04	0.08
2	0.02	0.04
1	0.01	0.02
0	0.005	0.01
00	0.0025	0.005

Engine builders and fuel injection equipment manufacturers have found that the particles greater than 4-microns and greater than 6-microns are particularly critical to the durability of the fuel injection system. They also recognize that the fuel systems **must** tolerate hard particles smaller than 4-microns that are difficult to filter out, even with the finest filtration. To maximize the efficiency and effectiveness of filtration, Cummins Inc. has adopted the recommendation of the World Wide Fuel Charter that fuel supplied to engines meet the ISO 4406 code of 18/16/13 maximum for respectively 4-, 6-, and 14-micron particle sizes.

Cummins Inc. recommends that if the fuel does **not** meet the ISO cleanliness code of 18/16/13 when supplied to the engine, additional filtration be applied before the fuel is delivered to the equipment's fuel tank. A Cummins® Distributor or Cummins Filtration™ representative can supply hardware and additional filtration guidance and can recommend countermeasures such as improved fuel quality from the fuel supplier, and/or better fuel handling, storage, dispensing, and fuel tank cleaning techniques.

Tank Vent Filtration

Particles in the 4- to 6-micron size range require laboratory equipment to identify, yet can do significant damage to high-pressure fuel systems when the cleanliness of the fuel in the tank exceeds the ISO 4406 code 18/16/13 maximum. Cummins Inc. requires that fuel tanks for QSX15 CM2250 X105 and QSX15 CM2350 X106 engines be fitted with a tank vent filter of at least 98.7 percent efficiency at 10-micron (3-micron is recommended) to prevent dirt from entering the tank as the fuel level drops.

Lubricating Oil Recommendations and Specifications

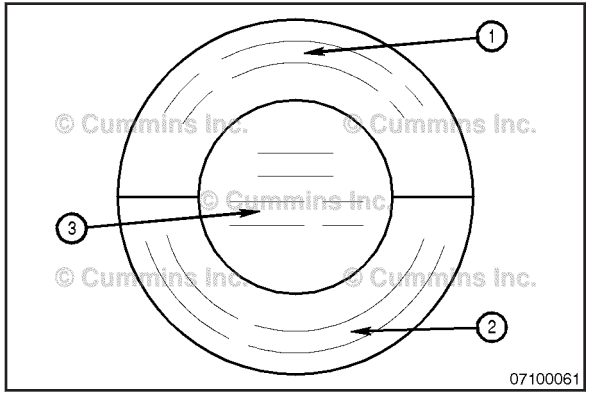
General Information

QSX15 CM2350 X105

- The use of quality engine lubricating oils, combined with appropriate oil drain and lubricating oil filter change intevals, is a critical factor in maintaining engine performance and durability.
- Cummins Inc. recommends the use of a high quality 5W30, 10W30, or 15W40 multiviscosity heavy duty engine lubricating oil that meets the requirements of Cummins® Engineering Specification (CES) 20081 (such as Valvoline™ Premium Blue™ or Valvoline™ Premium Blue Extreme™).
- Shortened drain intervals can be required with monograde oils, as determined by close monitoring of the oil condition with scheduled oil sampling. Use of single grade oils can affect engine oil control.
- Synthetic engine oils, American Petroleum Institute (API) Group III and Group IV basestocks, are recommended for use in Cummins® engines operating in ambient temperature conditions consistently below -25°C [-13°F]. Above this temperature, petroleum-based multigrade lubricants are recommended. Synthetic 0W-30 oils that meet API Group III and Group IV basestocks can be used in operations where the ambient temperature **never** exceeds 0°C [32°F]. 0W-30 oils do **not** offer the same level of protection against fuel dilution as do higher multigrade oils. Higher cylinder wear can be experienced when using 0W-30 oils in high-load situations.

For further details and an explanation of engine lubricating oils for Cummins® engines, refer to Cummins® Engine Oil and Oil Analysis Recommendations, Bulletin 3810340.

Additional information regarding lubricating oil availability throughout the world is available in the Engine Manufacturing Association (EMA) Lubricating Oils Data Book for Heavy Duty Automotive and Industrial Engines. This data book can be ordered from: Engine Manufacturers Association, Two North LaSalle Street, Suite 2200, Chicago, IL 60602; Phone: (312) 827-8700, Facsimile: (312) 827-8737 (www.enginemanufacturers.org).

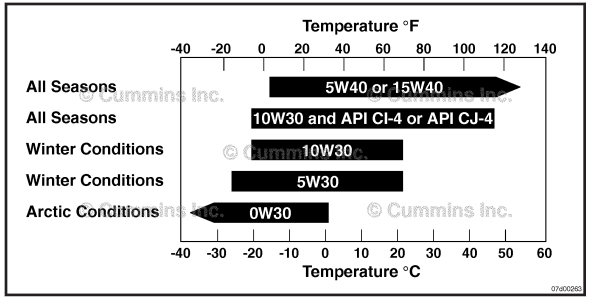


The API service symbols are shown in the accompanying illustration.

1 The upper half of the symbols display the appropriate oil categories.

2 The lower half contains additional oil information.

3 The center section identifies the SAE oil viscosity grade.



Oil viscosity **must** be chosen according to the typical climate conditions experienced by the user. Use of 15W-40 is recommended for the best engine durability at higher ambient temperatures. For cold conditions, 10W-30 or 5W-30 viscosity can be used for easier starting, improved oil flow, and improved fuel economy.

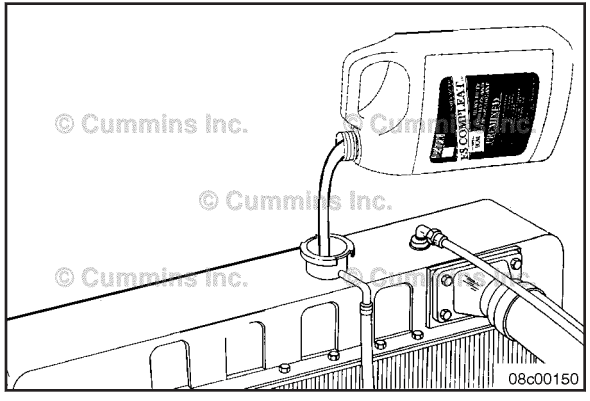
AfterMarket Oil Additive Usage

Cummins Inc. does **not** recommend the use of aftermarket oil additives. Present high-quality fully additive engine lubricating oils are very sophisticated, with precise amounts of additives blended into the lubricating oil to meet stringent requirements defined in CES 20081 that is similar to API CJ-4.

These furnished oils meet performance characteristics that conform to the lubricant industry standards. Aftermarket lubricating oil additives are **not** necessary to enhance engine oil performance, and in some cases they can reduce the finished oil's ability to protect the engine.

New Engine Break-in Oils

Special "break-in" engine lubricating oils are **not** recommended for new or rebuilt Cummins® engines. Use the same lubricating oil that will be used during normal operation.



Coolant Recommendations and Specifications

Fully Formulated Coolant/Antifreeze

Cummins Inc. recommends using either a 50/50 mixture of good-quality water and fully formulated antifreeze, or fully formulated coolant when filling the cooling system. The fully formulated antifreeze or coolant **must** meet CES14603 specifications.

Most coolants which meet American Society of Testing and Materials (ASTM) D6210 also meet CES14603. However, some OAT coolants such as Shell™ Rotell ELC, Chevron™ Texaco™ Delo ELC and their private label counterparts meet ASTM D6210, but do **not** meet the elastomer compatibility test of CES14603. These coolants are acceptable for use, assuming the OEM added silicate at initial fill. Refer to Bulletin 3666132, Cummins® Coolant Requirements and Maintenance, Section 3, Extended Service Interval, for more details.

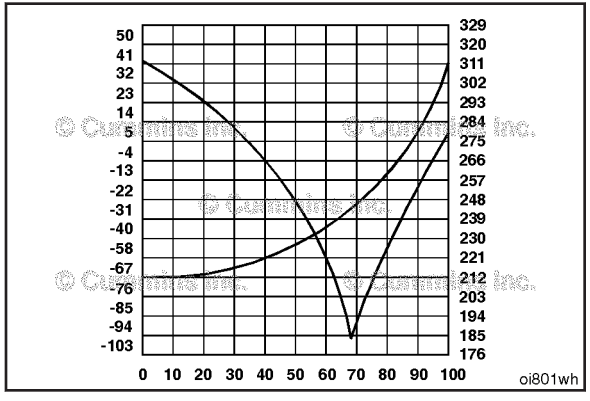
Good-quality water is important for cooling system performance. Excessive levels of calcium and magnesium contribute to scaling problems, and excessive levels of chlorides and sulfates cause cooling system corrosion.

Water Quality	
Calcium Magnesium (Hardness)	Maximum 170 ppm as ($CaCO_3$ + $MgCO_3$)
Chloride	Maximum 40 ppm as (Cl)
Sulfate	Maximum 100 ppm as (SO_4)

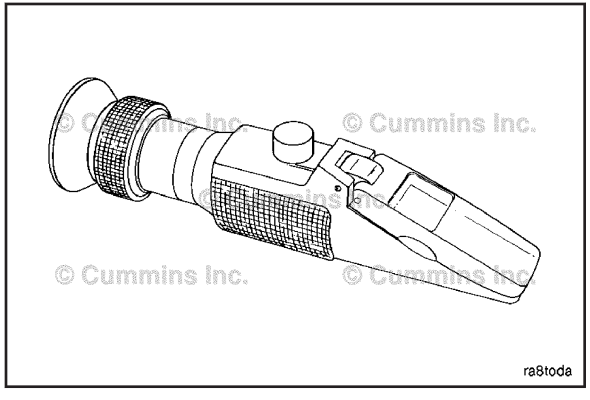
Cummins Inc. recommends the use of Fleetguard® Compleat ES™. It is fully formulated and meets or exceeds the following standards:

- CES14603
- ASTM D6210
- TMC RP329
- TMC RP330.

08c00127

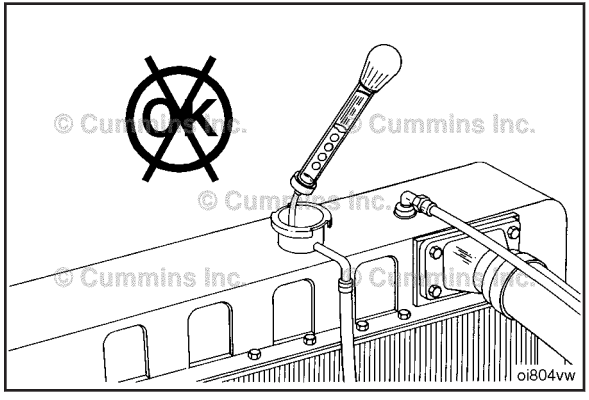


Fully formulated antifreeze **must** be mixed with good quality water at a 50/50 ratio (40-percent to 60-percent working range). A 50/50 mixture of antifreeze and water gives a -36°C [-33°F] freezing point and a 110°C [230°F] boiling point, which is adequate for locations in North America. The actual lowest freezing point of ethylene glycol antifreeze occurs at 68 percent. Using higher concentrations of antifreeze will raise the freezing point of the solution and increase the possibility of a silica gel problem.



A refractometer **must** be used to measure the freezing point of the coolant accurately.

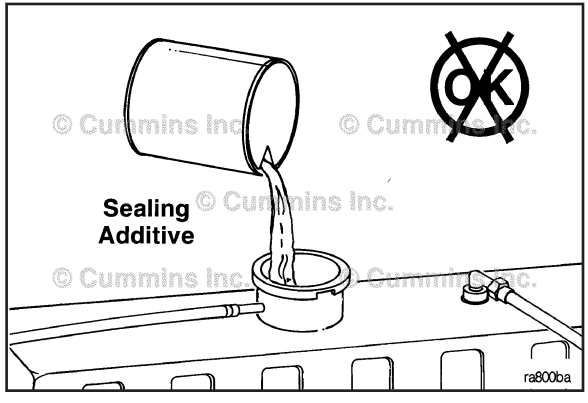
Do **not** use a floating ball hydrometer. The use of a floating ball hydrometer can give an incorrect reading.

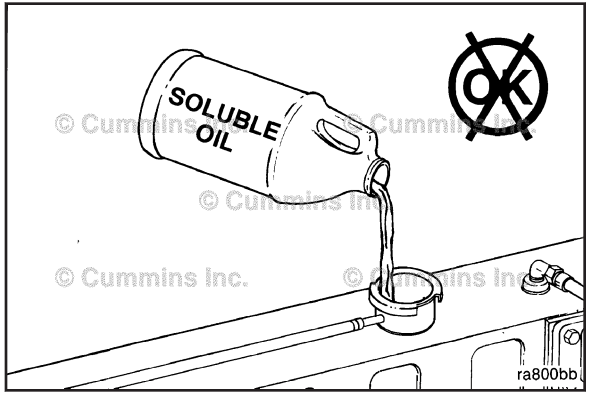


Cooling System Sealing Additives

Do **not** use sealing additives in the cooling systems. The use of sealing additives can:

- Buildup in coolant low-flow areas
- Clog coolant filters
- Plug radiators and oil coolers.



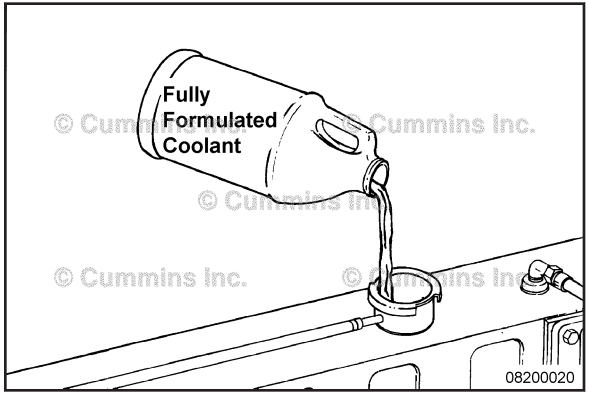


Cooling System Soluble Oils

Do **not** use soluble oils in the cooling system. The use of soluble oils can:

- Allow cylinder liner pitting
- Corrode brass, aluminum, and copper
- Damage heat transfer surfaces
- Damage seals and hoses.

Supplemental Coolant Additive (SCA)



⚠CAUTION⚠
QSX engines use aluminum parts that are in contact with the coolant. Improper coolant, coolant filter selection, and maintenance will likely result in corrosion of any of these parts. Insufficient concentration of the coolant additives will result in liner pitting and engine failure.

Fully formulated products contain supplemental coolant additives (SCA)s and are required to protect the cooling system from scale and fouling, solder corrosion, and general corrosion. The coolant filter is required to protect the cooling system from abrasive materials, debris, and precipitated coolant additives.

Testing SCA Concentration Level CC-2602 Test Kit

Precautions and Instructions for Proper Kit Use

Carefully follow the instructions to test the coolant. Take the appropriate action recommended by the kit.

- The coolant sample to be tested **must** be between 10°C [50°F] and 54°C [130°F]. If the sample is too cold or too hot, you will get incorrect results.
- To get the best color match results, compare test strip pads to the color chart in daylight or under cool white fluorescent lighting. If unsure about a specific color match when a test does fall between two colors on the color chart, choose the lower numbered (or lettered) block. It is safer to underestimate your results than to overestimate.

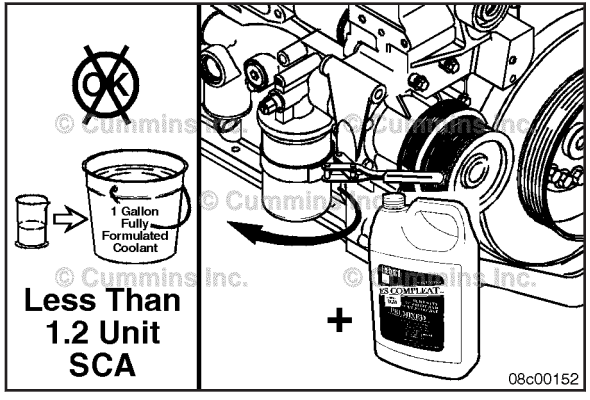
- The test strips do have a limited shelf life and are sensitive to humidity and extreme heat. Proper handling and storage is necessary to protect the life of the strips.
- Keep the cap tightly sealed on the test strip bottle **except** when removing a strip. Store away from direct sunlight and in an area where the temperature will generally stay below 32°C [90°F].
- Do **not** use the test strips after the expiration date stamped on the bottle.
- Discard the kit if the top pad on the unused strips have turned light brown.
- Use one strip at a time and take care **not** to touch any of the pads on the strip. Doing so will contaminate the pads and skew the test results.
- If the strip container is left uncapped for 24 hours, moisture in the air will render the strips useless, even though no discoloration will be evident.
- **Only** use the color chart supplied with the kit.
- Following the correct test times is very important. Use a clock or stopwatch.
- Do **not** utilize the test kit to maintain minimum SCA concentration levels (i.e., 1.5 units).
- When performing service that requires draining the cooling system, take special precautions to collect coolant in a clean non-galvanized container, seal to prevent contamination, and save for reuse.

Probablizer:

- 3318169S Plug - Installs on the engine for easy coolant sampling
- 3318168S Cap - Use with Monitor C bottle to sample coolant
- CC2700 Monitor C™ - Use lab analysis of coolant samples for more detailed analysis.

CC2602 Coolant Test Kit

- Works with any SCA formulation. Call 1-800-22FILTER (800-223-4583) if you have this test kit and the color chart does **not** show the number of units of SCA per gallon of coolant.)



Test Intervals

⚠ WARNING ⚠

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

Testing is recommended if the operator is **not** sure of the cooling system condition due to leaks, uncontrolled topping off of the system, or major coolant loss.

If the SCA concentration is below 1.2 units per gallon, replace the filter and precharge with liquid.

Check the SCA concentration level at least every 6 months, and anytime the coolant condition is unknown or corrosion is apparent within the cooling system.

Use Fleetguard® coolant test kit, CC2602, to check the concentration level. Instructions are included with the test kit.

Call the following numbers to get answers to any questions you have about cooling system maintenance:

Cummins Inc.	Fleetguard
1-800-DIESELS	**1-800-22FILTER**
1-800-343-7357	**1-800-223-4583**

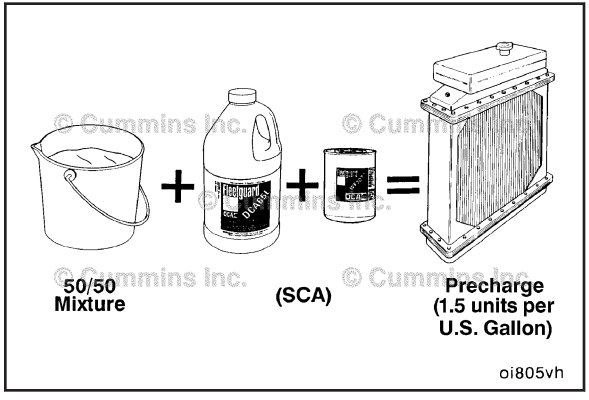
Coolant Replacement Requirements

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

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

Drain and flush the cooling system after 6000 hours or 3 years of service. However, if Fleetguard®'s ES coolant and ES filters are used, check chloride, sulfate, and pH levels according to Coolant Requirements and Maintenance, Bulletin 3666132, to determine whether the coolant **must** be replaced. Refill with either new fully formulated coolant or ES coolant.

NOTE: Dispose of used coolant or antifreeze in accordance with federal, state, and local laws and regulations.



Notes

Section W - Warranty

Section Contents

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All Engines Worldwide Generator Drive
Engines Warranted

This Warranty applies to new Engines sold by Cummins and delivered to the first user on or after April 1, 1999, that are used in generator drive applications anywhere in the world where Cummins approved service is available. These Engines will have the following rating designations:

Standby Power Rating

Engines of this rating are applicable for supplying emergency power for the duration of the utility power outage. No overload capability is available for this rating. Under no condition is an Engine allowed to operate in parallel with the public utility at the Standby Power rating. This rating should be applied where reliable utility power is available. A Standby rated Engine is to be sized for a maximum of an 80 percent average load factor and 200 hours of operation per year. This includes less than 25 hours per year at the Standby Power rating. Standby rating should never be applied except in true emergency power outages. Negotiated power outages contracted with a utility company are not considered an emergency.

Unlimited Time Running Prime Power Rating

Engines with this rating are available for an unlimited number of hours per year in a variable load application. Variable load is not to exceed a 70 percent average of the Prime Power rating during any operating period of 250 hours. Total operating time at 100 percent Prime Power shall not exceed 500 hours per year.

A 10 percent overload capability is available for a period of one hour within a twelve hour period of operation. Total operating time at the 10 percent overload power shall not exceed 25 hours per year.

Limited Time Running Prime Power Rating

Engines of this rating are available for a limited number of hours in a non-variable load application. It is intended for use in situations where power outages are contracted, such as in utility power curtailment. Engines may be operated in parallel to the public utility up to 750 hours per year at power levels never to exceed the Prime Power rating.

Limited Time Running Prime Power ratings differ from Unlimited Time Running in that even though the maximum power output of the Engines is the same, the Limited Time Running allows the Engine to be parallel to the public utility and run at the full Prime Power rating and must never exceed the Prime Power rating.

Continuous/Base Power Rating
Engines with this rating are available for supplying utility power at a constant 100 percent load for an unlimited number of hours per year. No overload capability is available for this rating.

Continuous/Base Power ratings differ from Unlimited Time Running Prime Power ratings in that the Continuous/Base Load ratings are significantly reduced from the Prime Power ratings. Continuous/Base Load ratings have no load factor or application restrictions.

Coverage

Base Engine Warranty
This Warranty covers any failures of the Engine, under normal use and service, which result from a defect in material or factory workmanship (Warrantable Failure).

Coverage begins with the sale of the Engine by Cummins and continues for the Duration stated below. The Duration commences either on the date of delivery of the Engine to the first user, or on the date the Engine is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first.

Base Engine Warranty

	Duration	
	Whichever Occurs First	
Rating	**Months**	**Hours**
Standby Power	24	400
Unlimited Prime Power	12	Unlimited
Limited Prime Power	12	750

Base Engine Warranty

	Duration	
	Whichever Occurs First	
Rating	**Months**	**Hours**
Continuous/Base Power	12	Unlimited

Engine aftertreatment components included in the Cummins Critical Parts List (CPL) and marked with a Cummins part number are covered under Base Engine Warranty.

Additional Coverage is outlined in the Emission Warranty section.

Extended Major Components Warranty

The Extended Major Components Warranty covers Warrantable Failures of the Engine cylinder block, camshaft, crankshaft and connecting rods (Covered Parts). Bushing and bearing failures are not covered. This Coverage begins with the expiration of the Base Engine Warranty and continues for the following stated Duration. The Duration commences either on the date of delivery of the Engine to the first user, or on the date the Engine is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first.

Extended Major Components Warranty

	Duration	
	Whichever Occurs First	
Rating	**Months**	**Hours**
Standby Power	36	600
Unlimited Prime Power	36	10,000
Limited Prime Power	36	2,250
Continuous/Base Power	36	10,000

Consumer Products
This Warranty on Consumer Products in the United States** is a LIMITED Warranty. **CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.** Any implied Warranties applicable to Consumer Products terminate concurrently with the expiration of the express Warranties applicable to the product. In the United States**, some states do not allow the exclusion of incidental or consequential damages, or limitations on how long an implied Warranty lasts, so the limitations or exclusions herein may not apply to you.

These Warranties are made to all Owners in the chain of distribution and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Cummins Responsibilities

During The Base Engine Warranty
Cummins will pay for all parts and labor needed to repair the damage to the Engine resulting from a Warrantable Failure when performed during normal business hours. All labor costs will be paid in accordance with Cummins published Standard Repair Time guidelines.

Cummins will pay for the lubricating oil, antifreeze, filter elements and other maintenance items that are not reusable due to the Warrantable Failure.

Cummins will pay reasonable travel expenses for mechanics to travel to and from the Engine site, including meals, mileage and lodging when the repair is performed at the site of the failure.

Cummins will pay reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

During The Extended Major Components Warranty
Cummins will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner Responsibilities

During The Base Engine Warranty

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during Warranty repairs unless such items are not reusable due to the Warrantable Failure.

During The Extended Major Components Warranty

Owner is responsible for the cost of all labor needed to repair the Engine, including the labor cost for Engine removal and reinstallation. When Cummins elects to repair a part instead of replacing it, the Owner is not responsible for the labor needed to repair the part.

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during repair of a Warrantable Failure.

During The Base Engine And Extended Major Components Warranties

Owner is responsible for the operation and maintenance of the Engine as specified in the applicable Cummins Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable Warranty, Owner must notify a Cummins distributor, authorized dealer or other repair location approved by Cummins of any Warrantable Failure and make the Engine available for repair by such facility. Service locations are listed on the Cummins Worldwide Service Locator at cummins.com.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for non-Engine repairs, "downtime" expenses, fines, all applicable taxes, all business costs and other losses resulting from a Warrantable Failure.

Owner is responsible for providing sufficient access to and reasonable ability to remove the Engine from the installation in the event of a Warrantable Failure.

Owner is responsible for maintaining an operating Engine hourmeter. If the hourmeter is not operational, Engine usage will be estimated at 400 hours per month.

Emission Warranty

Products Warranted

This Emission Warranty applies to new Engines marketed by Cummins that are used in the United States** or Canada in generator drive applications for Off-Highway use. This Warranty applies to Engines delivered to the ultimate purchaser on or after April 1, 1999 for Engines up to 750 horsepower and on or after January 1, 2000 for Engines 751 and over.

Coverage

Cummins warrants to the ultimate purchaser and each subsequent purchaser that the Engine is designed, built and equipped so as to conform at the time of sale by Cummins with all U.S. Federal emission regulations applicable at the time of manufacture and that it is free from defects in workmanship or material which would cause it not to meet these regulations within the longer of the following periods: (A) Five years or 3,000 hours of operation for industrial applications, five years or 3,500 hours of operation for industrial spark-ignited Engines (GTA855, G855, G5.9C, G8.3C, GTA8.9E, QSK19G, QSK60G) and five years or 2,500 hours of operation for industrial spark-ignited Engines (GKTA19-GC), whichever occurs first, as measured from the date of delivery of the Engine to the ultimate purchaser, or (B) The Base Engine Warranty.

If the vehicle in which the Engine is installed is registered in the state of California, a separate California Emission Warranty also applies.

Limitations

Engines with an emissions certification listed below must be operated using only diesel fuel having no more than the corresponding maximum sulfur content. Failure to use the specified fuel as listed in the Cummins Fuel Bulletin #3379001 Table 1 (Cummins Inc. Required Diesel Fuel Specifications) can damage the Engine and aftertreatment system within a short period of time. This damage could cause the Engine to become inoperable and failures

attributable to the use of incorrect fuels will be denied Warranty Coverage. Fuel specifications also need to comply with local fuel regulations (EN590 for Europe and ASTM D975 for North America) for Warranty eligibility.

Maximum sulfur levels by emissions certification level as listed on the Engine's dataplate are:

EPA 2007/2010/2013	max. 15 parts per million
EPA Tier 4 Interim / Final	max. 15 parts per million
EU Stage IIIB 2011	max. 15 parts per million
Euro 4/5	max. 50 parts per million
Euro 6	max. 10 parts per million

Additions to Limitations for HHP LBNG Engines:

Engines with an emissions certification listed below must be operated using only pipeline natural gas or non-commercial natural gas having no more than the corresponding sulfur content. Failure to use the specified fuel as listed in the engines applicable Operation and Maintenance Manual, Procedure 018-002 in Section V – Maintenance Specifications, can damage the Engine and after treatment system within a short period of time. This damage could cause the Engine to become inoperable and failures attributable to the use of incorrect fuels will be denied Warranty Coverage.

Maximum Sulfur Levels by Emissions Certification Level as listed on the Engine's Dataplate are (High Horsepower Lean-Burn Natural Gas Engines):	
EPA Tier 2 Nonroad	Maximum 20 parts per million (ppmv)
EPA NSPS	Maximum 20 parts per million (ppmv)

This Warranty does not apply to accessories supplied by Cummins which bear the name of another company. Such non-warranted accessories include, but are not limited to: alternators, starters, fans*, air conditioning compressors, clutches, filters, transmissions, air cleaners and safety shutdown switches.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that consumption exceeds Cummins published standards.

Failure of belts and hoses supplied by Cummins is not covered beyond the first 500 hours or one year of operation, whichever occurs first after the Warranty start date.

Parts used to repair a Warrantable Failure may be new Cummins parts, Cummins approved rebuilt parts or repaired parts. Cummins is not responsible for failures resulting from the use of parts not approved by Cummins.

A new Cummins or Cummins approved rebuilt part used to repair a Warrantable Failure assumes the identity of the part it replaced and is entitled to the remaining Coverage hereunder.

Cummins is not responsible for Engine performance problems or failures resulting from:

1 Use or application of the Engine inconsistent with its rating designation as set forth above.

2 Inadequate or incorrect installations deviating from Cummins Generator Drive Installation Guidelines.

CUMMINS IS NOT RESPONSIBLE FOR WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

In the United States** and Canada, this Warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Outside the United States** and Canada, in the case of consumer sales, in some countries, the Owner has statutory rights which cannot be affected or limited by the terms of this Warranty.

Nothing in this Warranty excludes or restricts any contractual rights the owner may have against third parties.

* Alternators, starters and fans ARE covered for the duration of the Base Engine Warranty on B3.3 Engines.

** United States includes American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico and the U.S. Virgin Islands.

All Engines United States And Canada Industrial (Off-Highway) Coverage

Products Warranted

This Warranty applies to new Engines sold by Cummins and delivered to the first user on or after April 1, 1999, that are used in Industrial (Off-Highway) applications in the United States* and Canada, except for Engines used in marine, generator drive and certain defense applications, for which different Warranty Coverage is provided.

Base Engine Warranty

This Warranty covers any failures of the Engine, under normal use and service, which result from a defect in material or factory workmanship (Warrantable Failures).

Coverage begins with the sale of the Engine by Cummins. Coverage continues for two years or 2,000 hours of operation, whichever occurs first, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first. If the 2,000 hour limit is exceeded during the first year, Coverage continues until the end of the first year.

Engine aftertreatment components included in the Cummins Critical Parts List (CPL) and marked with a Cummins part number are covered under Base Engine Warranty.

Additional Coverage is outlined in the Emission Warranty section.

Extended Major Components Warranty

The Extended Major Components Warranty covers Warrantable Failures of the Engine cylinder block, camshaft, crankshaft and connecting rods (Covered Parts).

Bushing and bearing failures are not covered.

This Coverage begins with the expiration of the Base Engine Warranty and ends three years or 10,000 (3,000 hours for A Series Engines) hours of operation from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or from when the Engine has been operated for 50 hours, whichever occurs first.

Consumer Products

The Warranty on Consumer Products in the United States* is a LIMITED Warranty. **CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.** Any implied Warranties applicable to Consumer Products in the United States* terminate concurrently with the expiration of the express Warranties applicable to the product. In the United States*, some states do not allow the exclusion of incidental or consequential damages, or limitations on how long an implied Warranty lasts, so the limitations or exclusions herein may not apply to you.

These Warranties are made to all Owners in the chain of distribution and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Cummins Responsibilities

During The Base Engine Warranty

Cummins will pay for all parts and labor needed to repair the damage to the Engine resulting from a Warrantable Failure.

Cummins will pay for the lubricating oil, antifreeze, filter elements and other maintenance items that are not reusable due to the Warrantable Failure.

Cummins will pay reasonable costs for mechanics to travel to and from the equipment site, including meals, mileage and lodging, when the repair is performed at the site of the failure.

Cummins will pay reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

During The Extended Major Components Warranty

Cummins will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner Responsibilities

During The Base Engine Warranty

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items provided during Warranty repairs unless such items are not reusable due to the Warrantable Failure.

During The Extended Major Components Warranty
Owner is responsible for the cost of all labor needed to repair the Engine, including the labor to remove and reinstall the Engine. When Cummins elects to repair a part instead of replacing it, Owner is not responsible for the labor needed to repair the part.

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during repair of a Warrantable Failure.

During The Base Engine And Extended Major Components Warranties
Owner is responsible for the operation and maintenance of the Engine as specified in the applicable Cummins Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable Warranty, Owner must notify a Cummins distributor, authorized dealer or other repair location approved by Cummins of any Warrantable Failure and make the Engine available for repair by such facility. Service locations are listed on the Cummins Worldwide Service Locator at cummins.com.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs and other losses resulting from a Warrantable Failure.

Limitations

Engines with an emissions certification listed below must be operated using only diesel fuel having no more than the corresponding maximum sulfur content. Failure to use the specified fuel as listed in the Cummins Fuel Bulletin

#3379001 Table 1 (Cummins Inc. Required Diesel Fuel Specifications) can damage the Engine and aftertreatment system within a short period of time. This damage could cause the Engine to become inoperable and failures attributable to the use of incorrect fuels will be denied Warranty Coverage. Fuel specifications also need to comply with local fuel regulations (EN590 for Europe and ASTM D975 for North America) for Warranty eligibility.

Maximum sulfur levels by emissions certification level as listed on the Engine's dataplate are:	
EPA 2007/2010/2013	max. 15 parts per million
EPA Tier 4 Interim / Final	max. 15 parts per million
EU Stage IIIB 2011	max. 15 parts per million
Euro 4/5	max. 50 parts per million
Euro 6	max. 10 parts per million

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil, fuel or diesel exhaust fluid or by water, dirt or other contaminants in the fuel, oil or diesel exhaust fluid.

For power units and fire pumps (package units), this Warranty applies to accessories, except for clutches and filters, supplied by Cummins which bear the name of another company.

For all other Industrial engines (except those previously mentioned), this Warranty does not apply to accessories which bear the name of another company. Such non-warranted accessories include, but are not limited to: alternators, starters, fans**, air conditioning compressors, clutches, filters, transmissions, torque converters, steering pumps, and non-Cummins fan drives, Engine compression brakes and air compressors.

Cummins Compusave units are covered by a separate Warranty.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that consumption exceeds Cummins published standards.

Failures of belts and hoses supplied by Cummins are not covered beyond the first 500 hours or one year of operation, whichever occurs first.

Parts used to repair a Warrantable Failure may be new Cummins parts, Cummins approved rebuilt parts or repaired parts. Cummins is not responsible for failures resulting from the use of parts not approved by Cummins.

A new Cummins or Cummins approved rebuilt part used to repair a Warrantable Failure assumes the identity of the part it replaced and is entitled to the remaining Coverage hereunder.

For all A Series Applications, including Industrial, travel reimbursement for non-transportable equipment will be limited to 4.0 hours, $0.25/mile and 250 miles maximum. Any costs beyond this limit are the customer's responsibility.

CUMMINS DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

This Warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

Emission Warranty

Products Warranted

This Emission Warranty applies to new Engines marketed by Cummins that are used in the United States* and Canada in vehicles designed for Industrial Off-Highway use. This Warranty applies to Engines delivered to the ultimate purchaser on or after April 1, 1999, for Engines up to 750 horsepower and on or after January 1, 2000, for Engines 751 horsepower and over.

Coverage

Cummins warrants to the ultimate purchaser and each subsequent purchaser that the Engine is designed, built and equipped so as to conform at the time of sale by Cummins with all U.S. Federal emission regulations applicable at the time of manufacture and that it is free from defects in workmanship or material which would cause it not to meet these regulations within the longer of the following periods: (A) ***Five years or 3,000 hours of operation for industrial applications, five years or 3,500 hours of operation for industrial spark-ignited Engines (GTA855, G855, G5.9C, G8.3-C, GTA8.9E, QSK19G) and five years or 2,500 hours of operation for industrial spark-ignited Engines (GKTA19-GC), whichever occurs first, as measured from the date of delivery of the Engine to the ultimate purchaser, or (B) The Base Engine Warranty.

If the vehicle in which the Engine is installed is registered in the state of California, a separate California Emission Warranty also applies.

Limitations

Engines with an emissions certification listed below must be operated using only diesel fuel having no more than the corresponding maximum sulfur content. Failure to use the specified fuel as listed in the Cummins Fuel Bulletin #3379001 Table 1 (Cummins Inc. Required Diesel Fuel Specifications) can damage the Engine and aftertreatment system within a short period of time. This damage could cause the Engine to become inoperable and failures attributable to the use of incorrect fuels will be denied Warranty Coverage. Fuel specifications also need to comply with local fuel regulations (EN590 for Europe and ASTM D975 for North America) for Warranty eligibility.

Maximum sulfur levels by emissions certification level as listed on the Engine's dataplate are:	
EPA 2007/2010/2013	max. 15 parts per million
EPA Tier 4 Interim / Final	max. 15 parts per million
EU Stage IIIB 2011	max. 15 parts per million
Euro 4/5	max. 50 parts per million
Euro 6	max. 10 parts per million

Failures, other than those resulting from defects in materials or workmanship, are not covered by this Warranty.

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolant or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil, fuel or diesel exhaust fluid or by water, dirt or other contaminants in the fuel, oil or diesel exhaust fluid.

Cummins is not responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all business costs or other losses resulting from a Warrantable Failure.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

* United States includes American Samoa, the Commonwealth of Northern Mariana Islands, Guam, Puerto Rico and the U.S. Virgin Islands.

** Alternators, starters, and fans ARE covered for the duration of the Base Engine Warranty on A Series and B3.3 Engines.

** Alternators and starters are covered for the duration of the Base Engine Warranty on QSK23 Engines.

*** Emissions Warranty for BLPG Industrial Off-Highway Engines is 5 years / 3,500 hours.

All Engines International Industrial (Off-Highway)

Coverage

Products Warranted

This Warranty applies to new Engines sold by Cummins and delivered to the first user on or after April 1, 1999, that are used in Industrial (Off-Highway) applications anywhere in the world where Cummins approved service is available, except the United States and Canada. Different Warranty Coverage is provided for Engines used in marine, generator drive and certain defense applications.

Base Engine Warranty

This Warranty covers any failures of the Engine, under normal use and service, which result from a defect in material or factory workmanship (Warrantable Failure).

Coverage begins with the sale of the Engine by Cummins. Coverage continues for two years or 2,000 hours of operation, whichever occurs first, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first. If the 2,000 hour limit is exceeded during the first year, Coverage continues until the end of the first year.

Engine aftertreatment components included in the Cummins Critical Parts List (CPL) and marked with a Cummins part number are covered under Base Engine Warranty.

Extended Major Components Warranty

The Extended Major Components Warranty covers Warrantable Failures of the Engine cylinder block, camshaft, crankshaft and connecting rods (Covered Parts).

Bushing and bearing failures are not covered.

This Coverage begins with the expiration of the Base Engine Warranty and ends three years or 10,000 hours (3,000 hours for A Series Engines) of operation, from the date of delivery of the Engine to the first user, or from the date the unit is first leased, rented or loaned, or when the Engine has been operated for 50 hours, whichever occurs first.

These Warranties are made to all Owners in the chain of distribution, and Coverage continues to all subsequent Owners until the end of the periods of Coverage.

Cummins Responsibilities

During The Base Engine Warranty

Cummins will pay for all parts and labor needed to repair the damage to the Engine resulting from a Warrantable Failure.

Cummins will pay for the lubricating oil, antifreeze, filter elements and other maintenance items that are not reusable due to a Warrantable Failure.

Cummins will pay reasonable costs for mechanics to travel to and from the equipment site, including meals, mileage and lodging, when the repair is performed at the site of the failure.

Cummins will pay reasonable labor costs for Engine removal and reinstallation when necessary to repair a Warrantable Failure.

During The Extended Major Components Warranty

Cummins will pay for the repair or, at its option, replacement of the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner Responsibilities

During The Base Engine Warranty

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during Warranty repairs unless such items are not reusable due to the Warrantable Failure.

During The Extended Major Components Warranty

Owner is responsible for the cost of all labor needed to repair the Engine, including the labor to remove and reinstall the Engine. When Cummins elects to repair a part instead of replacing it, Owner is not responsible for the labor needed to repair the part.

Owner is responsible for the cost of all parts required for the repair except for the defective Covered Part and any Covered Part damaged by a Warrantable Failure of the defective Covered Part.

Owner is responsible for the cost of lubricating oil, antifreeze, filter elements and other maintenance items replaced during repair of a Warrantable Failure.

During The Base Engine Warranty And Extended Major Components Warranties
Owner is responsible for the operation and maintenance of the Engine as specified in the applicable Cummins Operation and Maintenance Manual. Owner is also responsible for providing proof that all recommended maintenance has been performed.

Before the expiration of the applicable Warranty, Owner must notify a Cummins distributor, authorized dealer or other repair location approved by Cummins of any Warrantable Failure and make the product available for repair by such facility. Service locations are listed in the Cummins Worldwide Service Locator at cummins.com.

Owner is responsible for communication expenses, meals, lodging and similar costs incurred as a result of a Warrantable Failure.

Owner is responsible for non-Engine repairs, "downtime" expenses, cargo damage, fines, all applicable taxes, all business costs and other losses resulting from a Warrantable Failure.

Limitations

Engines with an emissions certification listed below must be operated using only diesel fuel having no more than the corresponding maximum sulfur content. Failure to use the specified fuel as listed in the Cummins Fuel Bulletin #3379001 Table 1 (Cummins Inc. Required Diesel Fuel Specifications) can damage the Engine and aftertreatment system within a short period of time. This damage could cause the Engine to become inoperable and failures attributable to the use of incorrect fuels will be denied Warranty Coverage. Fuel specifications also need to comply with local fuel regulations (EN590 for Europe and ASTM D975 for North America) for Warranty eligibility.

Maximum sulfur levels by emissions certification level as listed on the Engine's dataplate are:

EPA 2007/2010/2013	max. 15 parts per million
EPA Tier 4 Interim / Final	max. 15 parts per million
EU Stage IIIB 2011	max. 15 parts per million
Euro 4/5	max. 50 parts per million
Euro 6	max. 10 parts per million

Cummins is not responsible for failures or damage resulting from what Cummins determines to be abuse or neglect, including, but not limited to: operation without adequate coolants or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or intake systems; improper storage, starting, warm-up, run-in or shutdown practices; unauthorized modifications of the Engine. Cummins is also not responsible for failures caused by incorrect oil, fuel or diesel exhaust fluid or by water, dirt or other contaminants in the fuel, oil or diesel exhaust fluid.

For power units and fire pumps (package units) the Warranty applies to accessories, except for clutches and filters supplied by Cummins which bear the name of another company.

Except for the accessories noted previously, Cummins does not warrant accessories which bear the name of another company. Such non-warranted accessories include, but are not limited to: alternators, starters, fans*, air conditioning compressors, clutches, filters, transmissions, torque converters, steering pumps, non-Cummins fan drives and air cleaners.

Cummins Compusave units are covered by a separate Warranty.

Before a claim for excessive oil consumption will be considered, Owner must submit adequate documentation to show that consumption exceeds Cummins published standards.

Failures of belts and hoses supplied by Cummins are not covered beyond the first 500 hours or one year of operation, whichever occurs first.

Parts used to repair a Warrantable Failure may be new Cummins parts, Cummins approved rebuilt parts or repaired parts. Cummins is not responsible for failures resulting from the use of parts not approved by Cummins.

A new Cummins or Cummins approved rebuilt part used to repair a Warrantable Failure assumes the identity of the part it replaced and is entitled to the remaining Coverage hereunder.

For all A Series Applications, including Industrial, travel reimbursement for non-transportable equipment will be limited to 4.0 hours, $0.25/mile and 250 miles maximum. Any costs beyond this limit are the customer's responsibility.

CUMMINS DOES NOT COVER WEAR OR WEAROUT OF COVERED PARTS.

CUMMINS IS NOT RESPONSIBLE FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES.

THESE WARRANTIES SET FORTH HEREIN ARE THE SOLE WARRANTIES MADE BY CUMMINS IN REGARD TO THESE ENGINES. CUMMINS MAKES NO OTHER WARRANTIES, EXPRESS OR IMPLIED, OR OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

In the case of consumer sales, in some countries, the Owner has statutory rights which cannot be affected or limited by the terms of this Warranty.

Nothing in this Warranty excludes or restricts any contractual rights the Owner may have against third parties.

* Alternators, starters, and fans ARE covered for the duration of the Base Engine Warranty on A Series and B3.3 Engines.

* Alternators and starters are covered for the duration of the Base Engine Warranty on QSK23 Engines.

California Emission Control System Warranty, Off-Highway

Products Warranted

This Emission Control System Warranty applies to off-road diesel engines certified with the California Air Resources Board beginning with the year 1996 for engines up to 750 horsepower, beginning with the year 2000 for 751 horsepower and over, marketed by Cummins, and registered in California for use in industrial off-highway applications.

Your Warranty Rights and Obligations

The California Air Resources Board and Cummins Engine Company, Inc., are pleased to explain the emission control system warranty on your engine. In California, new off-road diesel engines must be designed, built and equipped to meet the State's stringent anti-smog standards. Cummins must warrant the emission control system on your engine for the periods of time listed below provided there has been no abuse, neglect or improper maintenance of your engine.

Your emission control system may include parts such as the fuel injection system and the air induction system. Also included may be hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, Cummins will repair your off-road diesel engine at no cost to you including diagnosis, parts and labor.

Manufacturer's Warranty Coverage

This warranty coverage is provided for 5 years or 3,000 hours of engine operation, whichever first occurs from the date of delivery of the engine to the first user. If any emission-related part on your engine is defective, the part will be repaired or replaced by Cummins.

California Emission Control System Warranty

Coverage

This list of emission control parts may be covered by the emission control system warranty under certain failure modes:

Aftertreatment System	**Base Engine System**
Component	**Component**
Aftertreatment Electroconnections	Cam Shaft
Aftertreatment Fuel Drain Valve	Cam Shaft Valve Lobe
Aftertreatment Fuel Injector/Regulator	Coolant Temperature Sensor
Aftertreatment Fuel Pressure Sensor	Crankcase Breather
Aftertreatment Fuel Shut-off Valve	Engine Oil Pressure Sensor
Aftertreatment Injector Manifold	Engine Oil Temperature
Aftertreatment Inlet and Outlet Modules	Engine Speed, Position Sensor, Cam Position Sensor
Aftertreatment Temperature Interface Module	Exhaust Valve
Aftertreatment System (cont')	**EGR System**
Component	**Component**
Aftertreatment Temperature Sensors	EGR Cooler
Decomposition Tube	EGR Differential Pressure Sensor
DEF Dosing Unit (Pump)	EGR Mixer/Venturi
DEF Dosing Valve	EGR Temperature Sensor

Diesel Oxidation Catalyst	EGR Mixer/Venturi
Diesel Particulate Filter (except for ash maintenance)	EGR Valve
Diesel Particulate Filter Differential Pressure Sensor	
NOx Sensors	
SCR Catalyst	
Air Handling	**Electronic Control System**
Component	**Component**
Barometric Air Pressure Sensor	Engine Control Module
Exhaust Gas Pressure Sensor	Engine Control Module Calibration
Exhaust Manifold	
Air Handling (cont')	**Fuel System**
Component	**Component**
Charge Air Cooler and Associated Plumbing	Fuel Lines
Intake Manifold	Fuel Pressure Sensor
Intake Manifold Temperature/Pressure Sensor	Fuel Pump
Turbocharger Actuator	Injector
Turbocharger Assembly	Secondary Fuel Pressure/Temperature Sensor
Turbocharger Compressor Inlet Air Temperature Sensor	
Turbocharger Speed Sensor	

Owner's Warranty Responsibilities

As the off-road diesel engine owner, you are responsible for the performance of the required maintenance listed in your Cummins Operation and Maintenance Manual. Cummins recommends that you retain all receipts covering maintenance on your off-road diesel engine, but Cummins cannot deny warranty solely for the lack of receipts or for your failure to ensure the performance of all scheduled maintenance.

You are responsible for presenting your off-road diesel engine to a Cummins dealer as soon as a problem exists. The warranty repairs should be completed in a reasonable amount of time, not to exceed 30 days.

As the off-road diesel engine owner, you should also be aware that Cummins may deny you warranty coverage if your off-road diesel engine or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

Your engine is designed to operate on diesel fuel only. Use of any other fuel may result in your engine no longer operating in compliance with California's emissions requirements.

If you have any questions regarding your warranty rights and responsibilities, you should contact Cummins Customer Assistance Department at 1-800-343-7357 (1-800-DIESELS) or the California Air Resources Board at 9528 Telstar Avenue, El Monte, CA 91731.

Prior to the expiration of the applicable warranty, Owner must give notice of any warranted emission control failure to a Cummins distributor, authorized dealer or other repair location approved by Cummins and deliver the engine to such facility for repair. Repair locations are listed in Cummins United States and Canada Service Directory.

Owner is responsible for incidental costs such as: communication expenses, meals, lodging incurred by Owner or employees of Owner as a result of a warrantable failure.

Owner is responsible for business costs and losses, "downtime" expenses, and cargo damage resulting from a warrantable failure. CUMMINS IS NOT RESPONSIBLE FOR OTHER INCIDENTAL OR CONSEQUENTIAL DAMAGES, INCIDENTAL OR CONSEQUENTIAL DAMAGES INCLUDE BUT ARE NOT LIMITED TO FINES, THEFT, VANDALISM OR COLLISIONS.

Replacement Parts

Cummins recommends that any service parts used for maintenance, repair or replacement of emission control systems be new, genuine Cummins or Cummins approved rebuilt parts and assemblies, and that the engine be serviced by a Cummins distributor, authorized dealer or the repair location approved by Cummins. The owner may elect to have maintenance, replacement or repair of the emission control parts performed by a facility other than a Cummins distributor, an authorized dealer or a repair location approved by Cummins, and may elect to use parts other than new genuine Cummins or Cummins approved rebuilt parts and assemblies for such maintenance, replacement or repair; however, the cost of such service or parts will not be covered under this emission control system warranty.

Cummins Responsibilities

Repairs and service will be performed by any Cummins distributor, authorized dealer or other repair location approved by Cummins using new, genuine Cummins or Cummins approved rebuilt parts and assemblies. Cummins will repair any of the emission control parts found by Cummins to be defective without charge for parts or labor (including diagnosis which results in determination that there has been a failure of a warranted emission control part).

Emergency Repairs

In the case of an emergency where a Cummins distributor, authorized dealer, or other repair location approved by Cummins is not available, repairs may be performed by any available repair location using any replacement parts. Cummins will reimburse the Owner for expenses (including diagnosis), not to exceed the manufacturer's suggested retail price for all warranted parts replaced and labor charges based on the manufacturer's recommended time allowance for the warranty repair and the geographically appropriate hourly labor rate. A part not being available within 30 days or a repair not being complete within 30 days constitutes an emergency. Replaced parts and paid invoices must be presented at a Cummins authorized repair facility as a condition of reimbursement for emergency repairs not performed by a Cummins distributor, authorized dealer, or other repair location approved by Cummins.

Warranty Limitations

Cummins is not responsible for failures resulting from Owner or operator abuse or neglect, such as: operation without adequate coolant, fuel or lubricants; overfueling; overspeeding; lack of maintenance of lubricating, cooling or air intake systems; improper storage, starting, warm-up, run-in or shutdown practices.

The manufacturer warrants to the ultimate purchaser and each subsequent purchaser that the engine is designed, built, and equipped so as to conform with all applicable regulations adopted by the Air Resources Board, and that it is free from defects in materials and workmanship which cause the failure of a warranted part.

Any warranted part which is not scheduled for replacement as required maintenance, or which is scheduled only for regular inspection to the effect of "repair or replace as necessary" is warranted for the warranty period.

Any warranted part which is scheduled for replacement as required maintenance is warranted for the period of time prior to the first scheduled replacement point for that part.

The owner will not be charged for diagnostic labor which leads to the determination that a warranted part is defective, if the diagnostic work is performed at a warranty station.

The manufacturer is liable for damages to other engine components caused by the failure under warranty of any warranted part.

Cummins is not responsible for failures resulting from improper repair or the use of parts which are not genuine Cummins or Cummins approved parts.

These warranties, together with the express commercial warranties and emission warranty are the sole warranties of Cummins. There are no other warranties, express or implied, or of merchantability or fitness for a particular purpose.

Notes

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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.

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APPLICABLE ONLY IN U.S.A. AND CANADA

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