Source Of The Engine Name

The ISB6.7 CM2350 B101 engine names are derived from many sources:
The IS portion of the name represents the Interact System. The Interact System is Cummins automotive/on-highway full-authority electronic engine control system.
The B portion of the name represents the engine family. The ISB is part of the B series mid-range engine family.
The 6.7 portion represents the engine displacement.
The CM2350 portion of the name represents the engine control system.
The B101 suffix means that this engine equipped with EPA 2013 On-Board Diagnostics (OBD) and following aftertreatment hardware:

- Exhaust Gas Recirculation (EGR)
- Aftertreatment Outlet NOx Sensor
- Diesel Oxidation Catalyst (DOC)
- Aftertreatment Diesel Particulate filter (DPF)
- Aftertreatment Diesel Exhaust Fluid (DEF) Quality Sensor
- Integrated Aftertreatment Dosing Control Unit
- Aftertreatment Airless Selective Catalytic Reduction (SCR)
- Aftertreatment intermediate NH3 Sensor
- Aftertreatment Outlet NOx Sensor
Base Engine Specifications:

- The ISB6.7 CM2350 is a 6.7 liter displacement inline 6 cylinder engine.
- Firing order: 1-5-3-6-2-4
- Rear gear train only
- Engine operation voltage 12 V and 24 volts.
  - All required components are available in 12 and 24 volts:
    - CM2350 ECM
    - Grid heaters
    - Aftertreatment NOx Sensors
    - VGT actuator
    - DEF Supply Module
    - Starter, Alternator
Base Engine Specifications:

Model, BHP, Peak Torque Lb-t@RPM , Governed RPM

School Bus Applications

- ISB6.7 200  520@1600  2600
- ISB6.7 220  520@1600  2600
- ISB6.7 240  560@1600  2600
- ISB6.7 250  660@1600  2600
- ISB6.7 260  660@1600  2600
- ISB6.7 280  660@1600  2600
- ISB6.7 300  660@1600  2600
Engine Dataplate Location And Information:

The dataplate contains the following information:
- Engine serial number,
- Control parts list (CPL),
- Model,
- Horsepower and rpm rating.

If the engine dataplate is not readable, the engine serial number can be identified on the engine block on top of the lubricating oil cooler housing. Additional engine information is available by reading the ECM dataplate.
Engine Quick Identifiers:

The CM2350 ECM with two connectors:

- A ninety six pin **Engine** harness connector
- A ninety six pin **OEM** harness connector

Aftertreatment System:

- New aftertreatment system sensors
  - Aftertreatment Intermediate NH3 Sensor
  - Diesel Exhaust Fluid (DEF) Quality Sensor (Optional)
  - Datalinked Temperature Sensors
- Dosing Control Module eliminated (Integrated with CM2350 ECM)

Air Handling

- New intake air throttle
- New programmable turbocharger actuator
Engine Systems

The following sections will cover the systems and components of the engines including:

- Mechanicals
- Air system
- Cooling system
- Lubrication system
- Fuel system
MECHANICALS
Front Gear Cover

The front gear cover houses the lubricating oil pump, front crankshaft seal, and camshaft speed indicator ring.

The front gear covers also contains the oil pressure switch, camshaft speed/position sensor, and crankshaft speed/position sensor.
Front Crankshaft Seal

The front crankshaft seal is a dual or non-lip style seal which utilize a built in wear sleeve and a concealed sealing lip.

Because the rotating portion of the seal does not contact the crankshaft, wear will not occur at the crankshaft but instead internal to the seal.

No wear sleeve or oversize front crankshaft seal is available.
Crankshaft Seal, Front - Install

- Use tool, Part Number 3164659, to install the oil seal into the front gear cover.
- Mount the replacer screw assembly onto the crankshaft nose.
- Install the two M12 x 1.25 x 60 mm socket head capscrews.
- Place the new front crankshaft seal over the crankshaft nose and slide it by hand toward the front gear cover as far as possible.
  - NOTE: Make sure the seal is positioned square with the crankshaft.
- While holding the replacer screw, install the crankshaft seal replacer onto the replacer screw assembly.
- Advance the crankshaft seal replacer toward the seal by rotating it clockwise until it is positioned against the seal.
- While holding the crankshaft seal replacer, rotate the replacer screw **counterclockwise** until the crankshaft seal replacer contacts the front gear cover.
Rear Crankshaft Seal

Lip-style rear crankshaft seal
Rear Crankshaft Seal - Continued

Each new rear crankshaft seal will come with 2 disposable seal drivers
- One for Front Gear Train Engine (1)
- One for Rear Gear Train Engine (2)

The rear crankshaft seal is installed in the flywheel housing bore, 2 installation methods available
Rear Crankshaft Seal - Install

Rear Crankshaft Seal Replacer Kit, Part #3164660

<table>
<thead>
<tr>
<th>Part #</th>
<th>Description</th>
<th>Q-ty</th>
</tr>
</thead>
<tbody>
<tr>
<td>3164666</td>
<td>Replacer screw assembly</td>
<td>1</td>
</tr>
<tr>
<td>3164664</td>
<td>Crankshaft seal replacer</td>
<td>1</td>
</tr>
<tr>
<td>3164174</td>
<td>Socket head capscrew, M12 x 1.25x 25 mm</td>
<td>2</td>
</tr>
<tr>
<td>3164217</td>
<td>Sheet metal screw, Number 10x25.4 mm [1 in] long</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Disposable plastic driver (purchased with rear crankshaft seal kit)</td>
<td>1</td>
</tr>
</tbody>
</table>
Rear Gear Train
Vibration Damper and Crankshaft Speed Indicator Ring

Viscous damper is standard

Vibration damper and crankshaft speed indicator ring are a permanent assembly

When either damaged replace as assembly
Rocker Levers

- Mounted on a common rocker shaft
- Receives pressurized oil for lubrication from a drilling in the rocker shaft
- Each rocker lever actuates two valves by the crosshead
- Each rocker lever has two drillings:
  - One drilling supplies lubrication oil to the push rod
  - Other drilling supplies lubrication oil to e-foot
Crosshead

Same as used on all 4 valve per cylinder “B” product

The crosshead allows the rocker lever to move both exhaust or intake valves at the same time.

The crosshead receives its lubrication from a drilling in the rocker lever and rocker shaft.
Overhead Set

Overhead setting is only required at the interval specified in the appropriate Operation and Maintenance / Owners manuals,

or, When engine repairs cause removal of the rocker levers and/or loosening of the adjusting screws.
Overhead Set

TDC 1
- 1I, 1E, 2I, 3E, 4I, and 5E.

TDC 6
- 2E, 3I, 4E, 5I, 6I, and 6E.

Intake 0.010 in
Exhaust 0.026 in
Rocker Lever Housings

Two options:

Standard (rocker cover mounted breather)
- Features two electrical connectors
- Connectors are part of the rocker cover gasket

Low Clearance (flywheel mounted breather)
- Three pass through connectors in rocker housing
- Three small wiring harnesses connect pass-through connectors to injectors
Rocker Lever Cover

Crankcase Breather mounted in the rocker cover
Same as used on many current increased displacement ISB series product

- Has a permanently attached breather baffle (1)
- Crankcase gases exist at the rear of the rocker lever cover and enter the crankcase breather tube
- Solids/liquids drain back into the crankcase through a tube connecting the breather to the top of the rear-gear housing
Open Crankcase Breather System

Consists of a housing, breather element, and drain tubes

Maintenance:
2,500 hrs or 75,000 miles
AIR INTAKE AND EXHAUST SYSTEM
Air Intake Diagram
Air Intake Connection

Two drillings for easier cleaning
- Change made on 2010 product

Same Differential pressure sensor for B & L
ENGINE INTAKE THROTTLE ACTUATOR

- Intake throttle actuator is used on the midrange engines provides better air control for EGR mixing

- The ITA acts as an EGR assist device to reduce pumping losses to EGR flow and exhaust restriction

- Allows for greater optimization of engine timing. Closing the ITA limits the intake (boost) air and reduces the pressure the EGR flow works against

- ITA closes when EGR and VGT are not capable of providing the commanded EGR flow without assistance
ENGINE INTAKE THROTTLE ACTUATOR

Actuator controls the movement of the throttle plate.

- The position of the engine intake throttle actuator moves between fully open (100 percent) and fully closed (0 percent).
- Normally Open / Spring Loaded

Expected Actuator Position

- At key off – 100 %
- At engine start - 90 %
- While the engine is running, the engine intake throttle actuator should never be fully open (100 %)
- Actuator position could be monitored with INSITE™
ENGINE INTAKE THROTTLE ACTUATOR - Codes

- Actuator Codes
  - 175 - Electronic Throttle Control Actuator Driver Circuit - Voltage above normal, or shorted to high source
  - 176 - Electronic Throttle Control Actuator Driver Circuit - Voltage below normal, or shorted to low source
  - 177 - Electronic Throttle Control Actuator - Mechanical system not responding or out of adjustment

- Position Sensor Codes
  - 3539 - Engine Intake Throttle Actuator Position Sensor Circuit - Voltage above normal, or shorted to high source
  - 3541 - Engine Intake Throttle Actuator Position Sensor Circuit - Voltage below normal, or shorted to low source
  - 3542 - Engine Intake Throttle Actuator Position Sensor - Data erratic, intermittent or incorrect
Exhaust Diagram
Variable Geometry Turbocharger

Images shown are from ISB6.7 CM2350
Variable Geometry Turbochargers Function

✓ The Variable Geometry Turbochargers primary function is to build boost pressure more quickly to improve transient response.

✓ The VG turbo can also be used to increase the exhaust manifold backpressure. This increased backpressure is used to force a portion of the exhaust gases through the EGR system. This helps to increase the pressure on the exhaust gas over that of the boosted air from the charge-air-cooler.

✓ The VGT can also be used to provide exhaust braking.
VGT Components

1. Turbo Speed Sensor
2. The turbine and housing
3. Yoke Mechanism

1. Nozzle Ring
2. Shroud Plate
3. The compressor and housing
The VGT Actuator has built in electronics that send information to the ECM about its travel capabilities.

The travel capabilities include total range of movement (fully opened/ fully closed) the amount of energy required to accomplish movement and current position of the actuator.

All of these electronic capabilities of the actuators provide diagnostic and fault code reporting through the ECM.
Fully Closed Nozzle Ring

- With the nozzle ring fully closed, the turbine volute exit area is at its minimum.
- This creates the maximum exhaust manifold pressure.
- Turbocharger shaft speed and boost pressure are at their highest.
Sector gear setup

Smaller frame size turbo on the ISL (same as B, but with Top mount actuator)

New Actuator
  - Re-flashable

There will be markings on the bearing housing for sector gear travel checks and installation alignment

Pinon gear on actuator may not rotate during actuator initial installation step
  - INSITE/Calibration
  - May cause confusion compared to previous product that had the pinion gear move for alignment

Hash marks engraved into bearing housing
Sector gear travel gauge
Variable Geometry Turbocharger - Remove

Preparatory Steps:

NOTE: Be sure the coolant is completely drained from the engine. After draining the coolant, it may be necessary to unhook the turbocharger coolant return hose.

- Steam clean the area around the turbocharger actuator and dry with compressed air.
- Drain the coolant.
- Apply compressed air to push coolant out of the cavity between the turbocharger bearing housing and the actuator.
- Remove the turbocharger actuator wiring harness zip ties and P-clips. Take note of the wiring harness routing.
Variable Geometry Turbocharger - Remove

- Disconnect the wiring harness from the turbocharger actuator by sliding the locking tang to the open position, then push down on the release lever and pull the connection apart.
- Remove the turbocharger actuator mounting capscrews with a 5 mm Allen wrench. **Discard the capscrews.**
- Remove the actuator.
- Remove and **discard the turbocharger actuator sealing gaskets.**
Clean and Inspect for Reuse

- Inspect the sector gear on the turbocharger for excessive wear, damaged teeth, or a broken shaft.

- Grasp the sector gear by hand and move it through its operational range.

- The sector gear must move smoothly by hand through its entire range of motion. It takes considerable effort to begin moving the sector gear. However, once the sector gear begins to move, minimal force is required to continue moving the sector gear through its operating range.

- The sector gear travel gauges are designed for specific turbocharger models. To determine the correct gauge, verify the turbocharger model number from the turbocharger dataplate. Select the gauge that matches the first three characters of the model numbers, such as He5xx or He4xx.
Variable Geometry Turbocharger - Install

**NOTE:** Following these instructions in order is very important.

**NOTE:** If the VGT actuator must be replaced, the new device must be calibrated. New VGT actuators are not calibrated by the manufacturer. ?!?!?

- Continue through the entire turbocharger actuator installation procedure before attempting to troubleshoot any other fault codes.
- Verify that the turbocharger actuator is removed from the turbocharger bearing housing.
- Verify that the turbocharger actuator electrical connector is disconnected from the engine wiring harness.
- Turn the keyswitch ON. Connect INSITE™ electronic service tool and wait 60 seconds.
- Connect the turbocharger actuator electrical connector to the engine wiring harness.
- If Fault Code 2634 becomes active, disconnect the turbocharger actuator connector from the engine wiring harness with the keyswitch ON. Connect the turbocharger actuator electrical connector. Fault Code 2634 will go inactive.
- It is normal and expected to have Fault Code 2449 active when a new turbocharger actuator is connected to the engine, because it is **not** calibrated to the turbocharger.
- Continue through the engine turbocharger actuator installation procedure before attempting to troubleshoot any other fault codes.
EGR Valve

Service Strategy

- One piece valve assembly (non-serviceable)

Service Procedures

- 011-022 EGR Valve
- 011-025 EGR Connection Tubes

EGR crossover tube is sealed with gaskets at each end – Exhaust manifold style gaskets
EGR Cooler

Same as 2010 cooler design
- 2010 EGR leak test kit and procedure
- EGR cooler o-rings must never be reused

No V-band clamps on crossover tubes (all 2 bolt flanges) with common gasket B, C, & L
COOLING SYSTEM
Cooling System Specifications

Coolant Capacity  11.5 liters [3.0 gal]

Standard Modulating Thermostat Range
  86 to 97°C [186 to 207°F]

Maximum Allowed Operating Temperature
  107°C [225°F]

Minimum Recommended Operating Temperature
  71°C [160°F]

Minimum Recommended Pressure Cap  90 kPa [13 psi]

Maximum Recommended Pressure Cap  172 kPa [25 psi]
Changes from ISB6.7 CM2250

Coolant vent lines:
- Turbocharger Actuator does NOT have vent line
- EGR cooler has vent line
- Added vent line from engine block

Proper de-aeration of system is still a critical factor for life of EGR cooler
Thermostat Modulation Range

Initial Opening 86°C MIN 186°F
89°C MAX 193°F

Fully Opened 97°C MAX 207°F

The thermostat contains two check balls to vent air past the thermostat when it is closed.

This helps to vent air during the cooling system fill process.
Sequence of Events for Coolant Fill and De-aeration for EGR engines

Please refer to QSOL for latest procedure
Background

Critical part of the engines equipped with EGR, is the proper coolant fill procedure.

- Air pockets in EGR cooler result in cooler failure
- Customer complaints of incorrect coolant level following service events involving the cooling system

Changes have been made to the following Service Procedures

- 008-018 Cooling System
- 008-020 Cooling System Diagnostics
Diagnostic Improvements

In the event of a cooling system related failure, it is recommended the coolant level switch(s) be checked for proper operation. Refer to OEM troubleshooting information for operational checks & repairs

Removal & reinstallation of the coolant level switch(s) is not recommended for diagnostics

- The switch bodies are typically made of composite materials
- The switch should only be removed if being replaced, or required as part of the OEM troubleshooting procedure
- Installation torque is critical. Refer to OEM service literature for more information
De-Aeration

Heater Lines:

- When possible isolate the engine from any heating system loops if the OEM has installed flow valves
- This helps prevent heater circuits from draining and creating additional air pockets
- Air trapped in the heating circuits can be some of the most difficult to purge due to length of the plumbing, numerous heater cores, and associated control valves

OEM Recommendations:

- Consult the OEM service literature to understand any special coolant drain and fill requirements of recommendations
- Some OEMS may also place special instructions near cooling system access or fill locations
Basic Cooling System Re-fill procedure

Sequence of Events for Coolant Fill and Deaeration

- Initial Fill
- Set for 2-3 Minutes Top Off
- Run for 2 Minutes at Low Idle
- Volume after 2 Minutes of Low Idle Top Off
- Volume after High Idle Top Off
- Run at High Idle until Thermostat Opens (approximately 10 Minutes)
- Full Hot
CUMMINS COOLANT REPLACER KIT
Coolant replacer accomplishes several important tasks:

- Reduces the time required to drain and fill cooling systems.
- Reduces the risk of air pockets trapped in the cooling system. (It is known that air trapped in the engine can cause engine damage or shortened component life, and result in low coolant level complaints after the unit/engine is released to the customer.)
- Reduces coolant spills and waste.
- Reduces the possibility of contact with hot coolant.
COOLANT REPLACER KIT, PART # 2892459.

Capacity - 68 L [18 gal]
Main function:
- Coolant drain
- Coolant fill
- Pressure testing of the cooling system

The coolant replacer can be used immediately on equipment with a quick disconnect fitting in the cooling system.
- Volvo® trucks built since 2000 and Navistar trucks built since 2010 are equipped from the OEM with a quick disconnect fitting installed in the cooling system.

Service locations can install quick disconnect fittings during the service event to allow usage of the coolant replacer in the future.
- Part Number 2892474 (1/4” NPT)
- Part Number 2892475 (3/8” NPT)
LUBRICATION SYSTEM
System Specifications

Crankcase Ventilation System: Open

Oil filter: LF3970

Oil pans are available in:

- 15 quart (14.2 liter) capacity in ridged front sump
- 15 quart (14.2 liter) capacity in ridged rear sump
- 19 quart (18 liter) capacity in suspended front sump
- 19 quart (18 liter) capacity in suspended rear sump
Specifications Continued …

Oil Pressure:
- Low idle (minimum allowed) 69 kPa [10 psi]
- At rated (minimum allowed) 207 kPa [30 psi]

Oil-regulating valve-opening pressure range:
448 kPa [65 psi] to 517 kPa [75 psi]

Oil filter differential pressure to open bypass
345 kPa [50 psi]

Lubricating Oil Filter Capacity: 0.95 liters [1 qt]
Maximum Oil Temperature: 138°C [280°F]
Cummins Inc. recommends the use of a high-quality SAE 15W-40 heavy-duty engine oil, such as Valvoline Premium Blue™.

While the preferred viscosity grade is 15W-40, lower viscosity multigrade oils can be used in colder climates.

Any viscosity grade lower than 15W-40 must still meet CES 20081.
Lubricating Oil Cooler and Cover

9 plate oil cooler
Cover common with other Cummins oil coolers
Pressure Regulator
Dump to Sump Design
Torque sequence is critical

NOTE: Snug capscrew numbers six and eight, then tighten in stages the sequence shown.

First Stage Torque Value
- 17 Nm (150 in-lb)

Second Stage Torque Value
- 28 Nm (248 in-lb)
Lubricating Oil Filter and Dipstick

- Locking Dipstick
  - Because of the crankcase breather

- Filter Head and bypass valve are part of the oil cooler cover

- Could be remotely mounted
Fuel System
HPCR Fuel System Safety

- Wear your safety glasses
- Use cardboard or paper for identifying/troubleshooting high-pressure leaks...
- Never use your hands or fingers

1800 bar = 26,106 PSI

2.068 Bar (30 PSI) is enough to penetrate human skin and cause a pressure injection.

- Always wait at least 10 minutes following engine shut down before opening the high pressure fuel system
- If possible, use INSITE to monitor the fuel pressure to ensure it is safe to open the system
- Never place your hands near fuel system fittings when loosening them
Fuel System Cleanliness During Repairs Is Very Important

Clean all fuel system fittings, lines, and components before disassembly.

Make sure that no dirt or debris enters the fuel system components to prevent the passing of contaminants to the high pressure fuel rail and injectors.

Small amounts of dirt and debris can cause a malfunction of these components.

⚠️ WARNING ⚠️

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

⚠️ WARNING ⚠️

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

Steam clean the fuel pump and the area around the fuel pump.

Dry with compressed air.
Fuel Quality Specifications

Ultra Low Sulfur Diesel (ULSD) fuel is required
B20 biodiesel blend is suitable for use
Refer to the fuels service bulletin #3379001 for more details.

Pressure side fuel filter: 5 micron
Suction Side fuel filter: 25 micron
Fuel System Specifications

- High-pressure common rail (HPCR) system
- 1800 Bar System Pressure
- Single-Stage High Pressure Relief Valve
- Full authority electronic control of injectors
- Manually primed fuel system
- Engine mounted and off engine mounted suction side fuel filter options

The suction side fuel filter must include:
- Water separator
- Water-in-fuel (WIF) sensing features

Optional 12 or 24 VDC fuel heater with integral thermostatic control is available from Cummins
Priming Pump

ISB CM2350 engines do not utilize an electric motor driven lift pump.

The OEM installed hand priming pump is used to prime the fuel system. It can be remote or mounted on the engine.

During normal engine operation, the gear pump mounted on the fuel pump will draw fuel from the OEM fuel tank.
Fuel Filter Head / Bracket

The fuel filter head and bracket are separate pieces.

- The bracket mounts to the intake manifold cover
- The filter head mounts to the filter bracket
Pressure Side Fuel Filtration

Provided by Cummins

- 5 micron rating
- Engine or remote mounted options

NanoNet™ media provides

- a substantial improvement in particle efficiency in the 4, 5 and 6 micron range.
- a substantial improvement in particle efficiency under vibrations
- A lower ΔP across the media
High-Pressure Fuel Pump

Gear driven by the crankshaft gear.

Pump pressure is 1800 bar.

2 mounting locations:
- high position
- low position.
High-Pressure Fuel Pump

The high-pressure fuel pump consists of 3 main components:

- **Gear pump** - used to increase supply fuel pressure before delivering the fuel to the high-pressure section of the fuel pump. This is not a serviceable component.

- **Fuel pump actuator** - used to control the fuel pressure developed by the fuel pump. This is a serviceable component.

- **Pumping chamber** - uses three radial pumping plungers to build high fuel pressure (250 to 1800 bar [3626 to 26,107 psi]).
Fuel Pump Actuator

- PWM (Pulse Width Modulated) device driven by the ECM
- “Normally Open”
- The fuel pump actuator is a serviceable part.
- Troubleshooting procedures have been updated to reflect when the fuel pump actuator should be replaced vs. the entire fuel pump assembly.
INJECTORS AND FUEL LINES GROUP
Low Pressure Fuel Lines

- Quick connect fuel lines are utilized on the low pressure side of the fuel system.
- Fuel supply line connecting the fuel pump outlet to the fuel filter head inlet.
- Fuel supply line connecting the fuel filter head outlet to the fuel pump inlet.
Fuel Manifold

- No fuel return manifold as found on other Cummins HPCR engines
  - The OEM drain line will attach at fuel pump drain connection.
- To aid in separating fuel system drain flows, quick disconnect fittings have been added
  - Critical fuel drain flows for troubleshooting include
    - Fuel Pressure Relief Valve
    - Injector Drain
    - Fuel Pump Drain
Fuel Rail Supply Line

High pressure fuel from the high pressure pump to the fuel rail.
Fuel Rail

The fuel rail contains high pressure fuel from the fuel pump.

The fuel pressure relief valve is a cartridge located at the front end of the fuel rail, Fuel pressure relief valve

1) Fuel pressure relief valve drain
2) High pressure fuel supply fitting from fuel pump
3) Mounting bracket (s)
4) High pressure injector supply fitting (s)
5) Fuel pressure sensor
Fuel Rail Pressure sensor

New design and service procedure

Higher torque value to install

Socket must be used
Fuel connector

Why Fuel System Clean Care Really Does Matter?
The high-pressure connector and injector must be replaced if failure is observed

- The high-pressure connector should be replaced anytime the injector is replaced

Be sure not to over torque the connector retaining nut. Over torquing the retaining nut may cause the connector to rotate out of the connector retaining slot.
Fuel Injector

The injector is manufactured by Bosch

The injector retainer is part of the fuel injector

The injectors entrance into the combustion chamber is sealed with a brass seal
Using The Right Tools

Three return flows

- Injector Return
- High Pressure Pump Return
- High Pressure Relief valve Return

Isolating the flows with the allows us to determine which component is has excessive leakage.

Excessive leakage can cause.

- Hard or no start conditions
- Low power with fault codes indicating low rail pressure
CM2350 Electronic Controls
Identification

Mounting Locations (B, L, & X)

Cooling Strategies
- Air on ISB6.7

Battery supply & return integrated into the OEM 96 pin connector

Integrated Aftertreatment DEF

Dosing control

More Datalinked sensor

Options

96 way connector service
Fault Codes Types

All Fault codes could be categorized and troubleshoot in following categories:

- Electrical failure
  - Inputs
  - Outputs
- Mechanical failure / conditions / response
- ECM Logical Faults
- Communications Faults
Fault Codes Types

Electrical Failure

- INPUT Components
  - Voltage Above Normal, or Shorted to High Source
  - Voltage Below normal, or Shorted to Low Source
- OUTPUT Components
  - Current above normal or grounded circuit
  - Current below normal or open circuit

Mechanical Failure

- Data erratic, intermittent or incorrect (also could be Communication failure)
- Mechanical system not responding or out of adjustment
- Abnormal rate of change
Fault Codes Types

ECM Logical Faults
- Data not Rational
- Data erratic, intermittent or incorrect (also could be Mechanical failure)
- Data Valid But Above Normal Operating Range
  - Least Severe Level, Moderately Severe Level, Most Severe Level
- Data Valid But Below Normal Operating Range
  - Least Severe Level, Moderately Severe Level, Most Severe Level
- Condition Exists
- Out of Calibration

Communications Faults
- Received Network Data In Error
- Abnormal update rate
- Root Cause Not Known
- Bad intelligent device or component
What is ‘Fault Code State Change’?

‘Fault Code State Change’ is the process of creating the ‘opposite’ fault code to troubleshoot sensors, harnesses, and ECM’s.

Understanding the ‘fault code state change’ logic can make troubleshooting as easy as disconnecting a sensor or unplugging the engine harness from the ECM.
Using Test Leads to Change the Fault Code State
Using Test Leads to Change the Fault Code State
ECM INPUTS
ECM Inputs – Sensors

**Engine Sensors**

- Ambient Air Temperature Sensor (Required, OEM provided)
- Crankcase Ventilation System Pressure Sensor
- Engine Camshaft Speed / Position Sensor
- Engine Coolant Level Sensor 1
- Engine Coolant Level Sensor 2 (optional)
- Engine Coolant Temperature Sensor
- Engine Crankshaft Speed/Position Sensor
- Engine Exhaust Gas Recirculation Outlet Pressure Sensor
- Engine Fuel Temperature Sensor
- Engine Intake Throttle Actuator Position Sensor
- Engine Oil Rifle Pressure Sensor / Switch
- Exhaust Gas Pressure Sensor
- Exhaust Gas Recirculation Differential Pressure Sensor
- Exhaust Gas Recirculation Temperature Sensor
- Injector Metering Rail Pressure Sensor
- Intake Manifold Pressure Sensor
- Intake Manifold Temperature Sensor
- Turbocharger Compressor Intake Pressure Sensor
- Turbocharger Compressor Intake Temperature Sensor
- Turbocharger Speed Sensor
- Water in Fuel Indicator Sensor (Optional)
- Fuel Tank Level Sensor (OEM)

**Aftertreatment Sensors**

- Aftertreatment Diesel Exhaust Fluid Dosing Temperature Sensor
- Aftertreatment Diesel Exhaust Fluid Pressure Sensor
- Aftertreatment Diesel Exhaust Fluid Quality Sensor
- Aftertreatment Diesel Exhaust Fluid Tank Level Sensor
- Aftertreatment Diesel Exhaust Fluid Tank Temperature Sensor
- Aftertreatment Diesel Particulate Filter Differential Pressure Sensor
- Aftertreatment Diesel Particulate Filter Outlet Pressure Sensor
- Aftertreatment Diesel Oxidation Catalyst Intake Temperature Sensor
- Aftertreatment Diesel Particulate Filter Intake Temperature Sensor
- Aftertreatment Diesel Particulate Filter Outlet Temperature Sensor
- Aftertreatment Outlet NOx Sensor
- Aftertreatment Intake NOx Sensor
- Aftertreatment SCR Intermediate Temperature Sensor
- Aftertreatment SCR Intermediate NH3 Gas Sensor
- Aftertreatment SCR Outlet Temperature Sensor
ECM Inputs - Sensors - OEM Provided

Accelerator Position Sensor
- Dual Analog
- PWM

Engine Coolant Level Sensor 1 & 2

Fan Speed Sensor

Magnetic Pickup VSS

Remote Accelerator Position Sensor

Water in Fuel Sensor

DEF Tank Temperature Sensor

DEF Tank Level Sensor

Fuel Tank Level Sensor
ECM Outputs - Lamps and Gauges - OEM Provided

Amber Warning Lamp
Air Shutoff Valve Lamp
Diesel Exhaust Fluid Lamp
Diesel Exhaust Fluid Level Gauge
Diesel Particulate Filter Lamp
High Exhaust System Temperature (HEST) Lamp
Malfunction Indicator Lamp (MIL)
Stop Lamp
Wait To Start (WTS) Lamp
ECM Outputs - Relays/Solenoids - OEM Provided

- Idle Shutdown Relay
- Air Heater Relay (MR Only)
- Fan Clutch Relay/Solenoid
- Starter Lockout Relay
- DEF Line Heater Relay
- DEF Line 4 (Supply Module) Heater Relay
- DEF Coolant Flow Valve Solenoid
96 way connector Service
96 – Way Connector

Rotate!
Do not pry
EPA 2013 Aftertreatment for Mid-Range Engines

Version 1.2
Cummins Aftertreatment System Overview

HOW WE DEAL WITH BYPRODUCTS OF THE COMBUSTION ???

Cummins Particulate Filter

DEF Dosing Valve

Decomposition Reactor

Selecteive Catalytic Reduction (SCR) Catalyst

PM

0.01

ENGINE-OUT

PM FILTER

TAIL-PIPE OUT

NOx

0.2

ENGINE-OUT

EGR

SCR

TAIL-PIPE OUT
2013 MR System Architecture

CM 2350 with AT Controls + DEF Doser Controls

EGR-COOLER

AIR THROTTLE

CHARGE AIR COOLER

NOx

DEF Tank

Mixer

Cyclone Mixer (end inlet SCR)

DEF Doser

SCR Catalyst

AMOX

DOC

DPF

SCR 1

SCR 2

NOx

Cyclone Mixer

SM

UQ

DEF

= Change from 2010
2013 Aftertreatment Component Naming Convention
AFTERTREATMENT DIESEL OXIDATION CATALYST AND DIESEL PARTICULATE FILTER
Cummins Particulate Filter Cut-a-way
Aftertreatment Diesel Particulate Filter Section Connections

Function:

- Provide an airtight seal between each of the aftertreatment sections
- Limit ability to install components incorrectly or backwards
- Clocking features
- Allow service to individual components.

Specs:

- V-Band Clamp
- Graphite Gasket
- Gasket retaining ring to aid in installation
Diesel Oxidation Catalyst (DOC)

Function:
- Converts NO → NO2
- Converts fuel to heat (no flames) – by the means of the Hydro Carbon injections in cylinder.
- Provide mounting location for aftertreatment gas temperature sensor #2
- Provide a mounting location for the differential pressure sensor tube

Specs:
- Platinum Washcoat
- Flow Through design
- Insulated & un-insulated
Midrange Hydro Carbon Injection

Injection pressure from high pressure pump

- Capable of (4) injections per power stroke
  - Pilot
  - Main
  - Post
  - Very Late Post (Aftertreatment Injection)
Flow-Through vs. Wall Flow

Diesel Oxidation Catalyst

Diesel Particulate Filter
Diesel Particulate Filter (DPF)

Function:
- Convert soot from fuel to CO2 and N2
- Convert soot from oil to CO2 and N2
- Store ash until cleaning

Specs:
- Made of Ceramic
- Wall Flow Filter
- Insulated & un-insulated
Diesel Particulate Filter (DPF) – Also could be

Silicon Carbide Diesel Particulate Filter

The appearance is dark grey color with light grey jointing cement
DPF-DOC Insulation Change
ALL Sensors must be removed prior Disassembly and after Assembly.
Regeneration Definitions

Passive Regeneration
- Normal Operating Conditions
  - Normal engine operation

Active Regeneration
- Normal Operating conditions or Stationary (Parked)
- (Only if Passive Regeneration can not reduce or maintain acceptable soot level)
  - EGR off
  - Thermal Management
  - Aftertreatment Injection

Stationary Regeneration (Active)
- Only Stationary (Parked)  [Requires INSITE or dash switch]
  - Increased idle speed
  - EGR off
  - Thermal Management
  - Aftertreatment Injection
  - (only available when soot level is high enough for Active Regeneration)
Passive Regeneration

\[ \text{NO} + \text{O}_2 + \text{C} \]
(Nitric Oxide + Oxygen + Carbon)
(Normal combustion byproducts)

\[ \sim 250 - 450 \text{ C} \]
\[ \sim 500 - 850 \text{ F} \]

\[ \text{NO}_2 \] (Nitrogen Dioxide)

\[ \sim 310 \text{ C} \]
\[ \sim 600 \text{ F} \]

\[ \text{CO}_2 + \text{N}_2 \]
(Carbon Dioxide + Nitrogen)
Stationary Regeneration (Active)

*Thermal Management*

*Increased Idle RPM*

\[ \text{NO} + \text{O}_2 + \text{C} + \text{HC} \]
(Nitric Oxide + Oxygen + Carbon + Hydrocarbon)

**DOC**

- HC Above 250°C only
- HC Above 500°F only

**Heat + NO + O_2 + C**
- \(~500\ C\)
- \(~932\ F\)

**DPF**

- \(\text{CO}_2 + \text{N}_2 + \text{H}_2\text{O}\)

Regeneration
Stationary Regeneration (Active)

Aftertreatment Diesel Particulate Filter Regeneration

DURING REGENERATION, EXHAUST GAS TEMPERATURE COULD REACH 800 C (1472 F), AND EXHAUST SYSTEM SURFACE TEMPERATURE COULD EXCEED 700 C (1292 F). Expected engine speed may reach between 1000 to 1500 RPM. Please read carefully and follow these instructions to avoid the risk of fire, property damage, burns or other serious personal injury.

To prepare for a stationary regeneration:

1. Select an appropriate location to park the vehicle
   - On a surface that will not burn or melt under high temperatures (such as clean concrete or gravel, NOT grass or asphalt)
   - Away from anything that can burn, melt, or explode
     - Nothing within 2 feet of the exhaust outlet
     - Nothing that can burn, melt, or explode within 5 feet (such as gasoline, wood, paper, plastics, fabric, compressed gas containers, hydraulic lines)
     - No gas or vapors nearby that could burn, explode, or contribute to a fire (such as LP gas, gasoline vapors, oxygen, nitrous oxide)
   - Away from people who might come near the exhaust outlet
   - A location where you can observe the exhaust area during regeneration

2. Park the truck securely
   - Set the parking brake
   - Place transmission in Park if provided, otherwise in Neutral
   - Set wheel chocks at front and rear of at least one tire

3. Set up a safe exhaust area
   - If bystanders might enter the area, set up barriers to keep people at least 5 feet from the exhaust outlet during regeneration
   - When indoors, attach an exhaust discharge pipe rated for at least 800 C (1472 F)
   - Keep a fire extinguisher nearby

4. Check exhaust system surfaces
   - Confirm that nothing is on or near the exhaust system surfaces (such as tools, rags, grease, debris)

5. Prepare for engine speed changes during regeneration
   - Do not operate any PTO powered devices. These devices must be disconnected before starting the regeneration
   - Stay clear of the engine compartment

Ensure that the vehicle and surrounding area are monitored during regeneration. IF ANY UNSAFE CONDITION OCCURS, STOP REGENERATION IMMEDIATELY.

Once regeneration is completed, exhaust gas and exhaust surface temperatures will remain elevated for 3 to 5 minutes

Have all conditions noted above been met?

[ ] Yes  [ ] No
**Active Regeneration**

*Thermal Management*

\[
\text{NO} + \text{O}_2 + \text{C} + \text{HC}
\]

(Nitric Oxide + Oxygen + Carbon + Hydrocarbon)

- HC Above 250 °C only
- HC Above 500 °F only

Heat + NO + \text{O}_2 + \text{C}

~500 °C

~932 °F

\[
\text{CO}_2 + \text{N}_2 + h_2O
\]
Stationary Regeneration (Active)

OEM switch

Engine will run at this condition for up to 60 minutes depending on...

- Soot load
- Ambient air temperature
Operator Interface Lamps

New DPF lamp - Normally OFF. When ON, the Duty-Cycle should be increased OR a Stationary Regeneration performed

New HEST (High Exhaust System Temperature) lamp – OEM Mandatory. Used to indicate higher than normal exhaust temperatures. Information Only- Driver interaction not needed.

Check Engine Lamp – used with DPF Lamp to indicate need for Service Action – Coupled with De-Rate

Stop Engine Lamp – used with DPF Lamp to indicate need for Immediate Service Action – Coupled with Severe De-Rate Must be taken to a repair location.

Stationary Regen Switch – Used to initiate a STATIONARY Regen – can also use INSITE service tool Will only function if soot level is high enough for Active Regen
**Situation**  |  **Indication**  |  **Desired Response**
---|---|---
Normal Operation  | None  | None
  • Passive Regen  
  • Stationary Regen  
Disabled
<table>
<thead>
<tr>
<th>Situation</th>
<th>Indication</th>
<th>Desired Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Operation</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

- Passive Regen
- Active Regen As Conditions Permit

*Increasing Soot Load*
**Situation**

Normal Operation

- Aftertreatment outlet temperatures higher than normal operation

**Indication**

HEST Lamp On Solid

**Desired Response**

None

*Increasing Soot Load*
**Situation**

Regen Needed – Low Priority

- Passive Regen
- Active Regen As Conditions Permit
- Stationary Regen Available

**Indication**

DPF Lamp On
Solid

**Desired Response**

Provide Regen Opportunity

- Alter Duty Cycle
- Start Stationary Regen
- Seek Service

---

*Increasing Soot Load*
**Situation**

Regen Needed – Medium Priority
- Passive Regen
- Active Regen as Conditions Permit
- Stationary Regen Available

**Indication**

DPF Lamp Flashing

Moderate De-Rate

**Desired Response**

Suggest Regen
- Alter Duty Cycle
- Start Stationary Regen
- Seek Service

*FC 2639*
**Situation**

Regen Needed – High Priority

- Passive Regen
- Active Regen Disabled
- Stationary Regen Available

**Indication**

- DPF Lamp Flashing
- Severe De-Rate
- Check Engine Lamp On Solid *FC 1921*

**Desired Response**

Require Regen

- Start Stationary Regen
- Seek Service

---

*Increasing Soot Load*
**Situation**

Regen Needed - Stop

• Passive Regen
• Active Regen Disabled
• Stationary Regen Disabled

**Indication**

Stop Engine Lamp On Solid
Severe De-Rate
*FC 1922*

**Desired Response**

Stop Engine at Earliest Opportunity

• Seek Service

---

*Increasing Soot Load*

**Empty**  **Auto**  **Low**  **Medium**  **High**  **Stop**
What is Ash?

Ash – Material from oil additive package collected in the DPF.

McGeehan, Chevron SAE 11/05
Aftertreatment System Handling

Handling

- Durable, but you need to handle with care
- The substrate is ceramic – if you drop it, it can crack
  - Transmission jacks work well to remove horizontal systems
- Ship to Recon in the same box you received it in to minimize shipping damage

Cleaning of Aftertreatment filters

- Use only approved cleaning equipment
- Do NOT use a liquid to clean.
Warranty

Will cover progressive damage due to engine component failures

- Any failure that results in excessive oil, fuel or soot into the exhaust system.

Will cover failures related to materials and workmanship.

Will not cover damage due to neglect

- Cummins Particulate Filter cleaning is treated like changing engine oil.
AFTERTREATMENT SELECTIVE CATALYTIC REDUCTION (SCR) SYSTEM
Cummins Aftertreatment System Architecture Overview

DEF Dosing Valve sprays a fine mist of DEF into hot exhaust stream

Decomposition occurs in 3 steps within the Decomposition Tube
- Step 1: Evaporation
- Step 2: Thermolysis
- Step 3: Hydrolysis

Cummins Particulate Filter
Selective Catalytic Reduction (SCR) Catalyst
Decomposition Tube

Decomposition occurs in 3 steps within the Decomposition Tube

Step 1: Evaporation
Step 2: Thermolysis
Step 3: Hydrolysis
Dosing Valve

Solenoid injector that delivers pressurized urea into exhaust
Mounted on exhaust pipe with flange
Water cooled
Doser Gasket

- Insulated Gasket
- Includes an insulation layer
- Utilizes current sealing surface
- Retains thermal isolator
- Addition of metal spacers under DM mounting feet
Injector Guard

- Injector Guard
- Customer Option
- EBU P/N – 2888113
SCR Aftertreatment

Aftertreatment Intermediate NH3 Sensor

Aftertreatment Outlet NOx Sensor
SCR Aftertreatment

- Aftertreatment SCR Intermediate Temperature
- Aftertreatment SCR Outlet Temperature
- Aftertreatment SCR Sensor Table
- Aftertreatment Intermediate NH3 Sensor
- Aftertreatment Outlet NOx Sensor
DEF SUPPLY DIAGRAM
The SCR system is comprised of many components but requires a minimal amount of servicing or driver intervention.

The SCR system is comprised of FIVE main states:

- Initializing
- Priming
- Dosing
- Purging
- Heating.
Initializing

Beginning:
- Engine ignition switch is turned on but not start engine.

Action:
- System initialization and self-test.

Ending:
- Priming stage is begin.
Priming State

Beginning:
- Engine start successfully.
- And exhaust temperature is higher than preset value.

Action:
- Pump running to build up constant DEF pressure.
  - Can be monitored by Insite.
- Dosing Valve Test. (Dosing valve will open 2 seconds)
  - DEF pressure should decrease and should recover quickly.

Ending:
- DEF pressure is OK and dosing valve is OK.
Dosing State

Beginning:
- When system successfully primed, it is ready to dose.

At Dosing State:
- Pump runs continuously to maintain system pressure around 900 kPa (130 Psi).
- Dosing valve is closed. No DEF spray into exhaust.
- When ECM determines need to dose it will energize solenoid with PWM signal.
- DEF will be delivered into exhaust by impulse injection.
- DEF pressure is kept in DEF that is supplied by pump and is returned to the DEF tank through backflow valve.

Required Conditions for Dosing
- Above 392 degrees F @ both Catalyst Inlet and Outlet
- No ACTIVE SCR System Related Fault codes
- DEF Tank Level above 6% (trimable)
- Above - 37.4 degrees F (DEF temp)
- Cummins NOx Calibration
Purging State

When the driver turns the key OFF, the dosing system will shut down with a purge cycle to prevent DEF from being left in the system and in cold climates, potentially freezing.

After a complete purge, the majority of the system will be free of any remaining DEF.

- The DEF dosing unit slides its internal return valve and causes a change in the flow direction of the DEF control.
- The DEF dosing unit pulls all of the DEF out of dosing valve and the lines then return the unused DEF to the DEF tank.
- In this process, the dosing valve will open, eliminating the vacuum created in the lines for a more complete purge process.

If the main power to DEF controller was removed (via battery cut off or other means) before the purging state was competed, an internal fault will be logged in the ECM.

- The incomplete purge counter can be viewed in INSITE™.
Heating State - Tank

If the ambient air temperature is below -4º C [25º F], the DEF controller will command the dosing system to go into the defrost state.

- The dosing unit will turn on its internal heater to defrost any remaining DEF inside it.
- If the application has the DEF line heating option, the heated DEF lines will also be commanded on.
- If the DEF tank temperature drops below -5º C [23º F], the DEF tank coolant valve will be commanded open by the DEF controller, engine coolant will flow through the tank to defrost the frozen DEF.
- The system will not prime until every component is defrosted.

If ambient conditions continue to be cold after the system has primed, the DEF controller will command a maintenance heating feature to prevent the system from freezing again.

- This feature will cycle the heating ON and OFF to the DEF lines, DEF tank and DEF dosing unit.
System Flows

[Diagram of system flows with labels such as DEF Tank, CM2350 ECM, Decomposition Pipe, Exhaust Gas Processor (EGP), Defensor, Outlet Temperature, Intake Temperature, and Air flow.]
Aftertreatment DEF Quality Sensor – OEM optional design

- Ultrasonic density meter
- Smart component (datalink)
- Shown as separate sensor
- In this configuration temperature and level sensors are hardwired to the ECM and DEF quality sensor communicates via datalink

[Image of sensor setup]
Aftertreatment DEF Quality Sensor – OEM optional design

- Ultrasonic density meter
- Smart component (datalink)
- Shown as integrated sensor with temperature and level
- All sensors in this setup are communicating via datalink
- Codes will vary due to setup configuration
Aftertreatment DEF Unit

Subcomponents

- Pump
- Reverting valve
- Pressure sensor
- Temperature sensors
- Filter
Electric-Heated DEF Unit

Pressure sensor (New position: clean side of filter)

Diaphragm pump + Reverting valve (New orientation in the housing, modified interface)

Main filter (New filter element, reduced size)

Integrated conductor path (instead of cable harness)

electrical heater
Pump Motor

Uni-directional diaphragm pump

Pump delivery: 20 L/h @ 9 bar (gauge)

Pump motor driven by PWM signal from ECM

Pump can only operate after DEF Unit defrosted to avoid damage

Max current draw: 4A @ 14 V
Reverting Valve

Enable purging with uni-directional pump

Current draw: 3A @ 16 V, -15 degC
Service Kit for High Capacity Filter will include

- Filter element
- Compensation device/equalizing element
- Tool for filter removal
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<th>New</th>
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<tr>
<td>Filter Element</td>
<td><img src="image3" alt="Current" /></td>
<td><img src="image4" alt="New" /></td>
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</table>
Non-Interchangeable Components

Proper Fit

Improper Fit
Aftertreatment Hardware

Aftertreatment OEM Supplied Parts

- DEF Line Heaters
- DEF Lines
- DEF Line Relays
- DEF Tank
- DEF Tank Temperature/Level Sensor/Urea Quality
- DEF Tank Heater
- DEF Tank Heater Control Valve – controls coolant flow to heat DEF Tank
- Coolant Lines – to tank and Aftertreatment DEF Dosing Valve
Diesel Exhaust Fluid (DEF)
Diesel Exhaust Fluid Specifications for Cummins® Selective Catalytic Reduction Systems

This service bulletin provides information for Diesel Exhaust Fluid (DEF), a fluid that may have a slight ammonia smell, used with Cummins® Selective Catalytic Reduction (SCR) systems. The purpose of this bulletin is to help the user understand correct specifications, usage, and handling of diesel exhaust fluid, which is:

- Nontoxic and nonpolluting
- Nonflammable
- Stable and colorless
- Composed of urea and water.
- Urea is naturally occurring and is biodegradable.

NOTE: Diesel exhaust fluid is the generic nomenclature, but it is also commonly referred to as AdBlue™ and Aqueous Urea Solution (AUS) 32.
WARNING

It is unlawful to tamper with or remove any component of the aftertreatment system. It is also unlawful to use 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.
Diesel Exhaust Fluid Specifications

The urea content of the solution must be 32.5 percent ± 0.7 percent by weight and must meet the International Standard ISO 22241-1 for diesel engines. 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.

**NOTE:** 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 the aftertreatment system, improper storage or shutdown practices, unauthorized modifications of the engine and aftertreatment system. Cummins Inc. 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 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.
Never add water or any other fluid besides what is specified to the diesel exhaust fluid (DEF) tank. The aftertreatment system may be damaged.

Adding water to the diesel exhaust fluid tank:
- will change the diesel exhaust fluid concentration levels, which may affect SCR efficiency.
- may add contaminants and/or affect the chemical properties of the diesel exhaust fluid, which may damage the aftertreatment system.
- will alter the freeze point and characteristics of the diesel exhaust fluid solution, potentially leading to damaged diesel exhaust fluid dosing system components during cold weather operation.

Handling, Storage, and Shelf Life of Diesel Exhaust Fluid

Handling: Diesel exhaust fluid is not harmful to handle, but can be reactive and/or corrosive to certain materials over time:
- Carbon steels, zinc coated carbon steels, and mild iron
- Nonferrous metals and alloys: copper, copper alloys, zinc, and lead
- Solders containing lead, silver, zinc, or copper
- Aluminum and aluminum alloys
- Magnesium and magnesium alloys
- Plastics or metals coated with nickel.

If diesel exhaust fluid comes in contact with any of the materials referenced, clean immediately. Reference the Disposal and Cleaning of Diesel Exhaust Fluid section of this service bulletin for additional information.
**Shelf Life:** The following conditions are ideal for maintaining diesel exhaust fluid quality and shelf life during prolonged transportation and storage:

- Storage temperature between -5°C to 25°C [23°F to 77°F]
- Store in sealed containers to reduce the possibility of contamination
- Avoid direct sunlight.

In these conditions, diesel exhaust fluid has a minimum expected shelf life of 18 months. However, each 5°C [9°F] increment above recommended temperatures reduces shelf life by 6 months (for example 30°C [86°F] = 12 month shelf life, 35°C [95°F] = 6 month shelf life, etc.).

**Storage:** 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 make sure the concentration does not fall out of specification. Reference the Testing section of this service bulletin.

For detailed information on handling, transportation, and storage, reference ISO 22241-3.

**Diesel Exhaust Fluid Cleanliness Practices**

Materials that come into contact with diesel exhaust fluid must be free from any contamination, oil, fuel, dust, detergents, and any other chemicals.
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 from a surface may result in an incorrectly diagnosed leak of the diesel exhaust fluid dosing system.

Before the use of containers, funnels, etc. that will be used to dispense, handle, or store diesel exhaust fluid, make sure to wash them 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 and Cleaning of Diesel Exhaust Fluid

If spillage occurs, the diesel exhaust fluid should be either transferred into a suitable container, or covered using an absorbent material and then disposed of according to local environmental regulations. The container must be labeled correctly.

Do not empty into the drainage system.

Do not empty/release into surface water.

Very small amounts of diesel exhaust fluid can be rinsed away with a large volume of water.
First Aid

In case of contact with eyes, immediately flush eyes with large amounts of water for a minimum of 15 minutes. Do not swallow internally. In the event that diesel exhaust fluid is ingested, contact a physician immediately.

Alternate Names/References for Diesel Exhaust Fluid

The following are other names used for diesel exhaust fluid (DEF):

- Urea
- AUS 32 (Aqueous Urea Solution 32)
- AdBlue™
- NOx Reduction Agent
- Catalyst Solution
- Stableguard 32.

Regardless of what the diesel exhaust fluid is called, it must meet the requirements as outlined in the specifications section of this service bulletin.
Testing

To test the concentration of the diesel exhaust fluid, use the Cummins® diesel exhaust fluid refractometer, Part Number 4919554. Follow the instructions provided with this service tool.

For detailed instructions on testing diesel exhaust fluid, reference ISO 22241-2.
Freezing

Diesel exhaust fluid freezes at approximately -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.

For further information, reference the diesel exhaust fluid manufacturer's Material Safety Data Sheet.

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.
DEF Freeze Point

Once the DEF has melted, it can be used without problem. The first melted drop has the same consistency as defined in the Diesel Exhaust Fluid specification.

The SCR system is designed to provide heating for the DEF tank and supply lines which will reduce the melting time for frozen DEF.

If DEF freezes, start up and normal operation of the vehicle is not inhibited so the operator is not impacted.
DEF Properties

Non-toxic and non-flammable.

Safe to handle and store.

Poses no serious risk to humans, animals, equipment or the environment if properly handled.

The product is slightly alkaline with a pH of approximately 9.0.
How Much will DEF Cost?

Automotive grade DEF is only slightly more expensive to produce compared to Agricultural grade DEF.

- Requires a higher purity urea base stock and deionized water

Higher prices of DEF are associated with smaller containers and low volume suppliers.

DEF prices loosely follow natural gas commodity prices
How Much DEF Will I Use?

Approximately 2% DEF consumption

Every 50 gallons of fuel = 1 gallon of DEF
Private Datalink On Aftertreatment Overview
Aftertreatment NOx Sensor

2013 model year engines will be using updated 24 and 12 volt NOx sensors.

- Accuracy improvement to ± 10 ppm/%
- Probe cover to improve water splash resistance
- Faster response time
- Extend the temperature range
- 4 pin connector change
- 24 volts and 12 volts sensors with specific part #'s
- Inlet and Outlet sensors use different connector key
- Different internal software for Inlet and Outlet sensors (Preprogrammed)
- NOx heating will being when the intake NOx sensor reaches 150 C and the outlet NOx sensor reaches 200 C
Datalinked Temperature Sensors (DPF & SCR)

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Aftertreatment Diesel Particulate Temperature Sensors Interface Module

Aftertreatment SCR Temperature Sensor Interface Module
Aftertreatment Intermediate NH3 Sensor

Smart component (datalink)
Designed to measure amount of the NH3 Gas (ammonia) and determine if DEF properly utilized (overspray and underspray)
2013 On-Board Diagnostics (OBD)

Version 1.1
2013 OBD Requirements

Mandated for all automotive Cummins engines

MIL lamps strategy

INSITE fault code reading and clearing strategy

Inducement charts (DEF)
On-Board Diagnostics (OBD) Terminology

**Diagnostic Trouble Code (DTC)** – A code reported and stored by the engine ECM which indicates a particular malfunction has been detected. Same as Cummins Fault Code.

**Malfunction Indicator Lamp (MIL)** – A dash lamp used to notify the operator when a malfunction has been detected that could impact emissions.
On-Board Diagnostics (OBD) Terminology

Trip
- Definition – condition(s) the engine must “operate” in order to run the diagnostics and ends with either key-off or 4 hours of engine run time
- Can be key-on, idle, stationary regen, etc

OBD faults will require multiple trips to light the MIL
- After 1 trip has failed the fault code will be shown as active in INSITE
- After MIL is lit the fault will show inactive after 1 trip passes, MIL will go out once all trips have passed
  - Example – 3 trips to light MIL, 3 trips to clear MIL
What’s different in an OBD system?

Malfunction Indicator Lamp (MIL)
- Latches ON when an OBD fault code is logged
- It takes 3 operation cycles (without the fault reoccurring) to clear the lamp

Extended diagnosing time is necessary for the various rationality and system monitors

Diagnostic approaches must be approved by the regulatory agency (including calibrations)

The OBD system detects deteriorated systems and components (not just total failures)

2 trip diagnostics exist; i.e. the failure must be detected in 2 consecutive trips before the MIL will be illuminated

Cummins must demonstrate the OBD system’s capabilities to detect failures

Changes to the system once in production must be approved by the regulatory agency
Check Engine Lamp - (Amber Warning Lamp)
This is the standard lamp that we have used in all previous Cummins applications. Used for Non-OBD faults.

Stop Engine Lamp
Used to indicate Engine Protection Fault Codes.

Malfunction Indicator Lamp (MIL)
This lamp is used to indicate an Emissions Related Failure has occurred (OBD Faults).
Recommended Service Direction

Follow “Conditions for Clearing the Fault Code” to perform one trip for verification purposes.

Once fault code is Inactive, use INSITE “Reset All Faults” option to clear the fault code and extinguish the MIL.
Conditions for Setting the Fault Codes

An internal circuit error has been detected in the aftertreatment outlet NOx sensor assembly.

Action Taken When the Fault Code Is Active

- The ECM illuminates the amber CHECK ENGINE lamp and/or the Malfunction Indicator Lamp (MIL) immediately when the diagnostic runs and fails.
- Engine torque will be reduced after 10 hours of engine operation with the fault code active.
- Vehicle speed will be limited to 8 kph (5 mph) after 40 hours of engine operation with the fault code active.

Conditions for Clearing the Fault Code

- To validate the repair, start and operate the engine to raise exhaust temperatures. This can be done by either driving the vehicle or initiating a stationary regeneration using INSITE™ electronic service tool.
- The exhaust gas temperature at the aftertreatment outlet NOx sensor must be above 150°C (302°F) before the sensor can run its internal diagnostics.
- The fault code status displayed by INSITE™ electronic service tool will change to INACTIVE immediately after the diagnostic runs and passes.
- The ECM will turn off the amber CHECK ENGINE lamp after the diagnostic runs and passes.
- For On-Board Diagnostic (OBD) engines, the ECM will turn off the MIL after three consecutive trips where the diagnostic runs and passes.
- The Reset All Faults command in INSITE™ electronic service tool can be used to clear active and inactive faults, as well as extinguish the MIL for OBD applications.

Shop Talk

Possible causes of this fault code include:

- The aftertreatment outlet NOx sensor has malfunctioned or is damaged
- The aftertreatment outlet NOx sensor internal heater has malfunctioned
- The NOx sensor part number is incorrect

Refer to Troubleshooting Fault Code 1887.
“Reset All Faults” option to clear MIL
Watchouts

Do not use “Reset Inactive Faults” if MIL is illuminated and there are no active faults.

MIL will stay latched ON until 3 consecutive successful trips are completed.

No fault code available in INSITE to select the “Reset All Faults” option.
MIL still illuminated

Reset All Faults option is not available
The End

Questions?