DIAGNOSTIC MANUAL

MaxxForce® 11 and 13 Engine

Navistar, Inc.

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Foreword

Navistar, Inc. is committed to continuous research and development to improve products and introduce technological advances. Procedures, specifications, and parts defined in published technical service literature may be altered.

NOTE: Photo illustrations identify specific parts or assemblies that support text and procedures; other areas in a photo illustration may not be exact.

This manual includes necessary information and specifications for technicians to maintain Navistar® diesel engines. See vehicle manuals and Technical Service Information (TSI) bulletins for additional information.

Technical Service Literature

4328086	MaxxForce® 11 and 13 and N13 with SCR *Engine Operation and Maintenance Manual*
0000001682	MaxxForce® 11 and 13 *Engine Service Manual*
0000001741	MaxxForce® 11 and 13 *Engine Diagnostic Manual*
EGED-475	MaxxForce® 11 and 13 *Hard Start and No Start Diagnostics Form*
EGED-530	MaxxForce® 11 and 13 *Performance Diagnostics Form*
0000002941	MaxxForce® 11 and 13 *Electronic Control Systems Diagnostics Form*

Technical Service Literature is revised periodically. If a technical publication is ordered, the latest revision will be supplied.

NOTE: To order technical service literature, contact your International dealer.

Service Diagnosis

Service diagnosis is an investigative procedure that must be followed to find and correct an engine application problem or an engine problem.

If the problem is engine application, see specific vehicle manuals for further diagnostic information.

If the problem is the engine, see specific *Engine Diagnostic Manual* for further diagnostic information.

Prerequisites for Effective Diagnosis

- Availability of gauges and diagnostic test equipment
- Availability of current information for engine application and engine systems
- Knowledge of the principles of operation for engine application and engine systems
- Knowledge to understand and do procedures in diagnostic and service publications

Technical Service Literature required for Effective Diagnosis

- *Engine Service Manual*
- *Engine Diagnostic Manual*
- Diagnostics Forms
- Electronic Control Systems Diagnostics Forms
- Service Bulletins

Safety Information

This manual provides general and specific maintenance procedures essential for reliable engine operation and your safety. Since many variations in procedures, tools, and service parts are involved, advice for all possible safety conditions and hazards cannot be stated.

Read safety instructions before doing any service and test procedures for the engine or vehicle. See related application manuals for more information.

Disregard for Safety Instructions, Warnings, Cautions, and Notes in this manual can lead to injury, death or damage to the engine or vehicle.

Safety Terminology

Three terms are used to stress your safety and safe operation of the engine: Warning, Caution, and Note.

Warning: A warning describes actions necessary to prevent or eliminate conditions, hazards, and unsafe practices that can cause personal injury or death.

Caution: A caution describes actions necessary to prevent or eliminate conditions that can cause damage to the engine or vehicle.

Note: A note describes actions necessary for correct, efficient engine operation.

Safety Instructions

Work Area

- Keep work area clean, dry, and organized.
- Keep tools and parts off the floor.
- Make sure the work area is ventilated and well lit.
- Make sure a First Aid Kit is available.

Safety Equipment

- Use correct lifting devices.
- Use safety blocks and stands.

Protective Measures

- Wear protective safety glasses and shoes.
- Wear correct hearing protection.
- Wear cotton work clothing.
- Wear sleeved heat protective gloves.
- Do not wear rings, watches or other jewelry.
- Restrain long hair.

Vehicle

- Make sure the vehicle is in neutral, the parking brake is set, and the wheels are blocked before servicing engine.
- Clear the area before starting the engine.

Engine

- The engine should be operated or serviced only by qualified individuals.
- Provide necessary ventilation when operating engine in a closed area.
- Keep combustible material away from engine exhaust system and exhaust manifolds.
- Install all shields, guards, and access covers before operating engine.
- Do not run engine with unprotected air inlets or exhaust openings. If unavoidable for service reasons, put protective screens over all openings before servicing engine.
- Shut engine off and relieve all pressure in the system before removing panels, housing covers, and caps.
- If an engine is not safe to operate, tag the engine and ignition key.

Fire Prevention

- Make sure charged fire extinguishers are in the work area.

NOTE: Check the classification of each fire extinguisher to ensure that the following fire types can be extinguished.

1. Type A — Wood, paper, textiles, and rubbish
2. Type B — Flammable liquids
3. Type C — Electrical equipment

Batteries

- Always disconnect the main negative battery cable first.
- Always connect the main negative battery cable last.
- Avoid leaning over batteries.
- Protect your eyes.
- Do not expose batteries to open flames or sparks.
- Do not smoke in workplace.

Compressed Air

- Use an OSHA approved blow gun rated at 207 kPa (30 psi).
- Limit shop air pressure to 207 kPa (30 psi).
- Wear safety glasses or goggles.
- Wear hearing protection.
- Use shielding to protect others in the work area.
- Do not direct compressed air at body or clothing.

Tools

- Make sure all tools are in good condition.
- Make sure all standard electrical tools are grounded.
- Check for frayed power cords before using power tools.

Fluids Under Pressure

- Use extreme caution when working on systems under pressure.
- Follow approved procedures only.

Fuel

- Do not over fill the fuel tank. Over fill creates a fire hazard.
- Do not smoke in the work area.
- Do not refuel the tank when the engine is running.

Removal of Tools, Parts, and Equipment

- Reinstall all safety guards, shields, and covers after servicing the engine.
- Make sure all tools, parts, and service equipment are removed from the engine and vehicle after all work is done.

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Engine Identification

Engine Serial Number

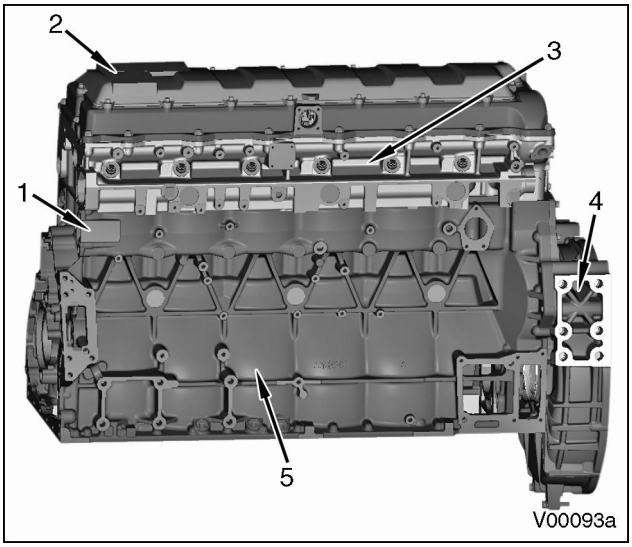


Figure 1 Engine serial number

1. Engine Serial Number (ESN) location
2. Engine emission label
3. Cylinder head
4. Flywheel housing
5. Crankcase

The Engine Serial Number (ESN) is located on the front of the crankcase (left side), below the cylinder head.

Engine Serial Number Examples

MaxxForce® 11: 106HM2XXXXXXX

MaxxForce® 13: 125HM2XXXXXXX

MaxxForce® 11: 106HM2YXXXXXXX

MaxxForce® 13: 125HM2YXXXXXXX

Engine Serial Number Codes

106 – Engine displacement (10.5 L)
125 – Engine displacement (12.4 L)
H – Diesel, turbocharged, Charge Air Cooler (CAC), and electronically controlled
M2 – Motor truck
Y – Huntsville, Alabama
7 digit suffix – Engine serial number sequence

Engine Emission Label



Figure 2 2010 U.S. Environmental Protection Agency (EPA) exhaust emission label (example)

The U.S. Environmental Protection Agency (EPA) exhaust emission label is on top of the valve cover (front left side). The EPA label typically includes the following:

- Model year
- Engine family, model, and displacement
- Advertised brake horsepower and torque rating
- Emission family and control systems
- Valve lash specifications
- ESN
- EPA, Onboard Diagnostics (OBD), EURO, and reserved fields for specific applications

Engine Accessory Labels and Identification Plates

The following engine accessories may have manufacturer's labels or identification plates:

- Air compressor
- Air conditioning compressor
- Alternator
- Cooling fan clutch
- Engine Control Module (ECM)
- High pressure (HP) fuel pump
- Power steering pump
- Starter motor
- Turbochargers

Engine Specifications

MaxxForce® 11 and 13 Diesel Engines	
Engine Configuration	4 stroke, inline six cylinder diesel
Advertised brake horsepower @ rpm	
• MaxxForce® 11	See EPA exhaust emission label
• MaxxForce® 13	See EPA exhaust emission label
Peak torque @ rpm	
• MaxxForce® 11	See EPA exhaust emission label
• MaxxForce® 13	See EPA exhaust emission label
Displacement	
• MaxxForce® 11	10.5 L (641 in³)
• MaxxForce® 13	12.4 L (758 in³)
Compression ratio	
• MaxxForce® 11	16.5:1
• MaxxForce® 13	17.0:1
Stroke	
• MaxxForce® 11	155 mm (6.10 in)
• MaxxForce® 13	166 mm (6.54 in)
Bore (sleeve diameter)	
• MaxxForce® 11	120 mm (4.72 in)
• MaxxForce® 13	126 mm (4.96 in)
Total engine weight (dry weight without trim or accessories)	

• MaxxForce® 11	1087 kgs (2392 lbs)
• MaxxForce® 13	1087 kgs (2392 lbs)
Firing order	1-5-3-6-2-4
Engine rotation direction (facing flywheel)	Counterclockwise
Aspiration	Dual turbocharged and charge air cooled
Combustion system	Direct injection turbocharged
Fuel system	High pressure common rail
Lube system capacity (including filter)	40 L (42 qts)
• MaxxForce® 11	
• MaxxForce® 13	
Lube system capacity (overhaul only, with filter)	44 L (46 qts)
• MaxxForce® 11	
• MaxxForce® 13	
Engine oil pressure at operating temperature with SAE 15W-40 oil	
• Low idle	69 kPa (10 psi) min.
• High idle	276 - 483 kPa (40 - 70 psi)
Idle speed (no load)	600 rpm, nominal
Thermostat operating temperature	
• Primary	83 °C - 95 °C (181 °F - 203 °F)
• Secondary	87 °C - 102 °C (189 °F - 216 °F)

Heavy Duty On Board Diagnostics (HD-OBD)

The EPA has added new regulations for 2010 to reduce heavy duty vehicle emissions. The HD-OBD system is designed specifically for electronically controlled heavy duty engines. The key goal for HD-OBD regulation is to keep engine emissions in specification for as long as a given vehicle is in use.

HD-OBD is legislated to be implemented in three phases:

- 2010: First engine for each Original Equipment Manufacture (OEM) becomes fully certified.
    - The lead engine is determined by a legislated equation based on projected sales volume & useful life of the engine.
    - For Navistar®, this is the EPA 2010 MaxxForce® 13 engine.
- 2013: One engine in each engine family becomes fully certified.
    - This will be the largest step of the three phases.
- 2016: All engines must be fully HD-OBD certified.

The HD-OBD system continuously monitors for proper engine operation, and will alert the vehicle operator to emission-related faults using the Malfunction Indicator Lamp (MIL).

The MIL is installed in the Electronic Instrument Cluster. When a detected emissions fault occurs, the MIL will be illuminated. Diagnostic information is also stored in the ECM, and may be accessed by the technician for diagnosis and repair of the malfunction. Diagnostic information is accessed by connecting the Electronic Service Tool (EST) to the in-cab Diagnostic Connector.

Engine Description

The MaxxForce® 11 and 13 diesel engines are designed for increased durability, reliability, and ease of maintenance.

The cylinder head has four valves per cylinder for increased airflow. The overhead valve train includes rocker arms and valve bridges to operate the four valves. The fuel injector is centrally located between the four valves, directing fuel over the piston for improved performance and reduced emissions.

The overhead camshaft is supported by seven bearings in the cylinder head. The camshaft gear is driven from the rear of the engine. The overhead valve train includes roller rocker arms and dual valves that open, using a valve bridge. For 2010, the camshaft has been redesigned to incorporate six additional lobes. These new lobes are used with the engine brake housings for operation of the MaxxForce® Engine Brake.

The MaxxForce® 11 engines use aluminum pistons, and the MaxxForce® 13 engines use one piece steel pistons. All pistons use an offset piston axis and centered combustion bowls. Crown markings show correct piston orientation in the crankcase.

The one-piece crankcase uses replaceable wet cylinder liners that are sealed by dual crevice seals.

The crankshaft has seven main bearings with fore and aft thrust controlled at the sixth bearing. One fractured cap connecting rod is attached at each crankshaft journal. The piston pin moves freely inside the connecting rod and piston. Piston pin retaining rings secure the piston pin in the piston. The rear oil seal carrier is part of the flywheel housing.

A gerotor lube oil pump is mounted behind the front cover and is driven by the crankshaft. Pressurized oil is supplied to various engine components. All MaxxForce® 11 and 13 engines also use an engine oil cooler and a cartridge-style engine oil filter, which are located in the engine lube oil module.

The low pressure fuel pump draws fuel from the fuel tank(s) through a chassis mounted filter/water separator. The low pressure fuel pump provides fuel for the engine mounted fuel module. Conditioned low pressure fuel is supplied from the engine mounted fuel module to the high pressure fuel pump, inlet air heater fuel solenoid, and the Downstream Injection (DSI) unit.

The high pressure fuel system is a direct fuel injected common-rail system. The common-rail includes a high pressure fuel pump, two fuel rail supply lines, fuel rail, six fuel injectors, and pressure relief valve.

The fuel injectors are installed in the cylinder head under the valve cover and are electronically actuated by the ECM.

MaxxForce® 11 and 13 engines use a dual stage, fixed geometry turbocharger assembly. Each stage includes a pneumatically operated wastegate, and

Charge Air Cooler (CAC). The Low Pressure Charge Air Cooler (LPCAC) is mounted on the lower right side of the engine, and uses the engine cooling system to regulate charge air temperatures. The High Pressure Charge Air Cooler (HPCAC) is mounted in front of the engine cooling package. The HPCAC is an air-to-air type cooler, and requires no connections to the engine's cooling system.

The Exhaust Gas Recirculation (EGR) system circulates cooled exhaust into the stream in the air inlet duct. The dual stage EGR cooler provides regulated cooling of the EGR gases before entering the air intake duct. This cools the combustion process, and reduces Nitrogen Oxides (NO_X) emissions.

The open crankcase breather system uses a Centrifugal Crankcase Oil Separator (CCOS) to return oil mist to the crankcase, and vent the cleaned crankcase gasses to the atmosphere. The CCOS is part of the oil module. The breather system has been redesigned, and uses no crankcase breather filter or external piping. Blowby gases enter the CCOS directly through the side of the crankcase.

The inlet air heater system warms the incoming air supply prior to and during cranking.

The MaxxForce® Engine Brake by Jacobs® is optional for both MaxxForce® 11 and 13 engine displacements. The engine brake is a compression release system that provides additional vehicle braking performance. The operator can control the engine brake for different operating conditions.

Optional Equipment

Optional cold climate features available are an oil pan heater and a coolant heater. Both heaters use an electric element to warm engine fluids in cold weather.

The oil pan heater warms engine oil to ensure optimum oil flow to engine components.

The coolant heater warms the engine coolant surrounding the cylinders. Warmed engine coolant increases fuel economy and aids start-up in cold weather.

Chassis Mounted Equipment

- The chassis mounted fuel filter/water separator removes a majority of the water and foreign particles that may enter the fuel system from the supply tank(s). This filter works with the engine mounted fuel module to eliminate foreign matter and moisture from the fuel before entering the fuel injection system.
- The Low Temperature Radiator (LTR) regulates the temperature of the LPCAC and the low temperature stage of the EGR cooler. The LTR is mounted in front of the radiator cooling package, and requires connections to the engine cooling system.
- The HPCAC lowers the temperature of the after the air is compressed by the turbochargers and has no connections to the engine cooling system. The HPCAC is an air-to-air cooler. The HPCAC is mounted in front of the radiator cooling package.
- The Diesel Oxidation Catalyst (DOC) oxidizes hydrocarbons and carbon monoxide, provides heat for exhaust system warm-up, aids in temperature management for the Diesel Particulate Filter (DPF), and oxidizes NO into NO_2 for passive DPF regeneration. The DOC is monitored by the ECM using one Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor positioned at the DOC inlet, and one Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor positioned at the DOC outlet.
- The DPF temporarily stores carbon-based particulates, oxidizes stored particulates, stores non-combustible ash, and provides required exhaust back pressure for proper engine performance. The DPF is monitored by the ECM using one Diesel Particulate Filter Outlet Temperature (DPFOT) sensor located at the outlet of the DPF, and one Diesel Particulate Filter Differential Pressure (DPFDP) sensor located on or near the DPF.

Engine Component Locations

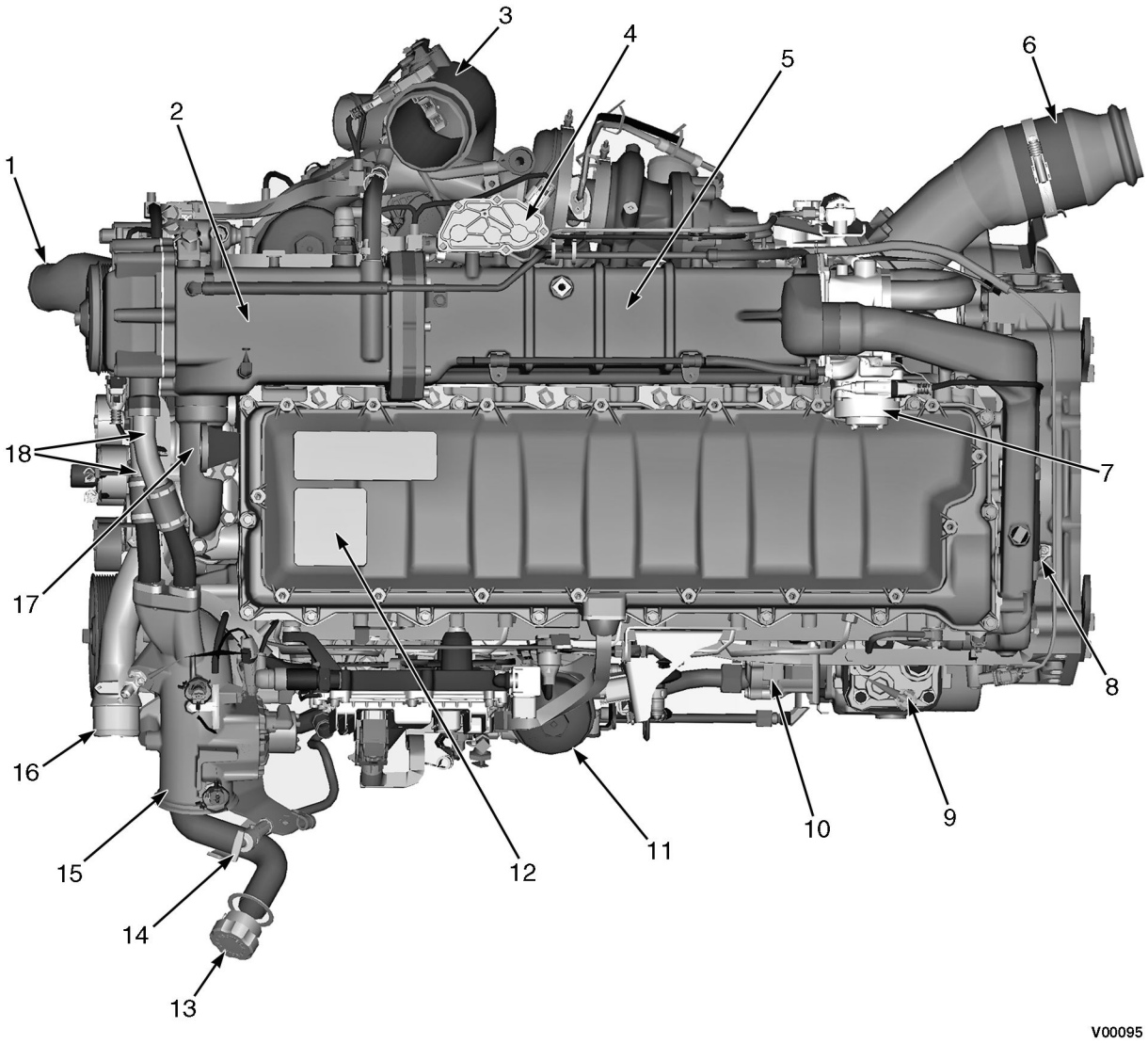


Figure 3 Component location – top view

1. Engine coolant inlet
2. Exhaust Gas Recirculation (EGR) cooler (low temperature stage)
3. Air intake duct
4. Air Control Valve (ACV) assembly
5. EGR cooler (high temperature stage)
6. Pre-DOC assembly
7. EGR Valve (EGRV)
8. Crankshaft Position (CKP) Sensor
9. Air compressor
10. Power steering pump
11. Engine mounted secondary fuel filter access
12. Emission label (location)
13. Engine oil fill
14. Engine oil level gauge
15. Intake throttle duct assembly
16. Engine coolant outlet
17. EGR cooler outlet pipe (coolant)
18. EGR cooler outlet tubes (gases)

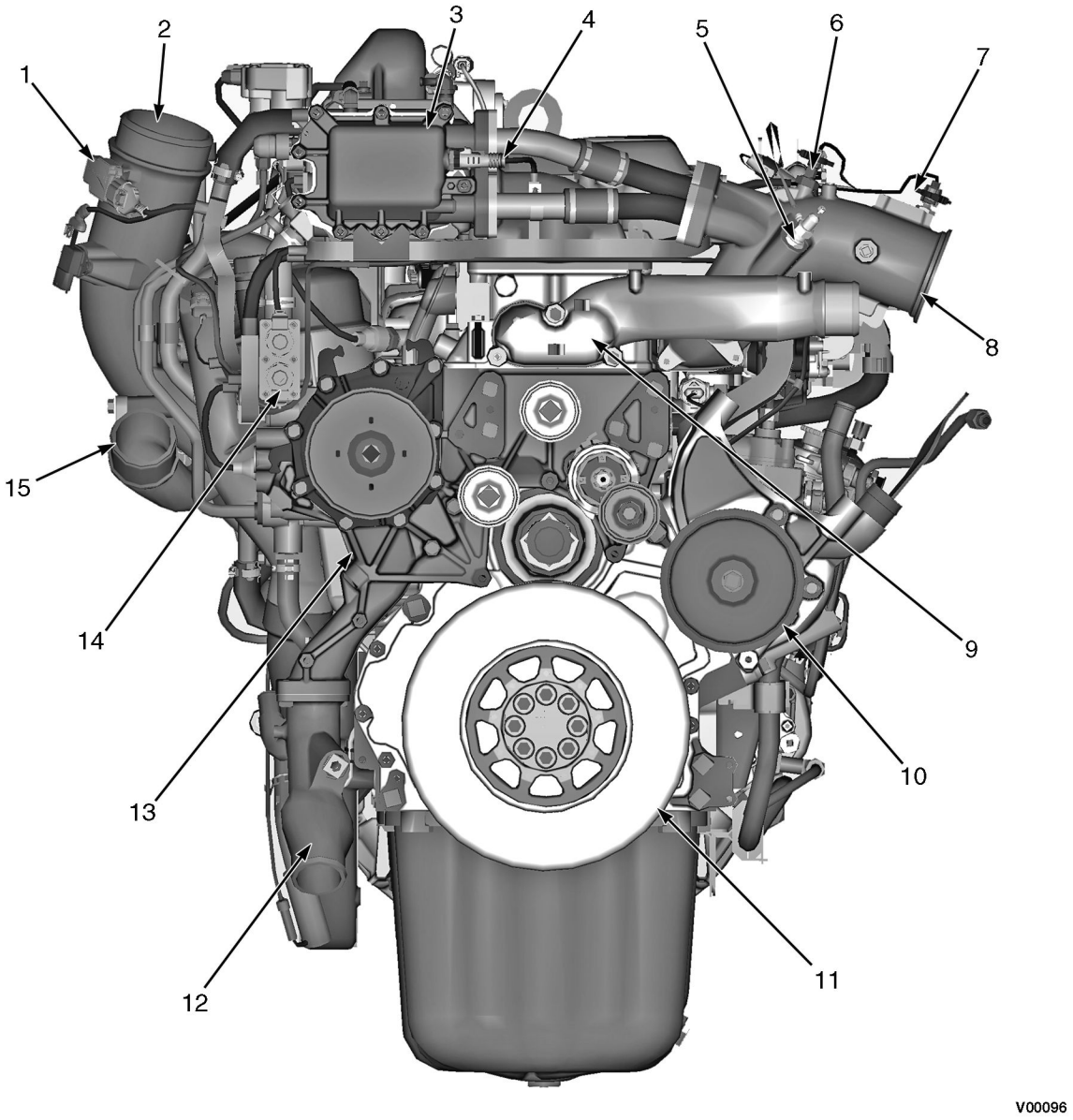


Figure 4 Component location – front view

1. Mass Air Flow (MAF) sensor
2. Air inlet duct
3. EGR cooler
4. EGR Temperature (EGRT) sensor
5. Inlet Air Heater Fuel Igniter
6. Intake Manifold Pressure (IMP) sensor
7. Charge Air Cooler Outlet Temperature (CACOT) sensor
8. Intake throttle duct assembly
9. Thermostat housing
10. HP pump pulley
11. Vibration damper
12. Water engine inlet
13. Water distribution housing.
14. Coolant Control Valve (CCV)
15. HP turbocharger compressor outlet

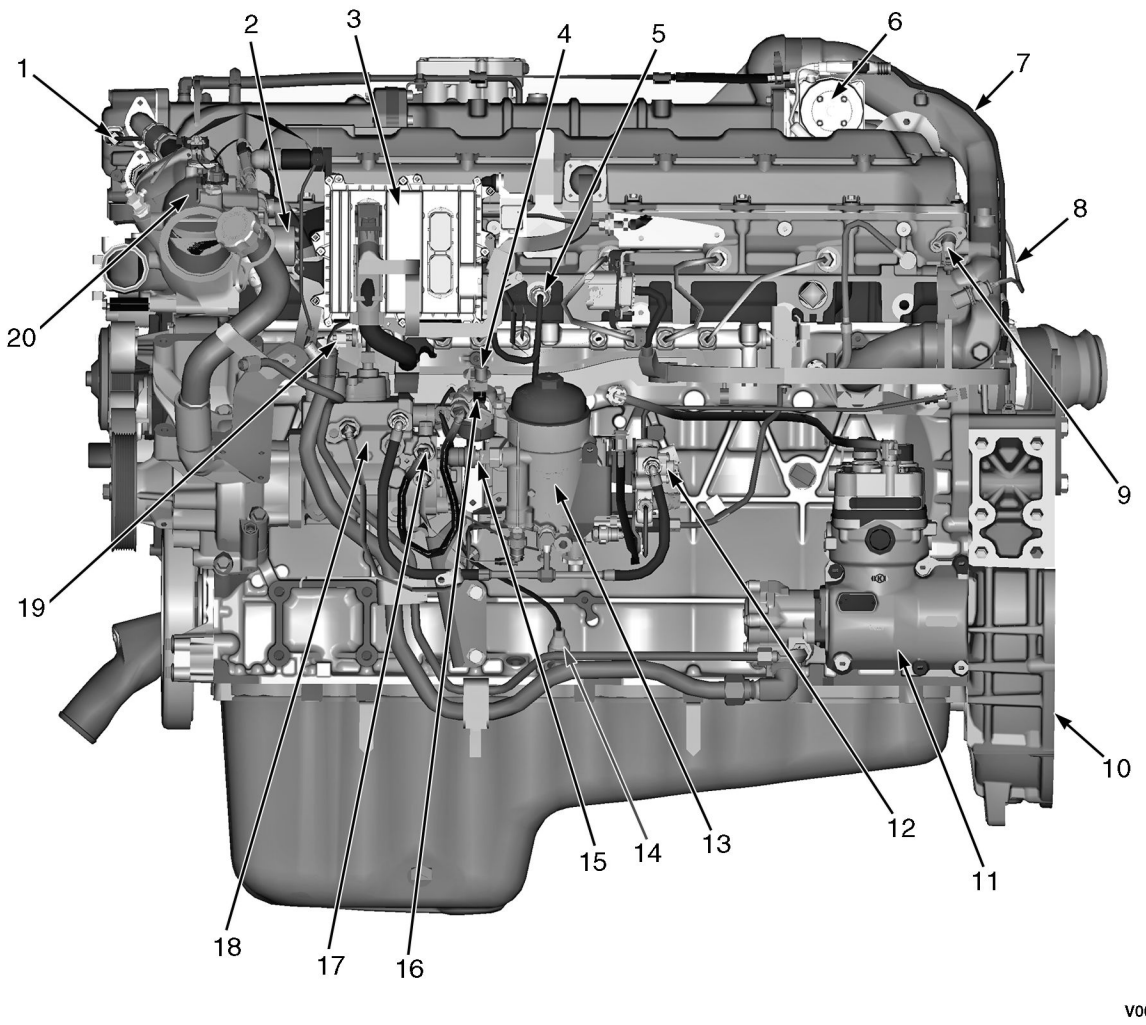


Figure 5 Component location – left view

1. EGRT sensor
2. Engine Throttle Valve (ETV)
3. ECM
4. Low Pressure (LP) fuel pressure test port
5. Intake Manifold Temperature (IMT)
6. EGRV
7. EGR cooler coolant manifold
8. Oxygen Sensor harness
9. Camshaft Position (CMP) sensor
10. Flywheel Housing
11. Air Compressor
12. DSI unit
13. Engine mounted secondary fuel filter access
14. Engine Oil Level (EOL) sensor
15. Fuel Delivery Pressure (FDP) sensor
16. Fuel primer pump assembly
17. LP fuel pump
18. HP fuel pump
19. Fuel Rail Pressure (FRP) sensor
20. Intake throttle duct assembly

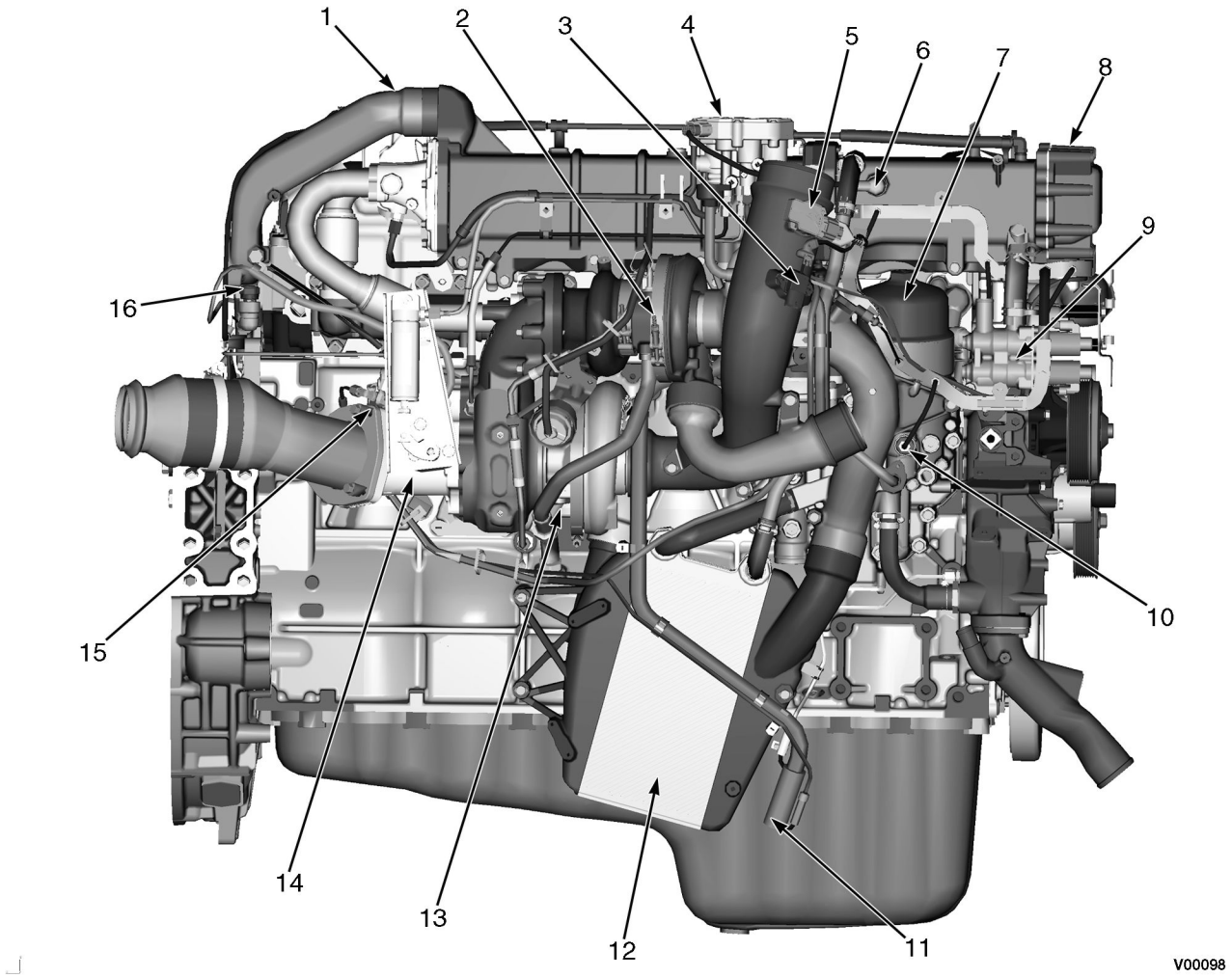


Figure 6 Component location – right view

1. EGR cooler coolant manifold
2. HP turbocharger
3. Humidity Sensor (HS) / Inlet Air Temperature (IAT) sensor
4. ACV
5. MAF sensor
6. Engine Coolant Temperature 2 (ECT2)
7. Oil filter cap
8. EGR Cooler
9. CCV
10. Engine Oil Pressure (EOP) sensor
11. Crankcase Oil Separator (CCOS)
12. LPCAC
13. LP Turbocharger
14. Exhaust Back Pressure Valve (EBPV)
15. Aftertreatment Fuel Injector (AFI)
16. Engine Coolant Temperature 1 (ECT1) sensor

Air Management System

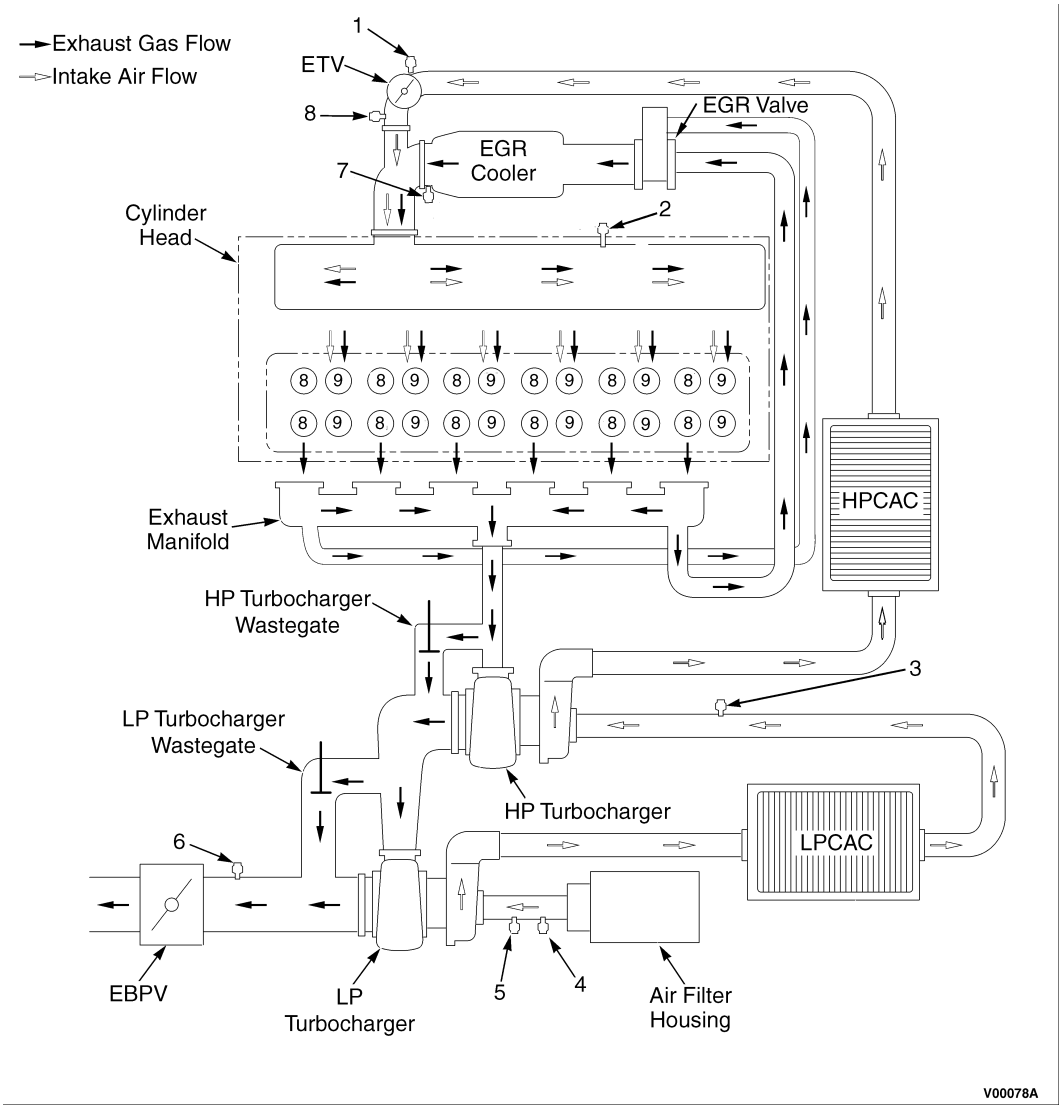


Figure 7 Air Management System

1. Charge Air Cooler Outlet Temperature (CACOT) Sensor
2. Intake Manifold Temperature (IMT) Sensor
3. LP Boost/LP Temperature Sensor
4. MAF Sensor
5. Humidity Sensor (HS) / Inlet Air Temperature (IAT) Sensor
6. Oxygen Sensor (O_2S)
7. Exhaust Gas Recirculation Temperature (EGRT) Sensor
8. Intake Manifold Pressure (IMP) Sensor

Airflow

Air flows through the air filter assembly and enters the low pressure turbocharger. The LP turbocharger increases the pressure and temperature of the before entering the LPCAC. Cooled and compressed air then flows from the LPCAC into the HP turbocharger (compressor inlet). Hot and highly compressed air flows from the HP turbocharger (compressor outlet) into the HPCAC where it is cooled, and into the intake throttle duct, and continues through the Engine Throttle Valve (ETV). The HP and LP turbochargers increase pressures up to 345 kPa (50 psi).

If the EGRV is open, exhaust gases pass through the EGR cooler and into the intake throttle duct where it is mixed with filtered air. This mixture flows into the intake manifold, and then the cylinder head. The intake manifold is an integral part of the cylinder head casting.

During cold weather, the inlet air heater system rapidly activates the heater element, vaporizing and igniting small quantities of fuel into the air inlet duct.

After combustion, exhaust gases exit through the cylinder head exhaust valves and ports. The exhaust gas is forced through the exhaust manifold where, depending on EGRV position, it is split between the EGR system and the exit path through the HP turbocharger, LP turbocharger, and EBPV.

The EBPV is operated by a pneumatic actuator. When the ACV is applied, the EBPV restricts flow and increases exhaust back pressure. Operation of the EBPV is controlled by the ECM using the ACV and the Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor. When the EBPV is opened, exhaust back pressure is released.

Exhaust gases exiting the engine systems flow through the EBPV, then through the vehicle Aftertreatment (AFT) system, and out the exhaust tail pipe.

Turbochargers

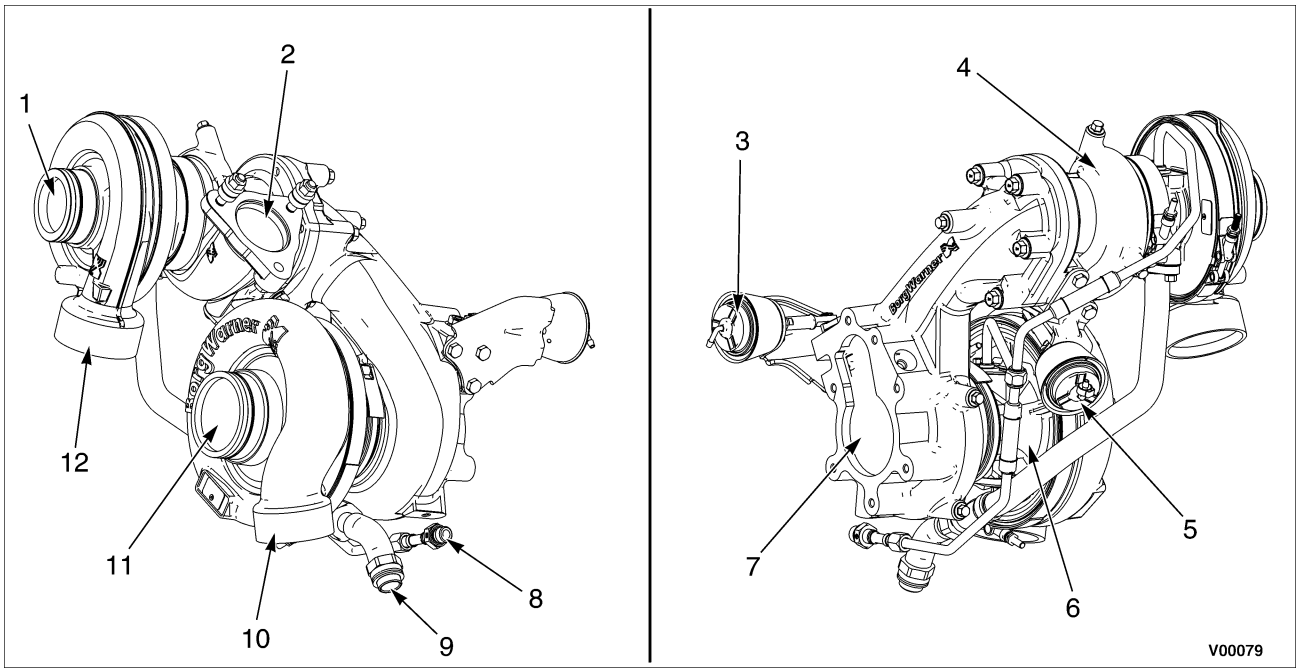


Figure 8 High and low pressure turbocharger components – inner and outer views

1. HP turbocharger compressor inlet
2. HP turbocharger turbine inlet
3. LP turbocharger wastegate actuator
4. HP turbocharger
5. HP turbocharger wastegate actuator
6. LP turbocharger
7. LP turbocharger turbine outlet
8. Oil supply line
9. Oil return line
10. LP turbocharger compressor outlet
11. LP turbocharger compressor inlet
12. HP turbocharger compressor outlet

MaxxForce® 11 and 13 engines are equipped with a pneumatically regulated two-stage turbocharging system. The HP and LP turbochargers are installed parallel on the right side of the engine.

Intake air flow: Filtered air enters the LP compressor, where it is compressed and directed to the LPCAC. Cooled LP air then enters the HP compressor, where it is further compressed and directed into the HPCAC. Compressed air then goes through the ETV and the intake throttle duct. This system provides high charge air pressure to improve engine performance and to help reduce emissions.

Exhaust gas flow: The HP turbocharger is connected directly to the exhaust manifold through the HP turbine inlet. Exhaust gases exit the HP turbine outlet and are directed to the LP turbine inlet. The HP and LP turbochargers are equipped with wastegates, which are controlled by two pneumatic actuators. Individual wastegates are used to regulate boost by controlling the amount of exhaust gases that bypass the turbine of each turbocharger. When boost demand is low, both wastegates are opened, allowing part of the exhaust gas flow to bypass the HP and LP turbines.

Control system signals associated with the HP and LP turbochargers have been renamed for 2010.

All signals related to the LP turbocharger are designated as Turbocharger 1 (TC1) signals, and are identified below:

- Turbocharger 1 Wastegate Control (TC1WC)
- Turbocharger 1 Turbine Outlet Pressure (TC1TOP)

All signals associated with the HP turbocharger are designated as Turbocharger 2 (TC2), and are identified below:

- Turbocharger 2 Wastegate Control (TC2WC)
- Turbocharger 2 Compressor Inlet Pressure (TC2CIP)

Air Control Valve (ACV)

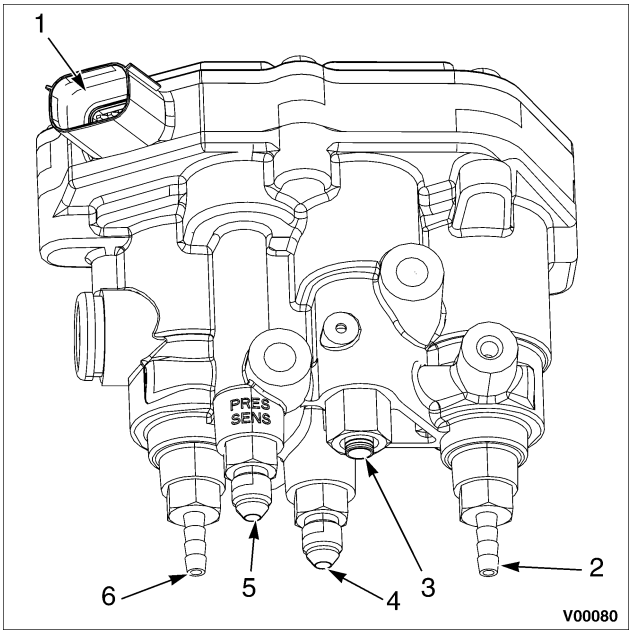


Figure 9 Air Control Valve (ACV) connections

1. Electrical connector
2. LP turbocharger wastegate control port
3. Vehicle air supply port
4. EBPV control port
5. TC1TOP sensor port
6. HP turbocharger wastegate control port

The ACV assembly contains the LP turbocharger wastegate control port, HP turbocharger wastegate control port, the EBPV control port, and the TC1TOP port. Although these components are integral to the ACV, each circuit is controlled by the ECM. The ACV controls compressed air for each control valve. The air supply port is connected to the vehicle's air system.

The ECM provides a Pulse Width Modulate (PWM) signal for operation of both wastegate control valves. With no PWM signal, the control valves are open, and vehicle air is supplied to the wastegate actuators. The air supplied will maintain both wastegates in the open position.

When an increase in the charge air pressure is required, the ECM supplies PWM voltage to close both control valves. Reduced air pressure is routed from the closed air control valves to the wastegate actuators causing the wastegate to close and vent air pressure. This results in increased charge air pressures. The limit values of the PWM signals are between approximately 9%, corresponding to a fully opened air control valve, and 100% corresponding to a closed air control valve.

The TC1TOP sensor and EBPV control valve are in the ACV. The EBPV control valve is also operated by the ECM using PWM, and the TC1TOP sensor is monitored by the ECM. The EBPV control valve operates the EBPV actuator.

Boost Control

Wastegate control valves, in the ACV, provide for operation of a pneumatic wastegate actuator for each turbocharger. Boost is controlled for each turbocharger independently, by signals sent from the ECM to the ACV. In normal operation the wastegates are actuated by the ACV using vehicle compressed air, regulated to 296 kPa (43 psi). Positioning of the wastegates by the ACV is based on boost pressure and temperature signals monitored by the ECM.

Because of the ability to generate very high charge air pressure levels and to avoid Charge Air Cooler (CAC) overloading, the wastegate actuator for each turbocharger is also spring loaded. When boost levels increase above specification, boost pressure alone will open the wastegates, and the exhaust gases will bypass the turbochargers. Exhaust back pressure is constantly monitored by the ECM using TC1TOP. The TC1TOP sensor is part of the ACV, and is connected to the exhaust system by a steel line.

Low Pressure Charge Air Cooler (LPCAC)

The LPCAC is installed between the HP and LP turbochargers, and is mounted to the lower right side of the engine. The LPCAC air inlet is connected to the low pressure turbocharger compressor outlet, and uses engine coolant to regulate the LP charge air temperature. The LPCAC air outlet is connected to the compressor inlet of the HP turbocharger.

High Pressure Charge Air Cooler (HPCAC)

The HPCAC is installed between the HP turbocharger and the intake throttle duct. The HPCAC air inlet is connected to the HP compressor outlet, and uses ambient airflow entering the front of the vehicle to reduce the charge air temperature. The HPCAC air outlet is connected directly to the intake throttle duct.

High Pressure Boost Pressure (HPBP) Sensor

This sensor monitors the pressure of the charge air entering the duct. The primary function of the sensor is to provide information used to ensure proper boost control. It is also used as part of EGR control.

Pressure sensor works by providing an analog voltage output to the ECM which is proportional to pressure being applied to an internal diaphragm in the sensor. The sensor is connected to the control module through the Reference Voltage (VREF), signal, and signal ground wires. A transfer function contained in the ECM software converts the analog voltage to a pressure value which is then used by software strategies requiring the pressure information.

The ECM continuously monitors the pressure sensor output voltage for determination of charge air pressure. High and low diagnostic voltage thresholds are evaluated to ensure that output voltage is within a valid range.

High Pressure Boost Temperature (HPBT) Sensor

This sensor monitors the temperature of the charge air entering the duct. The temperature measured is an input to the engine coolant control strategy. It also is used for evaluation of on-board diagnostics to ensure proper functionality of the charge air cooling system.

This temperature sensor is a thermistor and has two connections to the ECM. A thermistor varies resistance as temperature changes. When interfaced to the ECM circuitry, a change in sensor resistance results in a voltage change internal to the ECM. A transfer function contained in the ECM software translates the measured voltage to a temperature value.

The ECM continuously monitors the voltage resulting from the thermistor's changing resistance. High and low diagnostic voltage thresholds are evaluated to ensure that the output voltage is within a valid range.

Low Pressure Boost Pressure (LPBP) and Low Pressure Boost Temperature (LPBT) Sensors

This is a combination pressure and temperature sensor.

This sensor is a dual function sensor that detects pressure and temperature of the charge air entering the HP compressor. It is installed in the piping between the LP compressor outlet and the HP compressor inlet. This sensor is used for evaluation by on-board diagnostics to ensure proper functionality of the charge air cooling system.

This sensor consists of a thermistor which varies resistance as temperature changes. When interfaced to the ECM circuitry, a change in sensor resistance results in a voltage change internal to the ECM. An internal diaphragm which deflects due to pressure changes results in an analog voltage output to the ECM which is proportional to the pressure. Transfer functions contained in the ECM software translate the measured voltages into a temperature and a pressure value.

The ECM continuously monitors the voltages resulting from changes in both the temperature and pressure. High and low diagnostic voltage thresholds are evaluated to ensure that the output voltage is within a valid range.

Exhaust Gas Recirculation (EGR) System

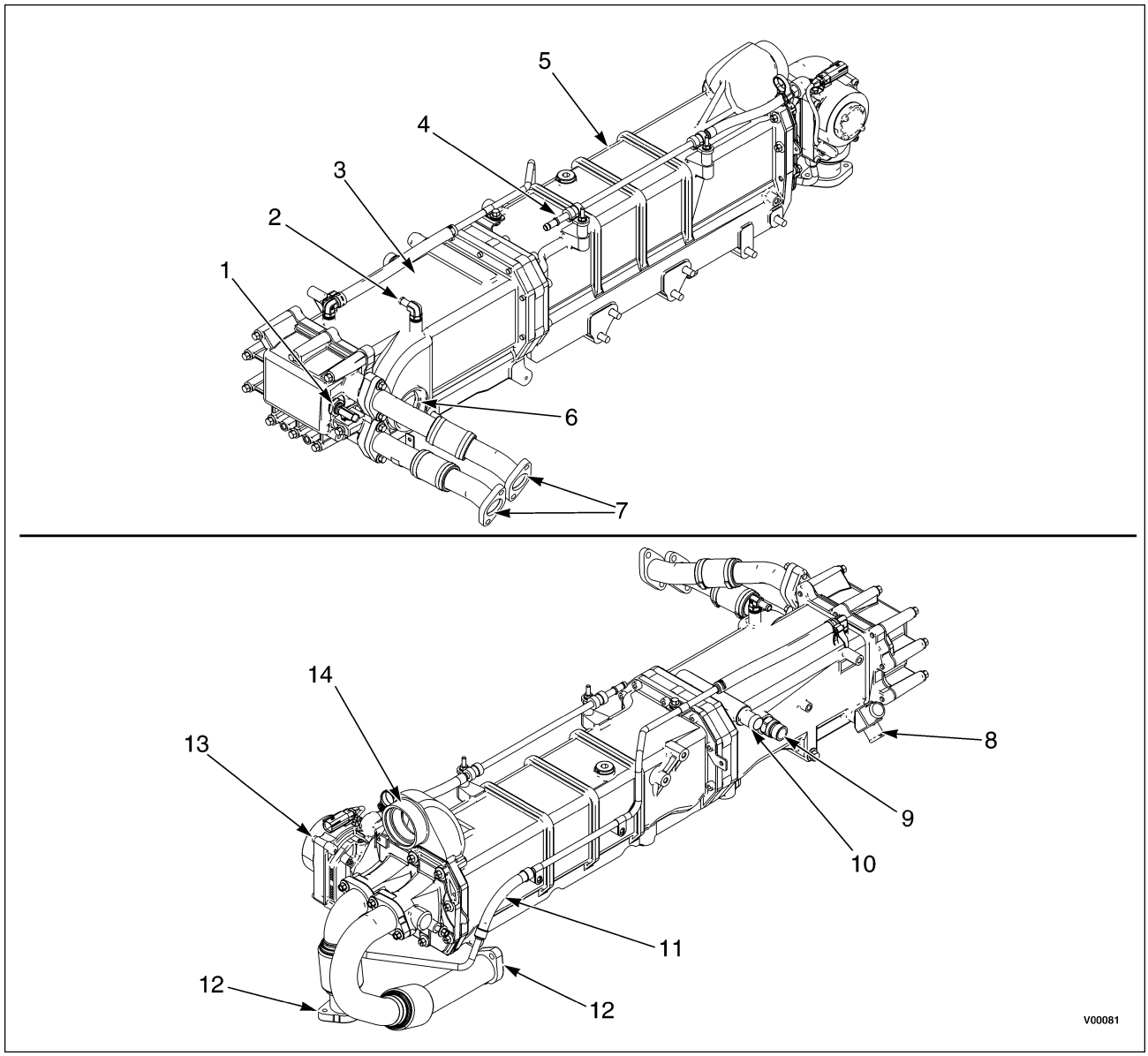


Figure 10 EGR system components

1. EGRT sensor
2. EGR cooler air bleed (to deaeration tank)
3. EGR cooler (low temperature stage)
4. EGRV coolant return line (to deaeration tank)
5. High temperature EGR cooler
6. Intake Manifold Temperature (IMT)
7. EGR cooler outlet tube (2) (gases)
8. Low temperature EGR cooler inlet (coolant)
9. Engine Coolant Temperature 2 (ECT2) sensor
10. Low temperature EGR cooler outlet (coolant)
11. EGRV coolant supply line
12. EGR cooler inlet tubes (gases)
13. EGRV
14. EGR cooler inlet (coolant)

EGR System Overview

The EGR system reduces NO_X engine emissions by introducing inert cooled exhaust gas into the air inlet duct. NO_X forms during a reaction between nitrogen and oxygen at high temperatures during combustion.

The ECM monitors signals from the CACOT sensor, Oxygen sensor (O_2S), Engine Coolant Temperature 1 (ECT1) sensor, EGRT sensor to control the EGR system.

EGR is switched off (EGRV closed) if any of the following conditions are present:

- Engine coolant temperature less than 10 °C (50 °F) will close the EGR valve
- Intake manifold temperatures less than 7 °C (45 °F) will close the EGR valve
- During engine brake operation

EGR Flow

Exhaust gas from the exhaust manifold flows through the EGR inlet tubes to the EGRV. When EGR function is activated, the EGRV opens and allows exhaust gas to enter the EGR cooler. Cooled exhaust gas flows from the front of the EGR cooler, through the EGR outlet tubes, and into the intake throttle duct where it is mixed with filtered air.

EGR System Control

The EGR system consists of the EGRV, ETV, and O_2S. The EGRV contains a PWM controlled valve and Exhaust Gas Recirculation Position (EGRP) sensor.

The EGRV is installed at the rear of the EGR cooler, on the right side of engine valve cover. The EGRV limits exhaust gas flow into the EGR cooler.

The ECM commands the EGRV to move and hold position. The EGRP sensor, located inside the EGRV, monitors and provides an EGRV position signal to the ECM.

The O_2S is installed in the exhaust, in front of the aftertreatment fuel injector. The O_2S has a heater element that heats the sensor to its normal operating temperature of 780 °C (1436 °F). During initial engine warm-up, the O_2S heater element is activated only after the engine coolant reaches 40 °C (104 °F) and the exhaust gas temperature DOCIT sensor exceeds 100 °C (212 °F) for more than 30 seconds.

EGRV Control

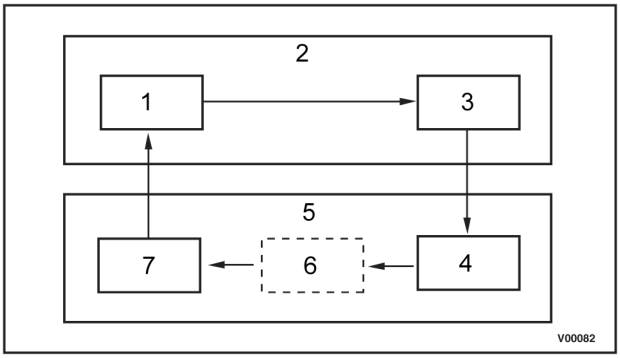


Figure 11 EGRV position control

1. EGR position monitored by ECM
2. ECM
3. ECM commands EGR to desired position
4. EGRV to desired position
5. EGRV
6. EGRV position matches ECM command
7. EGR position sent to ECM

The EGRV has an integrated position sensor, and provides feedback to the ECM indicating EGRV position.

EGR – Open Loop

During the engine warm-up period and before the O_2S reaches its normal operating temperature, the EGR system operates in open loop. In open loop, the EGR system is controlled by the ECM based on the charge air temperature, engine coolant temperature, engine speed, and load conditions.

EGR – Closed Loop

After the O_2S reaches its operating temperature, the EGR system switches to closed loop operation. In closed loop, the EGR system is controlled by the ECM based on coolant temperature and O_2S readings.

EGR Flow Cooling

The EGR system includes a two-stage EGR cooler, allowing the ECM to regulate EGR Cooler temperatures. The ECM monitors intake manifold temperature through the Exhaust Gas Recirculation Temperature 1 (EGRT1) sensor and to regulate EGR flow temperatures, the CCV regulates coolant flow through the LTR. Refer to Cooling System in this section for more information.

Aftertreatment (AFT) System

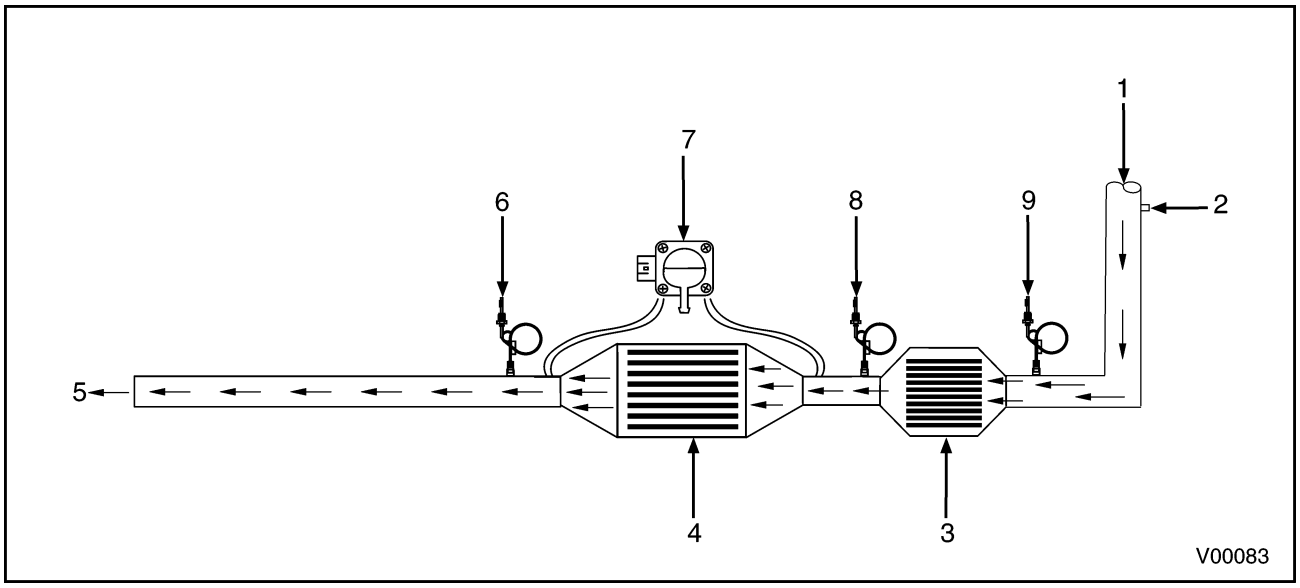


Figure 12 AFT system overview

1. Pre-DOC exhaust flow
2. Aftertreatment Fuel Injector (AFI)
3. DOC
4. DPF
5. Exhaust out to tail pipe
6. DPFOT sensor
7. DPFDP sensor
8. DOCOT sensor
9. DOCIT sensor

The AFT system, part of the larger exhaust system, processes engine exhaust to meet emission requirements. The AFT system traps particulate matter (soot) and prevents it from leaving the tailpipe.

The AFT system performs the following functions:

- Monitors exhaust gas temperatures DOC in, DOC out, and DPF out temperature and delta pressure across the DPF. It controls engine operating parameters for emission control and failure recognition
- May cancel regeneration in the event of catalyst or sensor failure
- Monitors the level of soot accumulation in the DPF
- AFT control system initiates regeneration automatically when DPF is full with soot and control engine operating parameters to increase temperature to have successful regeneration
- Maintains vehicle and engine performance during regeneration

Diesel Particulate Filter (DPF)

The DPF does the following:

- Captures and temporarily stores carbon-based particulates in a filter
- Allows for oxidation (regeneration) of stored particulates once loading gets to a particular level (restriction)
- Provides the required exhaust back pressure drop for engine performance
- Stores non-combustible ash

Diesel Oxidation Catalyst (DOC)

The DOC does the following:

- Oxidizes hydrocarbons and carbon monoxide (CO) in exhaust stream
- Provides heat for exhaust system warm-up
- Aids in system temperature management for the DPF

Aftertreatment (AFT) System Conditions and Responses

The operator is alerted of system status either audibly or with instrument panel indicators. Automatic or manual regeneration is required when levels of soot exceed acceptable limits. For additional information, see the applicable vehicle Operator's Manual and the vehicle visor placard.

Downstream Fuel Injection

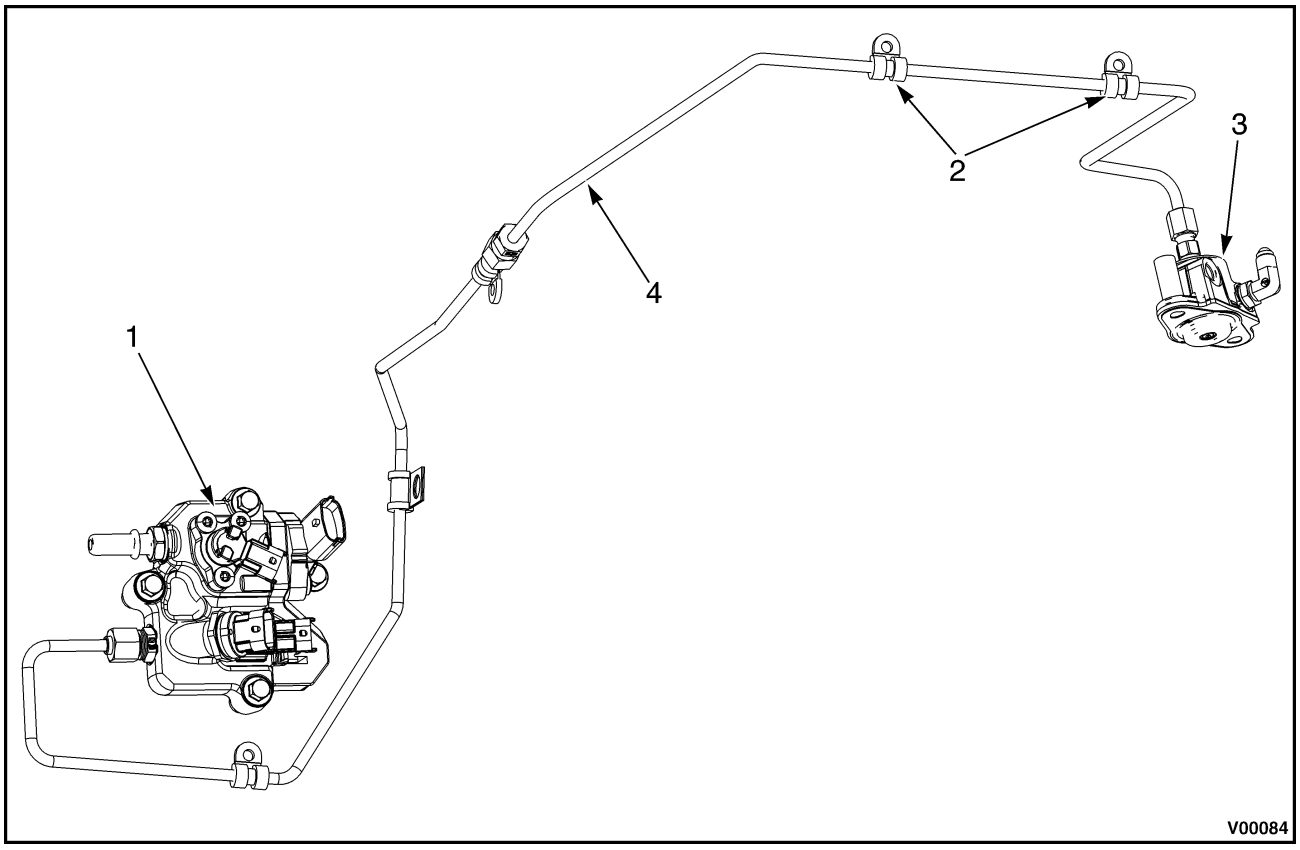


Figure 13 Downstream fuel injection components

1. DSI unit
2. Fuel line retainers (rear of engine block)
3. AFI
4. AFI fuel pressure line

The DSI system injects fuel into the exhaust system to increase temperature of the exhaust gases, and is necessary for DPF regeneration. DSI is controlled by the ECM. The ECM receives signals from the Aftertreatment Fuel Doser (AFTFD) sensor (located in the DSI unit), and control operation when downstream injection (regeneration) is required. The ECM also controls the Aftertreatment Fuel Shutoff Valve (AFTFSV) (located in the DSI unit) which controls the volume of fuel sent to the AFI in case of AFTFD malfunction.

Downstream Injection (DSI) Unit

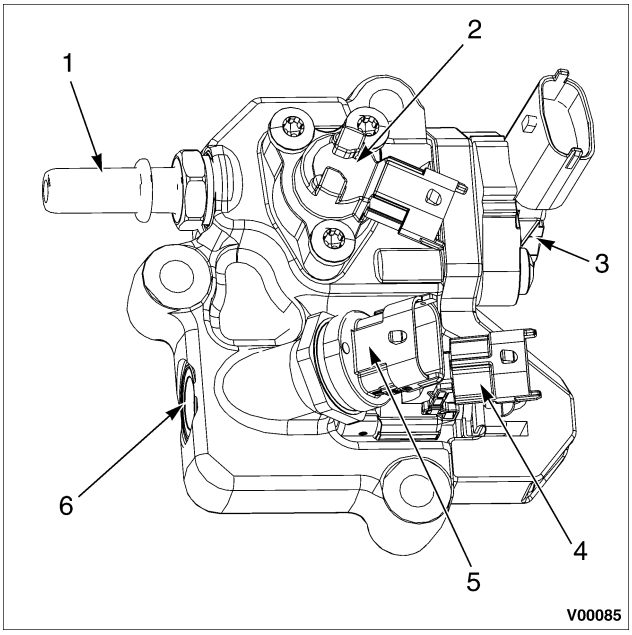


Figure 14 Downstream Injection (DSI) unit

1. Fuel supply from fuel filter assembly
2. Aftertreatment Fuel Shutoff Valve (AFTFSV)
3. Aftertreatment Fuel Inlet Sensor (AFTFIS)
4. Aftertreatment Fuel Doser (AFTFD)
5. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor
6. Fuel outlet port to AFI

The DSI unit is connected to the clean side of the low pressure fuel system, and will provide a metered amount of fuel to the AFI. The DSI unit provides pressurized fuel injection pulses to the AFI. The AFI is a mechanical poppet type injector, and will only inject fuel when fuel line pressure is increased above a specific pressure. The DSI unit is installed on the left side of the engine, to the rear of the fuel module.

The AFTFIS and AFTFP2 sensors monitor fuel pressure and temperature in the DSI system, and provide constant feedback to the ECM.

Aftertreatment Fuel Injector (AFI)

The AFI is located on the right side of the engine, and is installed in the turbocharger exhaust pipe after the exhaust O_2S.

Pressurized fuel is supplied to the injector by the DSI unit using the AFTFD valve. When the conditions required for regeneration are met, the ECM sends a PWM voltage to the AFTFD. During operation, the AFTFD increases fuel pressure to the AFI, causing injection of fuel into the exhaust pipe.

To protect the AFI internal components, continuous engine coolant flow through the AFI is maintained by external coolant supply and return lines.

Crankcase Oil Separator

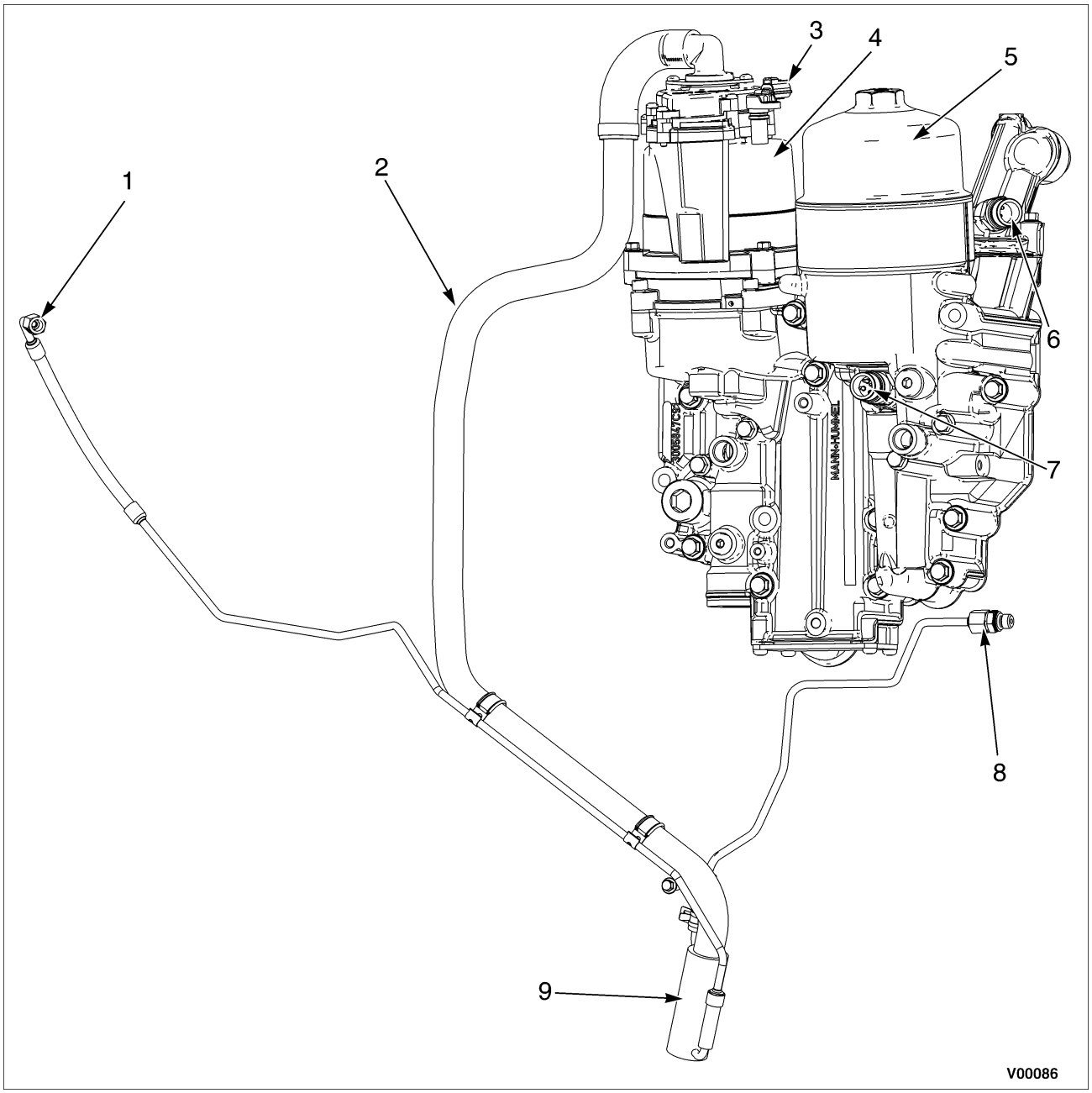


Figure 15 Oil Module with Crankcase Oil Separator

1. Coolant supply line
2. CCOS vent tube
3. Crankcase Oil Separator Speed (CCOSS) sensor
4. Crankcase Centrifuge Oil Separator (CCOS)
5. Oil filter access cap
6. Engine Oil Temperature (EOT) sensor
7. Engine Oil Pressure (EOP) sensor
8. Coolant return line
9. CCOS ventilation tube heater

Crankcase ventilation is provided using the CCOS. Excess crankcase vapors are filtered by the CCOS, and are then vented to the atmosphere.

A centrifugal oil separator, driven by engine oil pressure, separates and directs oil mist to the side of CCOS housing. The separated oil mist drains from the oil separator, through the crankcase, and into the oil pan. The oil separator is an integral part of the oil module.

Fuel Management System

Fuel System Components

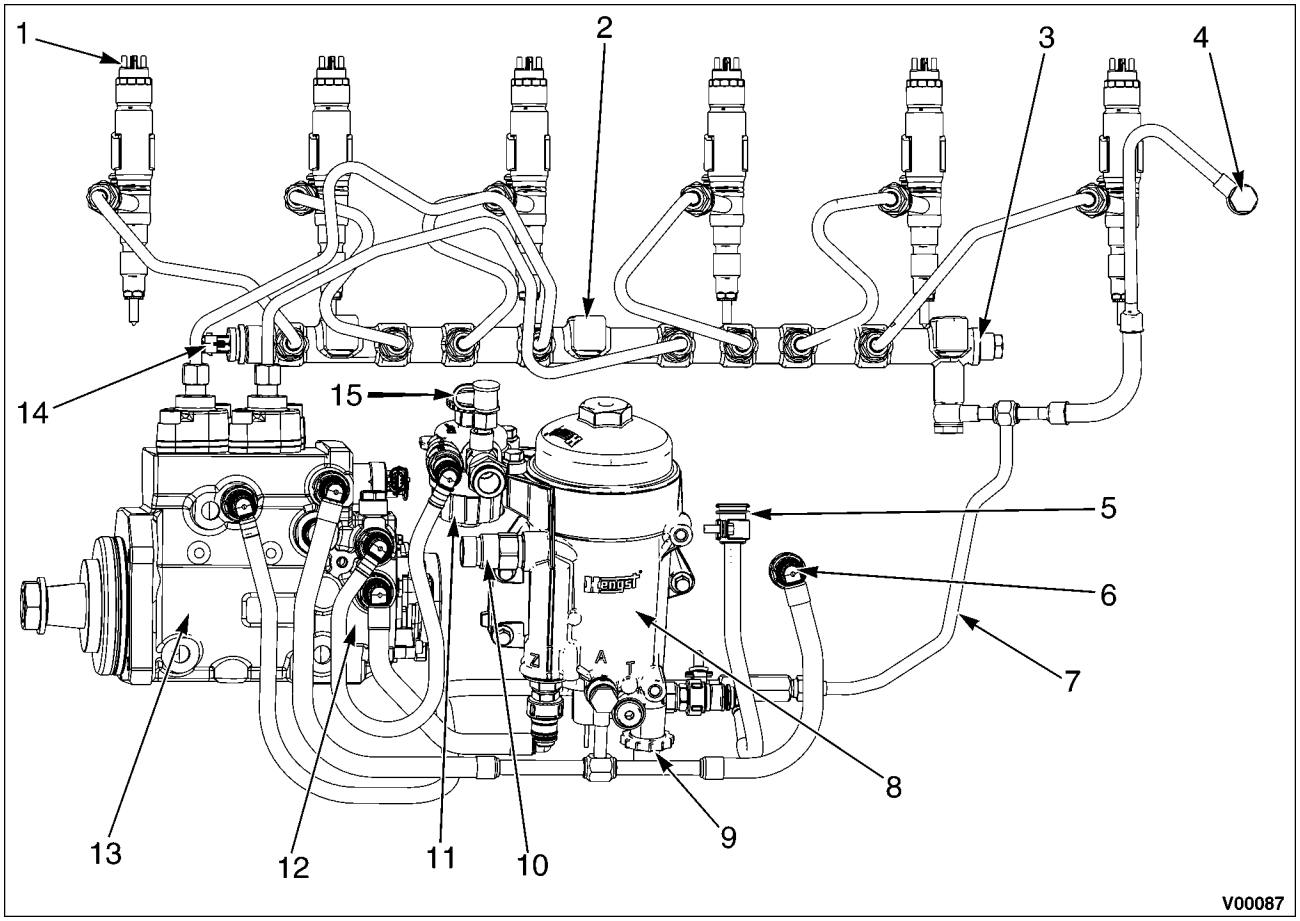


Figure 16 Fuel system

1. Injector (6)
2. Fuel Rail
3. Fuel rail pressure limiting valve
4. Fuel return from cylinder head
5. Engine fuel return connection (to chassis filter)
6. Fuel supply to DSI unit
7. Fuel return line
8. Fuel filter assembly
9. Drain screw
10. Fuel Delivery Pressure (FDP) sensor
11. Fuel primer pump assembly
12. LP fuel pump
13. HP fuel pump
14. Fuel Rail Pressure (FRP) sensor

MaxxForce® 11 and 13 engines are equipped with a high pressure common rail injection system. The common rail fuel injection system provides pressurized fuel to the fuel injectors for optimal fuel atomization in the combustion chamber.

All excess fuel is returned to the chassis mounted filter separator, before returning to the fuel tank.

The fuel system is controlled by the ECM, various sensors, and the Fuel Pressure Metering Unit (FPMU) located in the HP pump. For additional information, refer to LP Fuel System and HP Fuel System in this section.

Fuel Flow

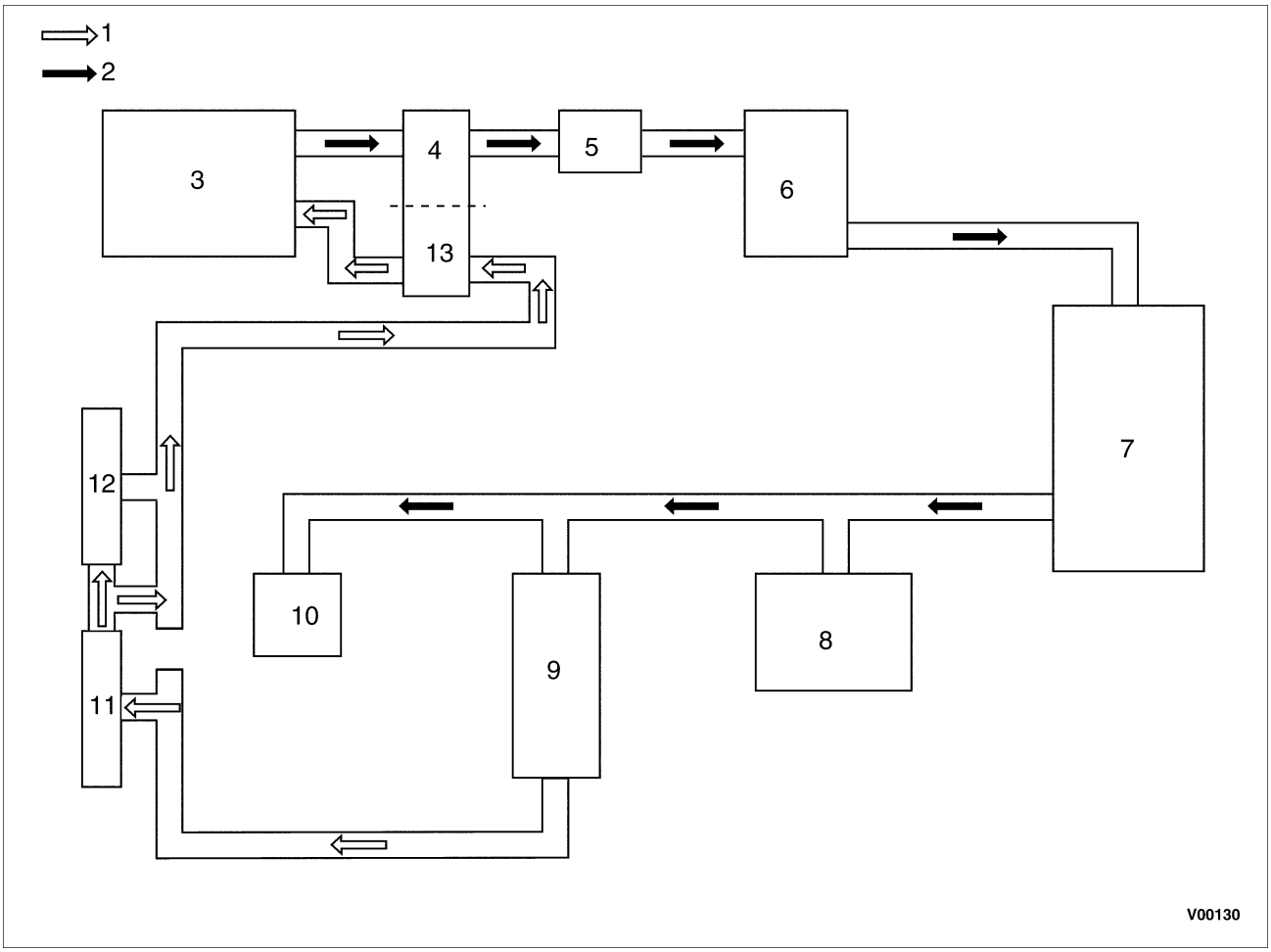


Figure 17 Fuel supply flow diagram

1. Fuel Return
2. Fuel supply
3. Fuel tank
4. Chassis mounted fuel filter/water separator (Top portion)
5. Fuel primer pump assembly with fuel strainer element
6. LP fuel pump
7. Fuel filter assembly (engine mounted)
8. DSI unit
9. HP fuel pump
10. Inlet Air Heater Fuel Solenoid (IAHFS)
11. Fuel rail
12. Fuel injectors
13. Chassis mounted fuel filter/water separator (bottom portion)

Fuel is pumped from the tank, through the chassis mounted fuel filter/water separator using the LP fuel pump. Fuel is pumped from the LP fuel pump to the engine mounted fuel filter assembly, before being supplied to the HP fuel pump. The high pressure fuel pump supplies high pressure fuel to the fuel rail, which feeds the injectors through individual tubes. The LP fuel pump and HP fuel pump are assembled as one gear driven unit, and are serviced as an assembly.

Low Pressure Fuel System

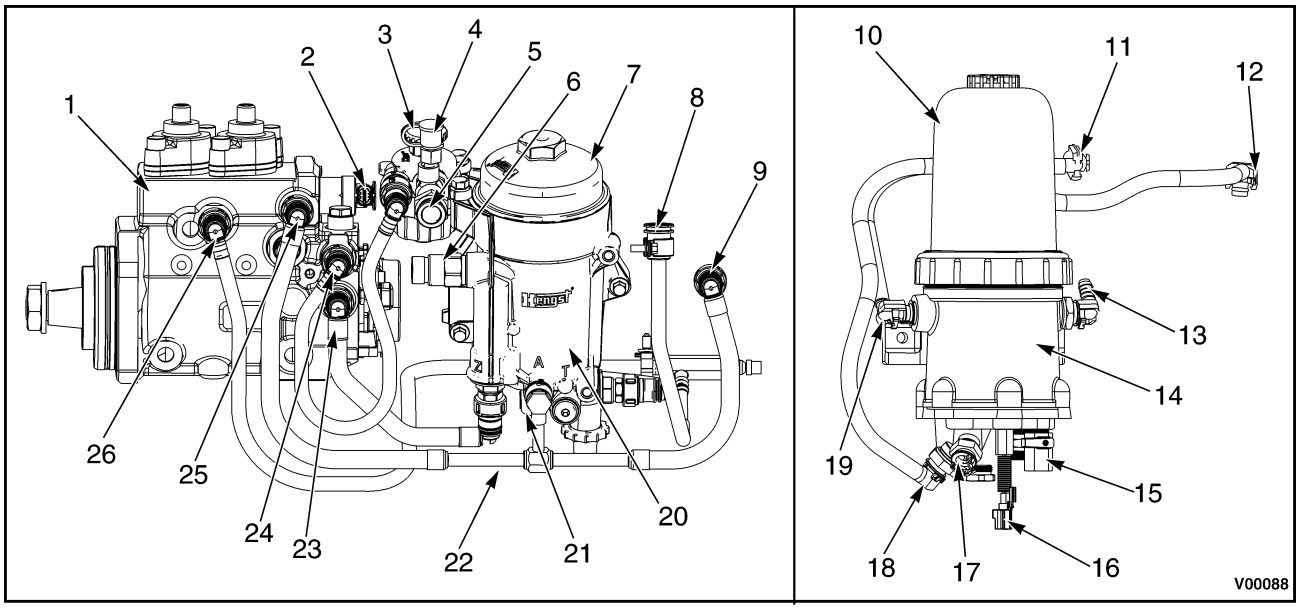


Figure 18 Low pressure (LP) fuel system

1. HP fuel pump
2. Fuel Pressure Control Valve (FPCV)
3. Fuel primer pump assembly w/ fuel strainer element
4. Fuel pressure test port
5. Engine fuel supply connection
6. FDP sensor
7. Engine mounted secondary fuel filter access
8. Engine fuel return connection
9. Fuel supply to DSI unit
10. Chassis mounted primary fuel filter access
11. Fuel supply to engine
12. Fuel return from engine
13. Fuel supply from tank
14. Chassis mounted fuel filter/water separator
15. Fuel Heater
16. Water In Fuel (WIF) sensor
17. Fuel return to tank
18. Fuel return from engine
19. Fuel supply to engine
20. Engine mounted fuel module
21. Inlet air heater port
22. Low pressure fuel supply line
23. LP fuel pump outlet
24. LP fuel pump inlet
25. HP fuel pump inlet
26. HP fuel pump return

The LP fuel pump pumps fuel from the tank through the chassis mounted fuel filter/water separator, fuel strainer element and engine filter element, then to the high pressure fuel system, inlet air heater system, and DSI.

In addition to providing high pressure fuel to the injectors, the fuel system provides filtered low pressure fuel to the downstream Injection and inlet air heater systems.

Chassis Mounted Filter/Water Separator

The chassis mounted filter/water separator removes debris and water from the fuel before it enters the fuel primer pump and low pressure fuel pump. The chassis mounted filter/water separator includes a Water In Fuel (WIF) sensor and optional fuel heater. Refer to Section 5 “Chassis Filter/Water Separator Maintenance and Inspection” in this manual for more information.

Fuel Primer Pump Assembly

During fuel system priming, fuel is drawn from the tank through the chassis mounted filter/water separator by the fuel primer pump assembly. The fuel primer pump assembly has an integrated fuel strainer element that can be cleaned. The fuel primer pump assembly is manually operated, and is used to prime the low pressure fuel system anytime the fuel system has been emptied. The primer pump provides unrestricted fuel flow to the low pressure pump during normal engine operation.

Low Pressure (LP) Fuel Pump

The LP fuel pump and the HP fuel pump are housed as one assembly. Fuel is drawn through the fuel primer pump assembly and into the LP fuel pump. The LP pump supplies fuel to the fuel filter housing assembly at pressures varying between 496 kPa (72 psi) at idle, and 896 kPa (130 psi) at rated speed. The LP fuel pump is equipped with an internal pressure regulator that relieves the fuel pressure internally if the pressure exceeds 1300 kPa (189 psi).

Fuel Filter Assembly

The fuel filter assembly is located on the left side of the engine and has a disposable filter element. An FDP sensor is installed on the front side of the fuel filter assembly, which measures fuel pressure between the LP fuel pump and the filter element. The fuel filter assembly also has a drain screw that allows water and dirt to be drained periodically. Because water may accumulate inside the fuel filter assembly, use the drain screw to drain water per maintenance schedule in the *Engine Operation and Maintenance Manual*. An additional function of the fuel filter assembly is fuel system self-deaeration. The air separated from fuel is pushed back into the fuel tanks through the return line. The fuel filter assembly also provides filtered fuel to the DSI and inlet air heater system. An orifice regulator is integrated into the fuel filter assembly, and regulates the fuel pressure for the inlet air heater system to 70 kPa (10 psi).

High Pressure Fuel System

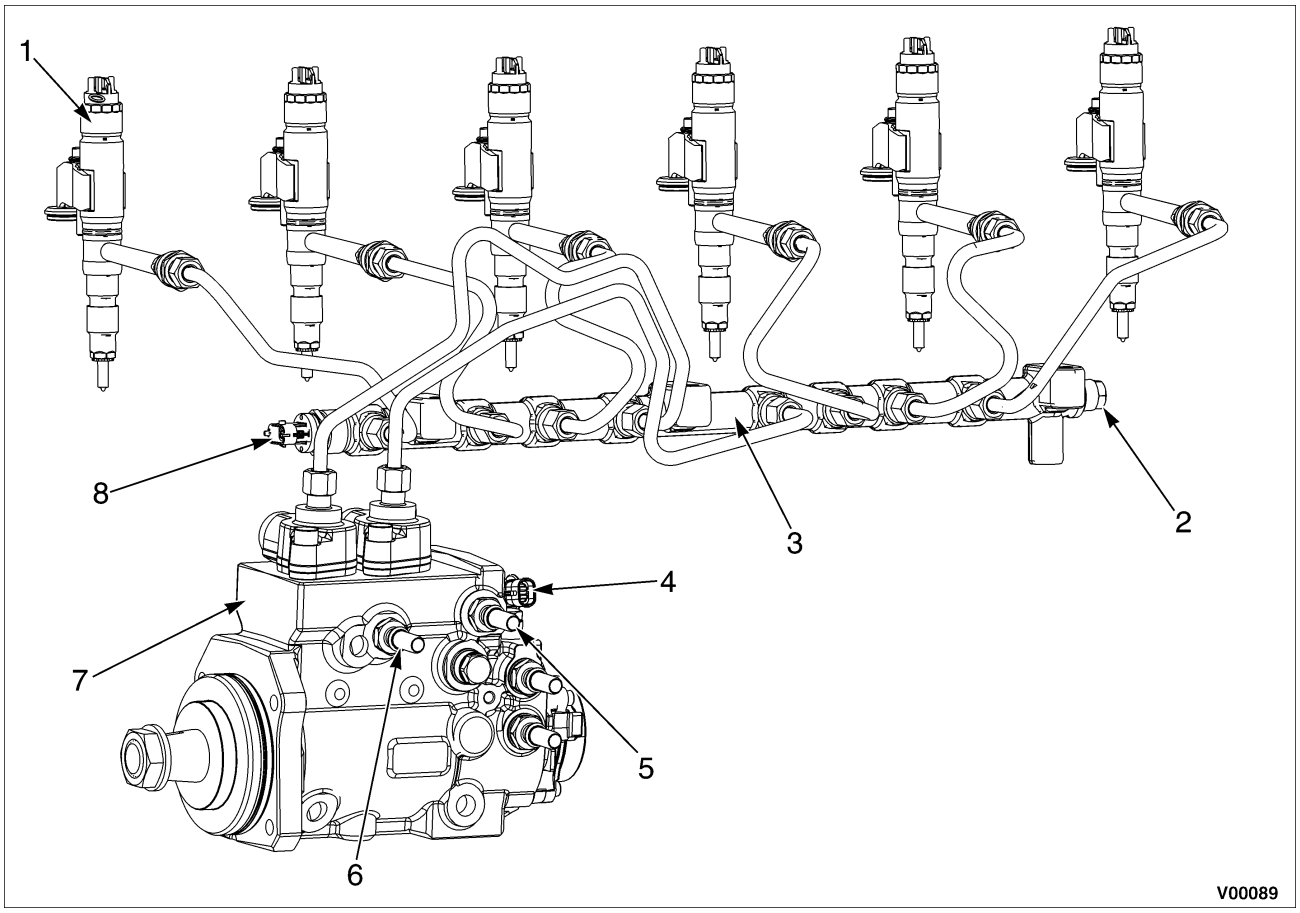


Figure 19 High pressure (HP) fuel system

1. Injector (6)
2. Rail pressure limiting valve
3. Fuel Rail
4. Fuel Pressure Control Valve (FPCV)
5. Fuel inlet - HP fuel pump
6. Fuel return - HP fuel pump
7. HP fuel pump
8. FRP sensor

Pressurization and injection are separate in the common rail injection system. The optimal injection pressure is generated by the high pressure pump at any engine speed. High pressure fuel quantity from high pressure pump is controlled by the FPCV. The injection timing and quantity are calculated in the ECM and implemented by solenoid valve controlled injectors. The use of solenoid valve controlled injectors allows three injections per cycle.

The first injection is used to reduce combustion noise and emissions by introducing a small amount of fuel into the cylinder, preventing a rapid rise in cylinder pressure when combustion begins. The second injection is the main injection. This injection allows high temperatures to be maintained during combustion, but not long enough to allow generation of large soot amounts. The third injection is done during the power stroke to maximize cylinder temperature and reduce engine soot generation.

The high pressure fuel system consists of the high pressure pump with integrated Fuel Pressure Metering Unit (FPMU), pressure pipe rail, high pressure fuel lines, injectors, FRP sensor, and pressure relief valve.

High Pressure (HP) Pump

The HP pump supplies the necessary quantity of HP fuel for all operating engine modes. The HP pump is gear driven and is fuel lubricated. Fuel from the LP fuel pump is forced through the fuel module assembly, and into the HP pump. The flow of fuel to the suction chamber of the HP pump is controlled by the FPCV, in order to control HP fuel output.

Fuel Pressure Control Valve (FPCV)

The FPCV is a variable position actuator installed on the suction side of the high pressure pump and controls the output fuel pressure. The ECM sends a PWM signal to control the FPCV. A 100% duty cycle PWM signal corresponds to minimum fuel pressure delivery, while a 0% duty cycle PWM corresponds to maximum fuel pressure delivery.

Fuel Rail

The fuel rail is a HP fuel storage unit. The storage volume of the fuel rail is designed to reduce pressure pulses caused by the HP pump and injectors, and to maintain constant fuel pressure even when large fuel quantities are injected into the cylinders. Connection between the fuel rail and injectors are made through two individual injection lines.

Fuel Rail Pressure (FRP) Sensor

The FRP sensor is a variable resistance sensor that monitors fuel pressure in the HP fuel rail. The FRP sensor is mounted in the front of the fuel rail, on the left side of the engine.

Rail Pressure Limiting Valve

The rail pressure limiting valve maintains fuel pressure inside the fuel rail below 260,000 kPa (37,710 psi). If HP pump output exceeds 260,000 kPa (37,710 psi), the pressure relief valve opens and allows fuel to flow into the fuel return line. With the pressure relief valve open, fuel pressure in the pressure pipe rail drops to approximately 110,000 kPa (15,954 psi).

Injectors

MaxxForce® 11 and 13 engines are equipped with electronically controlled injectors. During engine operation, injectors are supplied at all times with high pressure fuel, and the injector solenoid valves open up to three times per cycle. The injectors are positioned vertically in the center of the cylinder head and are held in place by brackets. The seal between the injectors and the combustion chamber consists of a copper washer on the tip of each injector.

Inlet Air Heater System

Inlet Air Heater System Components

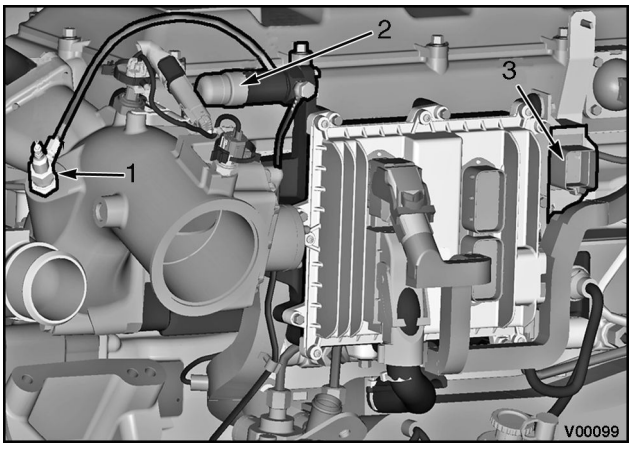


Figure 20 Inlet air heater system

1. Inlet Air Heater Fuel Igniter (IAHFI)
2. Inlet Air Heater Fuel Solenoid (IAHFS) valve
3. Inlet Air Heater Relay (IAHR)

Inlet Air Heater Fuel Igniter (IAHFI)

The inlet air heater system rapidly activates the heater element, vaporizing and igniting small quantities of fuel into the air inlet duct.

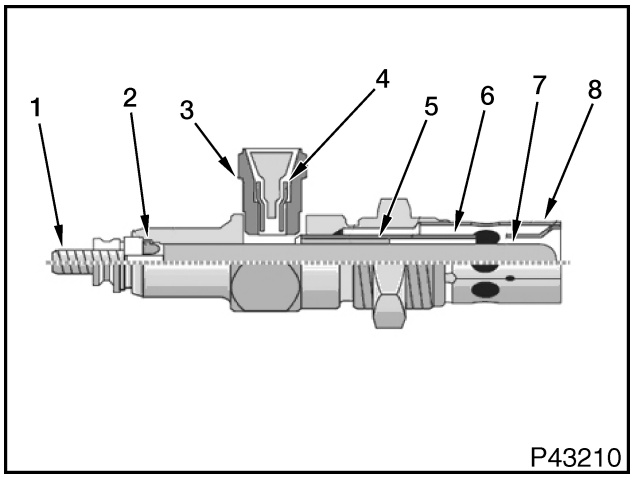


Figure 21 Inlet Air Heater Fuel Igniter (partial cut away view)

1. Electrical connection
2. Insulation
3. IAHFI fuel line connection
4. Metering device
5. Vaporizer filter
6. Vaporizer tube
7. Heater element
8. Protective sleeve

The IAHFI has an internal fuel metering device, a vaporizer filter, a vaporizer tube, a heater element, and a protective sleeve. The protective sleeve has holes that allow enough air to pass through the IAHFI to enable fuel vaporization and combustion.

The IAHFI is installed on the left front side of the engine, in the intake throttle duct.

Inlet Air Heater Relay (IAHR)

The IAHR is located on the left side of the engine at the rear of the ECM. The IAHR provides voltage to the IAHFI, and is controlled by the ECM.

Inlet Air Heater Fuel Solenoid (IAHFS) Valve

The IAHFS valve is located on the left side of the engine and is controlled by the ECM. The IAHFS valve is supplied with low fuel pressure regulated fuel from the fuel filter assembly.

When the ECM provides battery voltage to the IAHFS valve, the solenoid opens and allows fuel to flow to the IAHFI through the IAHFI fuel line.

Inlet Air Heater System Operation

The inlet air heater system operates only in temperatures lower than 10 °C (50 °F).

When the truck operator turns the ignition switch to ON, the wait-to-start lamp in the instrument cluster illuminates. Based on the temperature readings from the ECT sensor, the ECM activates the IAHR heater element. The IAHR then energizes the IAHFI for approximately 35 seconds.

Once the IAHFI is heated to approximately 1000 °C (1832 °F), the wait-to-start lamp starts to flash and the operator needs to crank the engine. When the engine starts rotating, the IAHFS valve opens and allows fuel to enter the IAHFI. Inside the IAHFI, fuel passes through the vaporizer tube. The vaporized fuel then mixes with in coming air and ignites in contact with the heater element.

Once the engine starts, the IAHFI remains energized and fuel continues to be injected, and the wait-to-start lamp continues to flash for a maximum of four minutes. When the wait-to-start lamp stops flashing, the IAHFI and the IAHFS valve are deactivated. If the operator accelerates while the wait-to-start lamp is flashing, the inlet air heater system will shutdown.

Oil Flow and Components

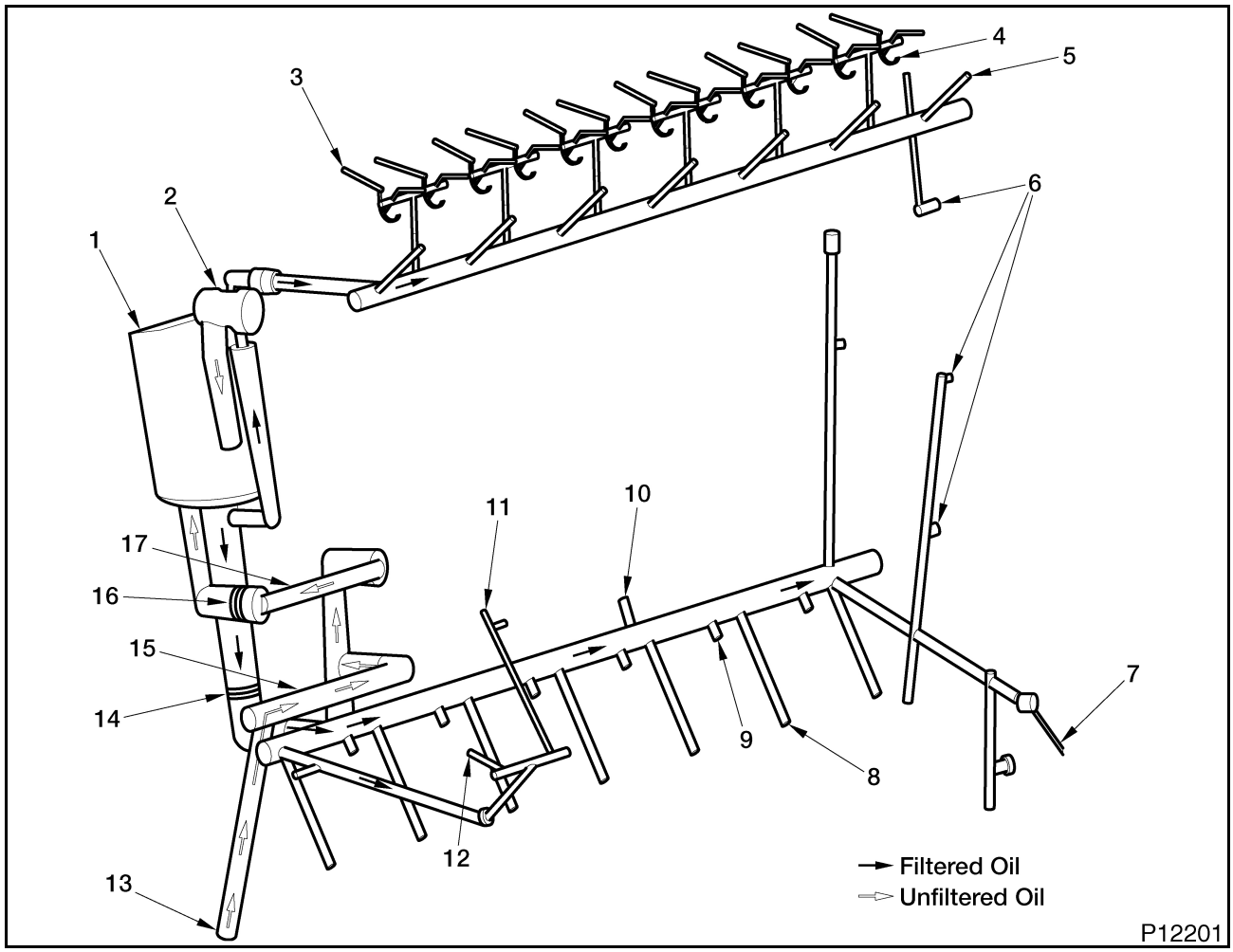


Figure 22 Oil flow

1. Oil filter element
2. Oil return from cylinder head
3. Oil supply to exhaust valve bridge
4. Oil supply to rocker gear
5. Oil supply to camshaft bearings
6. Oil supply to intermediate gears
7. Oil supply to air compressor
8. Oil supply to crankshaft main bearings
9. Oil supply to piston oil sprayer nozzles
10. Oil supply to turbochargers
11. Oil supply to drive housing
12. Oil supply to front cover
13. Oil pump output
14. Oil pressure relief valve
15. Oil supply to oil module
16. Oil return shutoff valve
17. Oil cooler

Unfiltered oil is drawn from the oil pan through the pickup tube and front cover passage by the crankshaft driven gerotor pump. The pressurized oil is moved through a vertical crankcase passage and into the oil module.

Inside the oil module, unfiltered oil flows through plates in the oil cooler heat exchanger. Engine coolant flows around the plates to cool the surrounding oil. An oil return shutoff valve, installed at the exit from the oil cooler, prevents oil from draining through the oil pump and back into the oil pan when the engine is stopped. If oil pressure coming out of the oil pump is too high, a pressure relief valve allows the excess oil to return through the crankcase and into the oil pan before entering the oil cooler.

Oil that exits the oil cooler flows through a return shutoff valve that prevents the oil from draining back into the oil pan. From the return shutoff valve, oil enters the oil filter element and flows from the outside to the inside of the filter element to remove debris. When the filter is restricted, an oil filter bypass valve opens and allows oil to bypass the filter so engine lubrication is maintained. If the oil pressure inside the oil filter element is too high, an oil pressure relief valve, located at the bottom of the oil filter element housing, allows the excess oil to return to the oil pan.

After passing through the oil filter element, oil flow is directed to the cylinder head and crankcase.

Clean oil enters the cylinder head through an external flange elbow connected directly to the oil module. Inside the cylinder head, oil flows through passages to lubricate the camshaft bearings, rocker arms, exhaust valve bridges, and cylinder intermediate gear.

Clean oil enters the crankcase directly from the oil module to lubricate the crankshaft, high pressure pump, air compressor, intermediate gears, and turbochargers. The crankshaft has cross-drillings that direct oil to the connecting rods.

Oil sprayer nozzles continuously direct cooled oil to the bottom of the piston crowns.

The turbochargers are lubricated with filtered oil from an external supply tube that connects the main oil gallery from the crankcase to the center housing of each turbocharger. Oil drains back to the oil pan through the low and high pressure turbocharger oil return pipes connected to the crankcase.

A service oil drain valve, located at the bottom of the filter element cavity, opens automatically when the filter element is lifted for replacement, and allows the oil from the oil filter element cavity to drain into the oil pan.

Oil is also supplied to the MaxxForce® Engine Brake housings (under valve cover) through specially designed rocker mounting bolts.

Crankcase Oil Separator

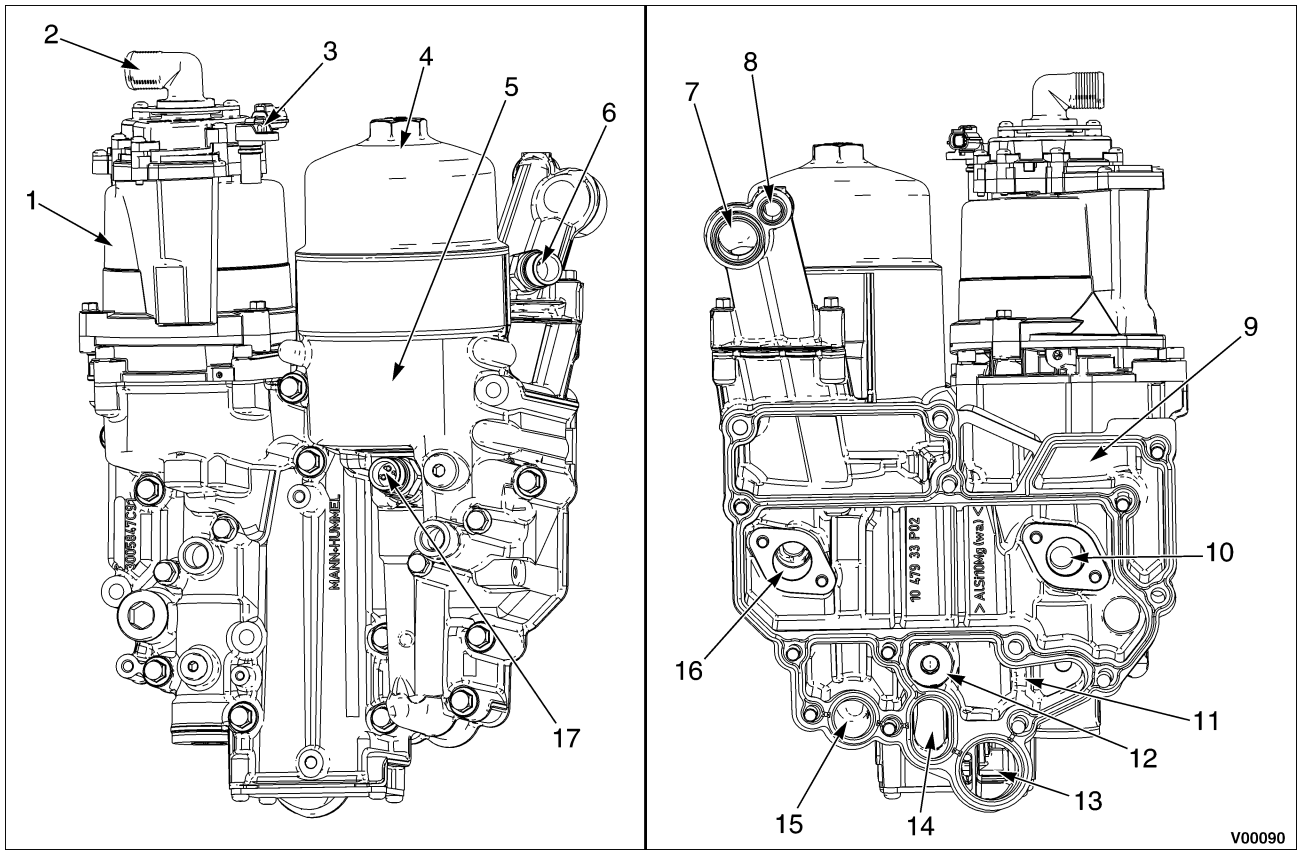


Figure 23 Oil module with crankcase oil separator assembly (inner and outer views)

1. CCOS
2. CCOS vent outlet
3. CCOSS sensor
4. Filter cover
5. Oil filter assembly
6. EOT sensor
7. Oil return from cylinder head
8. Oil supply to cylinder head
9. Crankcase gas inlet
10. Oil cooler inlet
11. Oil supply from oil pump
12. Regulator
13. CCOS oil return
14. Oil module pressure relief port
15. Oil out to crankcase
16. Oil cooler outlet to crankcase
17. EOP sensor

The oil module contains a canister style filter, oil cooler, EOP and EOT sensors, a pressure relief valve, an oil filter bypass valve, and an oil return shutoff valve. The oil module also collects, and then directs crankcase emissions to the CCOS. The oil that separates from the crankcase emissions, before it reaches the CCOS, is drained back into the oil pan through the oil return port.

Remote Mounted Centrifugal Oil Filter (Optional)

The Remote Mounted Centrifugal Oil Filter is used to remove particulates from engine oil, reducing wear and extending engine oil change intervals. During operation, dirty oil enters the oil supply port to a regulator valve. When engine oil pressure exceeds 248 kPa (36 psi), the regulator valve opens, and oil enters the centrifugal element through the center hollow spindle. Inside the element, centrifugal force separates contaminants from oil. Contaminants accumulate on the serviceable rotor surface as a solid cake. Clean oil exits through opposing twin nozzles that power the centrifuge and returns to the crankcase from the oil level control base. Oil level is managed by the oil float. When the oil float raises, compressed air enters the system to force oil back to the crankcase. When the oil float drops, the air supply port is closed.

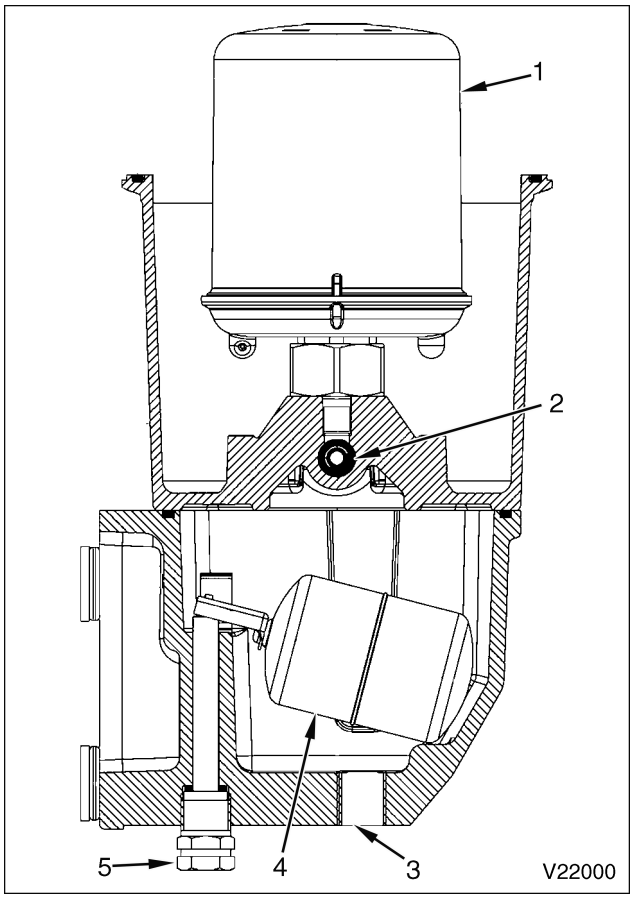


Figure 24 Remote Mounted Centrifugal Oil Filter

1. Serviceable rotor
2. Oil supply port (regulator valve)
3. Oil return port
4. Oil float
5. Air supply port (regulator valve)

Engine Cooling System

Cooling System Flow

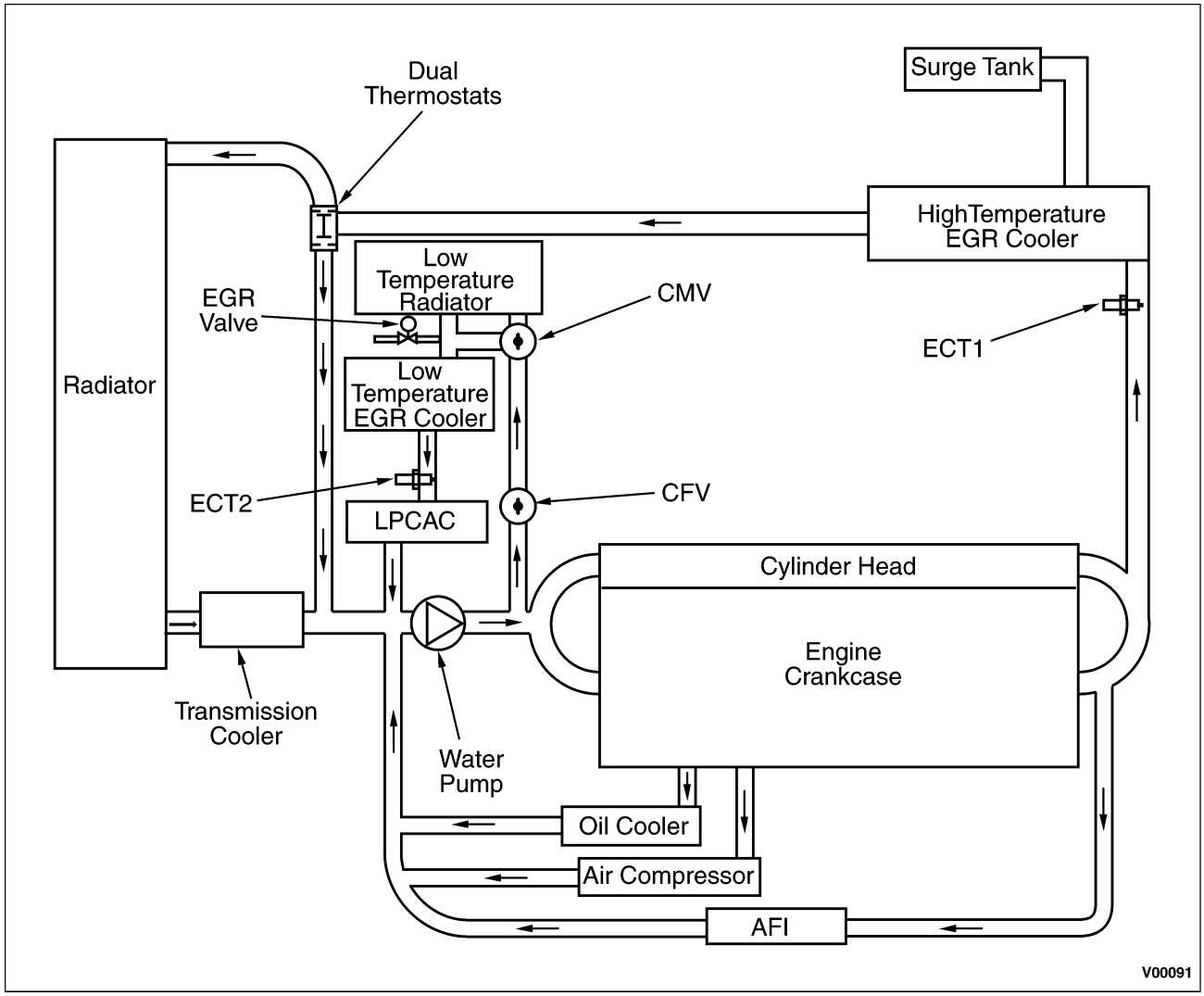


Figure 25 Cooling system flow

The water pump is installed on the water distribution housing and draws coolant from the radiator through the coolant inlet.

MaxxForce® 11 and 13 engines have no coolant passages between the crankcase and cylinder head through the cylinder head gasket. This eliminates the possibility of coolant leaks at the cylinder head gasket. Coolant in and out of the crankcase and cylinder head is directed through external passages. Coolant flows through the crankcase and cylinder head from front to rear. This coolant flows around the cylinder liners and combustion chambers to absorb heat from combustion.

Coolant exiting the crankcase and cylinder head at the rear of the engine is directed through an external coolant pipe to the high temperature stage of the EGR cooler. Coolant passes between the EGR cooler plates, travels parallel to the exhaust flow, travels through a transfer passage in the left side of the low temperature EGR cooler, into the EGR cooler return manifold and into the thermostat housing. A deaeration port on the top of the high temperature EGR cooler directs coolant and trapped air to the coolant deareation tank.

Coolant from the water pump also flows through the low temperature EGR Cooler and then through the LPCAC to regulate the charge air temperature. Flow through the low temperature EGR cooler/charge air cooler is controlled by the Coolant Mixer Valve (CMV) and Coolant Flow Valve (CFV). Depending on the coolant flow, CMV sends coolant through the low temperature EGR Cooler, or bypass indirectly to the LPCAC, after going through the LTR located in front of the main coolant radiator. When the charge air temperature is too low, CMV bypasses the LTR and directs all the coolant through the CAC. When the charge air temperature increases, CMV directs a percentage of the coolant to the LTR before it enters the CAC to cool the charge air. If the engine coolant temperature is too high, CMV sends all of the coolant flow through the LTR and through the LPCAC to help cool the engine faster.

Both CMV and CFV are controlled by the ECM based on signals from the Engine Coolant Temperature (ECT) sensor, ECT2 sensor, and the Intake Manifold Pressure (IMP) and Inlet Air Temperature (IAT) sensors.

Coolant flow to the radiator is controlled by two thermostats. When the thermostats are closed, coolant flowing out of the EGR cooler is directed through a bypass port inside the front cover into the water pump. When the thermostats are open the bypass port is blocked, and coolant is directed from the engine into the radiator.

Coolant passes through the radiator and is cooled by air flowing through the radiator from ram air and operation of the coolant fan. The coolant returns to the engine first through the transmission cooler, then through the engine coolant inlet elbow.

The air compressor is cooled with coolant supplied by a hose from the left side of the crankcase. Coolant passes through the air compressor cylinder head and returns through a coolant return line to the engine crankcase.

The oil module receives coolant from a passage in the crankcase. Coolant passes between the oil cooler plates and returns back to the water pump suction passage.

Thermostat Operation

MaxxForce® 11 and 13 engines are fitted with two thermostats in a common housing to ensure sufficient coolant flow in all operating conditions. The thermostat housing is installed on top of the water distribution housing.

The thermostat housing assembly has two outlets. One directs coolant to the radiator when the engine is at operating temperature. The second outlet directs coolant to the water pump until the engine reaches operating temperature. The thermostats begin to open at 83 °C (181 °F) and are fully open at 91 °C (196 °F).

When engine coolant is below 83 °C (181 °F), the thermostats are closed, blocking coolant flow to the radiator.

When coolant temperature reaches the opening temperature of 83 °C (181 °F), the thermostats open allowing some coolant to flow to the radiator. When coolant temperature exceeds 91 °C (196 °F), the lower seat blocks the bypass port directing full coolant flow to the radiator.

Coolant Control Valve (CCV) assembly operation

The CCV is installed on the upper right side of the water distribution housing and controls the coolant flow to the CACs.

The CCV has two separate solenoid actuated valves based on the charged air temperature and the two engine coolant temperature sensors: CMV, and CFV. The CMV and the CFV are part of the CCV assembly and cannot be serviced separately. The CMV and CFV solenoids are controlled by two separate PWM signals from the ECM. The PWM signal duty cycles vary between 0% and 100% depending on the coolant and charge air temperature.

Coolant Flow Valve (CFV)

The CFV is installed on the lower side of CCV and controls the amount of coolant flow through the LPCAC. The CFV will close to reduce the coolant flow through the LPCAC when the engine is operating at high speeds.

Coolant Mixer Valve (CMV)

The CMV is installed on the upper side of CCV and controls the coolant flow through the LTR. When the temperature of the charge air and coolant coming out of the LPCAC is low, the CMV directs the coolant through a LTR bypass directly into the LPCAC. This helps the engine reach its normal operating temperature faster. If the temperature of the charge air and coolant coming out of the LPCAC is high, the CMV directs the coolant flow through the LTR. This prevents overheating of the LPCAC, which can result in LPCAC failure.

Engine Brake System

Engine Brake Control System Components

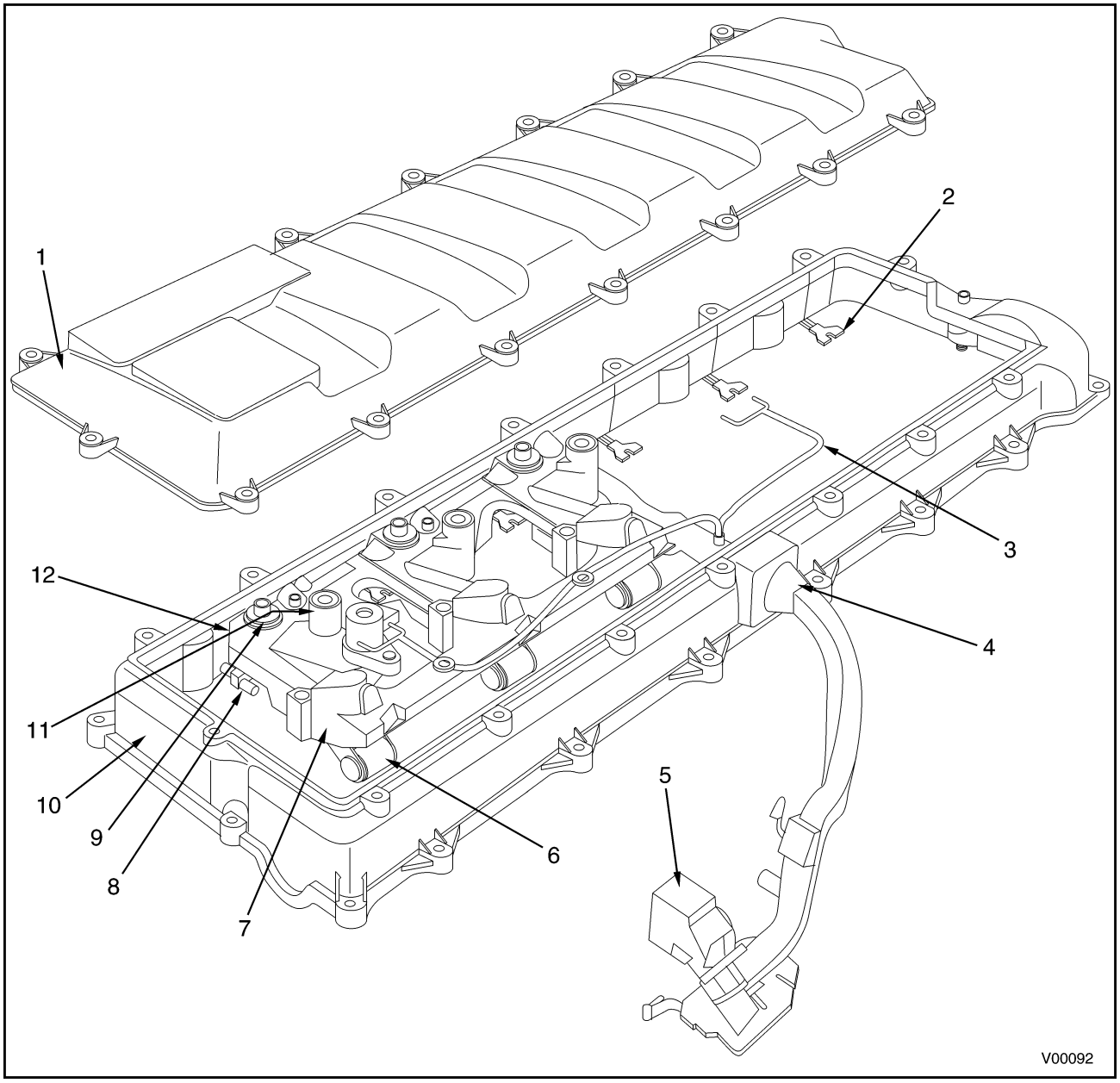


Figure 26 Engine brake control system components

1. Upper valve cover
2. Injector harness connector
3. Engine brake solenoid harness connector lead (2)
4. Pass through harness
5. ECM E1 connector
6. Master piston roller assembly (3 each housing)
7. Engine brake master piston (within housing)
8. Exhaust valve bridge
9. Engine brake slave piston
10. Valve cover base
11. Engine brake solenoid (1 each housing)
12. Engine brake housing assembly (2)

Engine Brake System Description

The MaxxForce® Engine Brake by Jacobs® braking system is standard equipment on the ProStar® and optional equipment on the TranStar® and WorkStar® for the MaxxForce® 11 and 13 engines. The braking system is a hydro-mechanical device that mounts under the engine's valve cover. It turns your power-producing diesel engine into a power-absorbing air compressor.

Here's how: when the driver releases the accelerator pedal, the forward momentum of the truck continues to turn the drivetrain and engine. The pistons continue to move up and down. Once activated, the engine brake opens the exhaust valves near the peak of the compression stroke, releasing the highly compressed air through the exhaust systems. Little energy is returned to the piston, and as the cycle repeats, the energy of the truck's forward motion is now directed toward motoring the diesel engine, thus reducing the forward motion causing the truck to slow down.

Engine Brake System Operation

The engine brake system consists of two hydraulic braking housings, activated using two ECM actuated brake solenoids, and an exhaust bridge (pin). The engine brake depends on engine oil for operation; minimum oil temperature for retarder activation is 40 °C (104 °F).

The operation of the engine brake is fully automatic once it is turned on by an ON/OFF switch by the operator. When the clutch is fully engaged and you remove your foot completely from the throttle, the engine brake is automatically activated.

NOTE: The operator can select various retarding levels by pressing a HIGH/MEDIUM/LOW switch depending on the retarding performance required.

Activation occurs through the following steps:

1. Engine oil pressure fills the housing passages up to the solenoid.
2. Activation of the engine brake is communicated by the ECM using the J1939 data link. When activated, the energized solenoid valve permits engine lube oil to flow under pressure through the control valve to both the master piston and slave piston circuits.
3. Oil pressure causes the master piston roller assembly to move down, picking up the motion of the cam (dedicated braking lobe) pushing the piston back into the housing creating high pressure oil.
4. The high pressure oil flows back through the master piston, slave piston, and control valve circuits.
5. The check ball in the control valve seats, trapping oil in the circuit creating a high pressure link between the slave piston and master piston.
6. Once the high pressure link is created, the master piston follows the cam profile causing the slave piston to move down, momentarily opening exhaust valve (single valve opening), while the engine piston is near its top dead center position, releasing compressed cylinder air to the exhaust manifold.
7. Compressed air escapes to atmosphere completing compression braking cycle.

NOTE:

1. **The MaxxForce® Engine Brake by Jacobs® will disengage during Anti-lock Brake System (ABS) braking.**
2. **Will interact with the vehicle cruise control for smooth operation during engine braking**
3. **Will interact with the Eaton UltraShift® Transmission for smooth up-shifts under fueling conditions**

Electronic Control System

Electronic Control System Components

MaxxForce® 11 and 13 engines are equipped with one control module; the Engine Control Module (ECM).

Operation and Function

The ECM monitors and controls engine operation to ensure maximum performance and adherence to emissions standards. The ECM, performs the following functions:

- Provide reference voltage (VREF)
- Condition input signals
- Process and store control strategies
- Control actuators

Reference Voltage (VREF)

The ECM supplies 5 volt VREF signals to various input sensors in the electronic control system. By comparing the 5 volt VREF signal sent to the sensors with their respective returned signals, the ECM determines pressures, positions, and other variables important to engine and vehicle functions.

Signal Conditioner

Signal conditioning circuitry in the ECM converts analog signals to digital signals, squares up sine wave signals, and amplifies low intensity signals.

Microprocessor

The microprocessor, located inside the ECM, processes stored operating instructions (control strategies) and value tables (calibration parameters). The microprocessor compares stored instructions and values with conditioned input values to determine the correct strategy for all engine operations.

Diagnostic strategies are also programmed into the ECM. Some strategies monitor inputs continuously and command the necessary outputs for correct performance of the engine.

Diagnostic Trouble Codes

Diagnostic Trouble Codes (DTCs) are stored by the ECM if inputs or conditions do not comply with expected values. Diagnostic codes for the 2010 MY are communicated using the Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI) identifiers, and are accessed using an electronic service tool with ServiceMaxx™ diagnostic software or a generic scan tool as well.

Microprocessor Memory

The ECM microprocessor includes Read Only Memory (ROM) and Random Access Memory (RAM).

ROM

ROM stores permanent information for calibration tables and operating strategies. Permanently stored information cannot be changed or lost when the ignition switch is turned to OFF or when power to the control modules is interrupted. ROM includes the following:

- Vehicle configuration, modes of operation, and options
- Engine Family Rating Code (EFRC)
- Engine warning and protection modes

RAM

RAM stores temporary information for current engine conditions. Temporary information in RAM is lost when the ignition switch is turned to OFF or power to control module is interrupted. RAM information includes the following:

- Engine temperature
- Engine rpm
- Accelerator pedal position

Actuator Control

The ECM controls the actuators by applying a low level signal (low side driver) or a high level signal (high side driver). When switched on, both drivers complete a ground or power circuit to an actuator.

Actuators are controlled in one of the following ways, depending upon type of actuator:

- Duty cycle (percent time on/off)
- PWM
- Switched on or off

Actuators

The ECM controls engine operation with the following:

- CCV
- EBPV
- EGRV
- ACV
- IAHR
- Inlet Air Heater Fuel Solenoid (IAHFS) valve
- ETV
- FPCV
- AFTFD
- AFTFSV
- IAHFI relay

Coolant Control Valve (CCV)

The CMV and CFV are a combined solenoid assembly that regulates coolant flow and temperature through the LPCAC and the low temp EGR cooler. The CMV and CFV are housed in the CCV assembly.

CFV controls the rate of coolant flow through the CAC, and the CMV regulates the temperature of the coolant, by directing the coolant either through the LTR or through an internal bypass. Both valves are controlled by the ECM.

The CCV is installed on the water distribution housing.

Exhaust Back Pressure Valve (EBPV) Control

The EBPV is controlled using the ACV assembly. The ACV assembly contains the EBPV control valve, and the TC1TOP sensor. Both are used by the ECM to control EBPV operation.

The EBPV regulates the amount of air pressure applied to the EBPV pneumatic actuator. The pneumatic cylinder actuates the valve (in the exhaust system) in response to commands by the ECM.

The EBPV actuator is mounted on a bracket, on the right side of the engine, after the turbocharger exhaust connection.

Exhaust Gas Recirculation (EGR) Valve

The EGRV is mounted on the rear of the EGR cooler, on top of the engine. The EGRV assembly receives the desired valve position from the ECM. The EGRV regulates the flow of exhaust gases through the EGR system.

Air Control Valve (ACV)

The ACV contains solenoids used for the control of the HP turbocharger wastegate, LP turbocharger wastegate, and EBPV. It also contains the TC1TOP sensor.

ACV solenoids are controlled through pulse width modulated signals sent by the ECM.

The ACV is located on the right side of the engine, mounted near the center of the EGR cooler.

Inlet Air Heater Relay (IAHR)

The inlet air heater system aids cold engine starting by warming the incoming air supply prior to, and during, cranking, and also up to four minutes for cold engine warm-up.

The ECM is programmed to energize the IAHFI heater element through the IAHR while monitoring certain programmed conditions for engine coolant temperature, inlet air temperature, engine oil temperature, and atmospheric pressure.

The IAHR delivers battery voltage to the heater element for a set time, depending on engine coolant temperature and altitude. The ground circuit is supplied directly from the battery ground at all times. The relay is controlled by switching on a voltage source from the ECM, and is installed to the rear of the ECM.

Inlet Air Heater Fuel Solenoid (IAHFS) Valve

The IAHFS valve controls fuel flow to the IAHFI during inlet air heater operation.

When inlet air heater is required, the ECM provides voltage to open the IAHFS valve during cranking.

The IAHFS valve is mounted on the intake throttle duct, on the top left side of the engine.

Engine Throttle Valve (ETV)

The ETV controls the flow of fresh air (boosted and cooled) into the engine's air intake path through the CAC to help heat the exhaust aftertreatment during regeneration, and to assist when heavy EGR is requested. The electronic portion of the ETV contains a microprocessor that monitors valve position, electronic chamber temperature, controls the electric motor, and reports diagnostic faults to the ECM. The ETV changes position in response to ECM signals.

The ETV is integrated into the intake throttle duct, on the top left side of the engine.

Fuel Pressure Control Valve (FPCV)

The FPCV is a variable position actuator that controls the flow of fuel to the suction side of the high pressure pump.

The FPCV changes valve position through pulse width modulated signals from the ECM.

The FPCV is mounted on the upper side of the high pressure pump. The FPCV and fuel pump are serviced as an assembly.

Aftertreatment Fuel Doser (AFTFD)

The AFTFD is used to provide HP fuel flow to the aftertreatment fuel injector. The AFTFD is controlled through an PWM signal sent by the ECM. The AFTFD is housed in the DSI unit, which is located to the rear of the fuel filter assembly.

Aftertreatment Fuel Shutoff Valve (AFTFSV)

The AFTFSV is used to prevent fuel flow to the aftertreatment fuel injector (AFI), and prevents all uncontrolled fuel delivery for the aftertreatment system during a AFTFD valve malfunction. The AFTFSV is controlled through an on-off signal sent by the ECM. The AFTFSV is housed in the DSI unit, which is located to the rear of the fuel filter assembly.

Engine and Vehicle Sensors

Thermistor Sensors

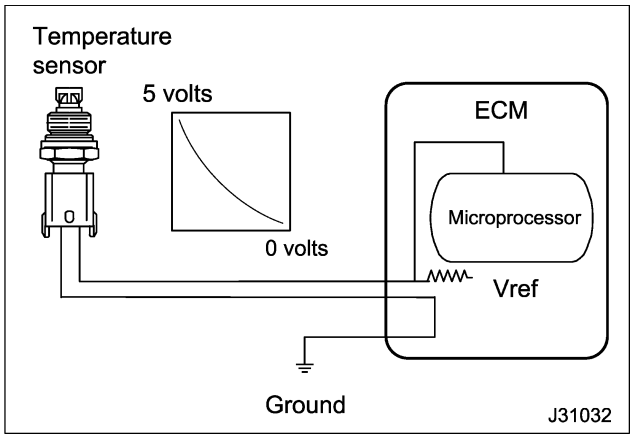


Figure 27 Thermistor

A thermistor sensor changes electrical resistance with changes in temperature. As temperature changes at the thermistor, voltage at the ECM will change accordingly. Thermistors work with the control module to produce a voltage signal directly proportional to temperature values.

A thermistor sensor has two electrical connectors, signal return and ground. The output of a thermistor sensor is a non-linear analog signal.

Thermistor type sensors include the following:

- Aftertreatment temperature sensors

- Engine Coolant Temp sensors
- EOT sensor
- TC2CIS
- CACOT sensor
- IMT sensor
- EGRT
- Ambient Air Temperature (AAT) sensor

Aftertreatment Temperature Sensors

Four sensors used in the Aftertreatment System include the following:

- Aftertreatment Fuel Inlet Sensor (AFTFIS)
- DOCIT
- DOCOT
- DPFOT

The AFTFIS provides a feedback signal to the ECM indicating temperature of the fuel supplied to the Downstream Injection (DSI) unit. The AFTFIS is a dual function sensor and also provides inlet fuel pressure values for the DSI unit. The AFTFIS sensor is installed in the DSI unit.

The DOCIT sensor provides a feedback signal to the ECM indicating DOC inlet temperature. The DOCIT sensor is the first temperature sensor installed past the turbocharger and just before the main DOC.

The DOCOT sensor provides a feedback signal to the ECM indicating DOC outlet temperature. The DOCOT sensor is the second temperature sensor installed past the turbocharger and just after the main DOC.

The DPFOT sensor provides a feedback signal to the ECM indicating DPF outlet temperature. The DPFOT sensor is the third temperature sensor installed past the turbocharger and just after the DPF.

During a catalyst regeneration, the ECM monitors all three temperature sensors.

Engine Coolant Temperature (ECT) Sensors

The ECT1 and ECT2 sensors are thermistor-type sensors that detect engine coolant temperature.

The ECT1 signal is monitored by the ECM for operation of the instrument panel temperature gauge, coolant temperature compensation, charge air temperature control, EGR system control, optional Engine Warning Protection System (EWPS), and the wait to start lamp. The ECM uses ECT1 sensor input as a backup, if EOT sensor values are out of range.

The ECT1 sensor is installed in the underside of the EGR coolant crossover manifold, at the back of the engine. The ECT2 sensor is installed in the low temperature stage of the EGR cooler, on the right side of the engine.

Engine Oil Temperature (EOT) Sensor

The EOT sensor is a thermistor sensor that detects engine oil temperature. The EOT sensor is installed in the side oil module flange, behind the oil filter cover, on the right side of the engine.

Turbocharger 2 Compressor Inlet Sensor (TC2CIS)

The TC2CIS sensor includes a thermistor sensor that monitors the temperature of charge air entering the HP turbocharger. This sensor also monitors boost pressure for the LP turbocharger.

The TC2CIS sensor is monitored by the ECM, and is used for calculating fuel delivery and controlling LP wastegate operation.

The TC2CIS is installed in the piping between the LP compressor outlet and the HP compressor inlet.

Charge Air Cooler Outlet Temp (CACOT) Sensor

The CACOT sensor is a thermistor sensor that monitors the temperature of charge air entering the intake air duct.

The CACOT signal is monitored by the ECM.

The CACOT sensor is installed on the intake air duct, before the ETV.

Intake Manifold Temperature (IMT) Sensor

The IMT sensor is a thermistor sensor that monitors temperature.

The IMT sensor is installed in the intake side of the cylinder head, on the left side of the engine.

Exhaust Gas Recirculation Temperature (EGRT) Sensor

The EGRT sensor is a thermistor sensor that detects the exhaust gas temperature entering the EGR cooler.

The EGRT signal is monitored by the ECM.

The EGRT sensor is installed in the front of the low temp EGR cooler on the left side.

Ambient Air Temperature (AAT) Sensor

The AAT sensor is a thermistor sensor that detects the temperature of ambient.

The AAT signal is monitored by the ECM.

The AAT sensor is installed in various places on the vehicle.

Variable Capacitance Sensors

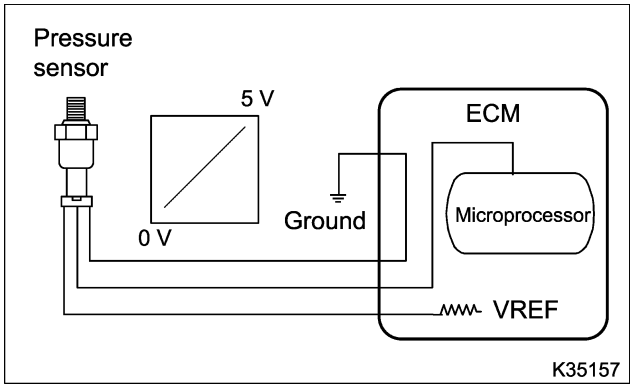


Figure 28 Variable capacitance sensor example

Variable capacitance sensors measure pressure. The pressure measured is applied to a ceramic material. The pressure forces the ceramic material closer to a thin metal disk. This action changes the capacitance of the sensor.

The sensor is connected to the control module through the VREF, signal, and signal ground wires.

The sensor receives the VREF and returns an analog signal voltage to the ECM. The ECM compares the voltage with pre-programmed values to determine pressure.

Variable capacitance sensors include the following:

- DPFDP sensor
- FDP sensor
- EOP sensor
- FRP sensor
- IMP sensor
- AFTFIS
- AFTFP2 sensor
- TC1TOP sensor

DPF Differential Pressure (DPFDP) Sensor

The DPFDP sensor provides a feedback signal to the ECM indicating the pressure difference between the inlet and outlet of the particulate filter.

The DPFDP sensor is a differential pressure sensor with two tap-offs installed at the DPF. A tap-off is located before and after the DPF.

Fuel Delivery Pressure (FDP) Sensor

The FDP sensor is a variable capacitance sensor that measures fuel supply pressure.

The FDP sensor provides feedback to the ECM for the LP fuel system.

The FDP sensor is installed in the front of the fuel filter assembly on the left side of the engine.

Engine Oil Pressure (EOP) Sensor

The EOP sensor is a variable capacitance sensor that detects engine oil pressure.

The EOP signal is monitored by the ECM for operation of the instrument panel pressure gauge and optional EWPS.

The EOP sensor is installed in the oil module, on the right side of the engine.

Fuel Rail Pressure (FRP) Sensor

The FRP sensor is a variable capacitance sensor that monitors fuel pressure in the HP fuel rail.

The FRP sensor measures fuel pressure just before injection.

The FRP sensor is mounted in the front of the fuel rail on the left side of the engine.

Intake Manifold Pressure (IMP) Sensor

The IMP sensor is a variable capacitance sensor that monitors the pressure of charge air entering the intake air duct.

The IMP signal is monitored by the ECM for control of the EGR system and turbocharger wastegates.

The IMP sensor is installed on the intake air duct, after the ETV.

Aftertreatment Fuel Inlet Sensor (AFTFIS)

The AFTFIS is a dual function sensor and includes a thermistor sensor that monitors inlet fuel Temperature for the DSI unit.

The AFTFIS includes a variable capacitance sensor that measures fuel pressure supplied by the DSI unit, and is used to monitor fuel delivery to the aftertreatment system.

The AFTFIS is located in the DSI unit, to the rear of the fuel filter assembly.

Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

The AFTFP2 sensor is a variable capacitance sensor that monitors fuel pressure after the Aftertreatment Shutoff Valve (AFTFSV).

The AFTFP2 sensor measures fuel pressure supplied by the AFTFSV to the AFTFD valve, and is used to monitor fuel delivery to the aftertreatment system.

The AFTFP2 sensor is located in the DSI unit, to the rear of the fuel filter assembly.

Turbocharger 1 Turbine Outlet Pressure (TC1TOP)

The TC1TOP sensor is a variable capacitance sensor that monitors exhaust back pressure.

The sensor measures back pressure in the exhaust system. A tap for the TC1TOP is located in the exhaust, between the LP turbocharger and EBPV.

The TC1TOP sensor is located in the Air Control Valve, on the right side of the engine.

Magnetic Pickup Sensors

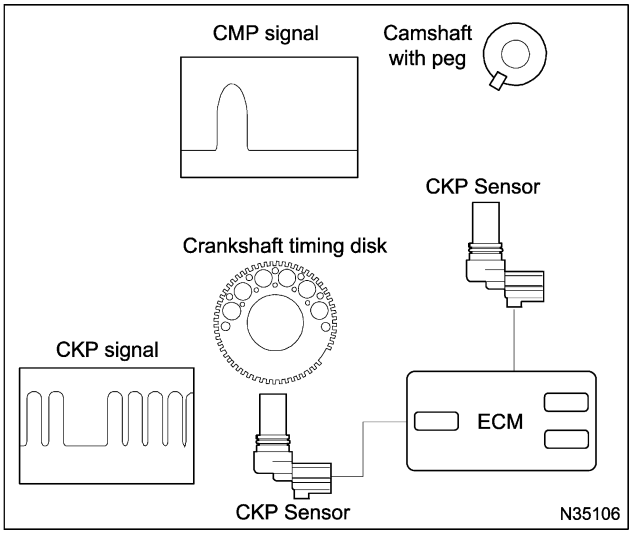


Figure 29 Magnetic pickup sensor example

A magnetic pickup sensor contains a permanent magnet core that is surrounded by a coil of wire. The sensor generates a voltage signal through the collapse of a magnetic field created by a moving metal trigger. The movement of the trigger then creates Alternate Current (AC) voltage in the sensor coil.

Magnetic pickup sensors used include the following:

- CKP sensor
- CMP sensor
- VSS
- CCOSS sensor

Crankshaft Position (CKP) Sensor

The CKP sensor is a magnetic pickup sensor that indicates crankshaft speed and position.

The CKP sensor sends a pulsed signal to the Engine Control Module (ECM) as the crankshaft turns. The CKP sensor reacts to holes drilled into the flywheel adjacent to the ring gear. For crankshaft position reference, teeth 59 and 60 are missing. By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing requirements.

The CKP sensor is installed in the top left of the flywheel housing.

Camshaft Position (CMP) Sensor

The CMP sensor is a magnetic pickup sensor that indicates camshaft speed and position.

The CMP sensor sends a pulsed signal to the ECM as a toothed wheel on the camshaft rotates past the CMP sensor. The ECM calculates camshaft speed and position from CMP signal frequency.

The CMP sensor is installed in the left rear of the cylinder head.

Vehicle Speed Sensor (VSS)

The VSS provides the ECM with transmission tail shaft speed by sensing the rotation of a 16-tooth gear on the rear of the transmission. The detected sine wave signal (AC) received by the ECM, is used with tire size and axle ratio to calculate vehicle speed. The VSS is located on the left side of the transmission housing for automatic transmissions, or at rear of the transmission housing for manual transmissions.

Crankcase Oil Separator Speed (CCOSS) sensor

The CCOSS sensor sends the ECM information about the speed of the crankcase oil separator internal components. The detected sine wave signal (AC) received by the ECM is used to monitor proper operation of the cyclonic oil separator, located inside the breather assembly on the engine oil filter assembly.

Potentiometer Sensors

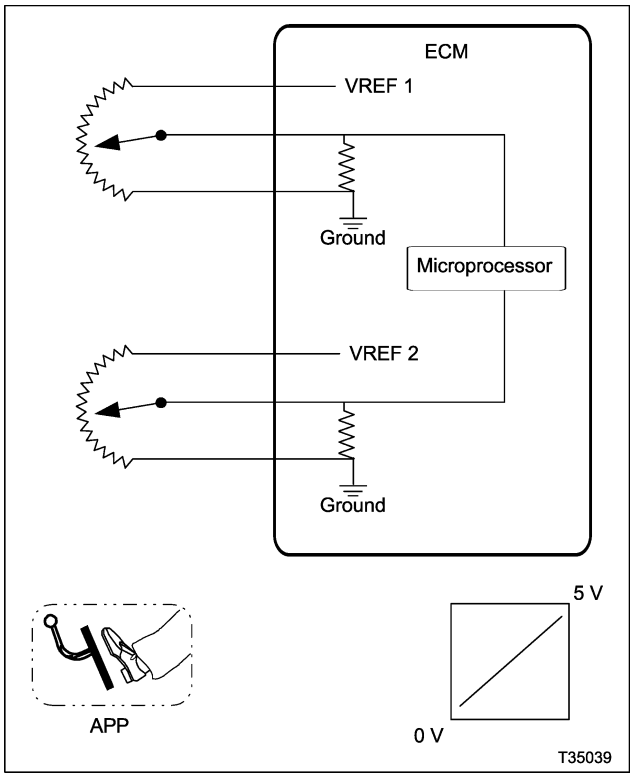


Figure 30 Potentiometer example

A potentiometer is a variable voltage divider that senses the position of a mechanical component. A reference voltage is applied to one end of the potentiometer. Mechanical rotary or linear motion moves the wiper along the resistance material, changing voltage at each point along the resistive material. Voltage is proportional to the amount of mechanical movement.

The engine has two potentiometers, both contained in the Accelerator Pedal Position (APP) Sensor.

Accelerator Pedal Position (APP)

The APP provides the ECM with a dual feedback signal (dual linear analog voltages) that indicate the operator's demand for power. The APP contains two potentiometers, and provides two individual signals (APP1 and APP2) to the ECM. The APP is installed in the cab on the accelerator pedal assembly.

Switches

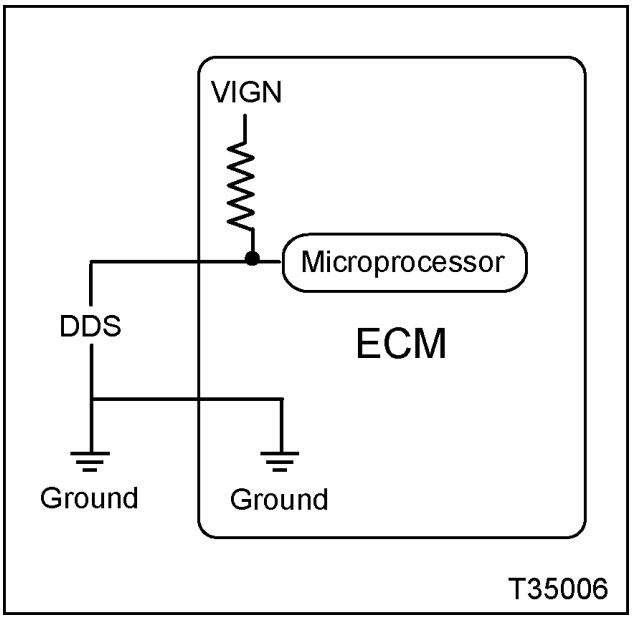


Figure 31 Switch example

Switch sensors indicate position, level, or status. They operate open or closed, regulating the flow of current. A switch sensor can be a voltage input switch or a grounding switch. A voltage input switch supplies the control module with a voltage when it is closed. A grounding switch grounds the circuit when closed, causing a zero voltage signal. Grounding switches are usually installed in series with a current limiting resistor.

Switches include the following:

- Driveline Disengagement Switch (DDS)
- Engine Coolant Level (ECL)
- Oil Level Sensor (OLS)

Driveline Disengagement Switch (DDS)

The DDS determines if a vehicle is in gear. For manual transmissions, the clutch switch serves as the DDS. For automatic transmissions, the neutral indicator switch functions as the DDS. The DDS signal is sent to the Body Controller (BC) and transmitted on the J1939 datalink to the engine ECM.

Engine Coolant Level (ECL) Switch

The ECL switch is part of the EWPS. The ECL switch is located on the deaeration tank. When the magnetic switch is open, the tank is considered full of coolant.

If engine coolant is low, the switch closes and the red ENGINE lamp on the instrument panel is illuminated.

Oil Level Sensor (OLS)

The OLS is part of the EWPS. The OLS is located on the engine oil pan. The OLS measures the volume of oil in the oil pan and broadcast the percentage volume over J1939 CAN.

If the level of engine lube oil is low, the red ENGINE lamp on the instrument panel is illuminated.

Additional Sensors

Oxygen Sensor (O_2S)

The O_2S monitors oxygen levels in the exhaust.

The O_2S is used to control the EGR flow to a specified air-to-fuel ratio by monitoring the level of unused oxygen in the exhaust stream.

The O_2S compares oxygen levels in the exhaust stream with oxygen levels in the outside air. The sensor generates an analog voltage and is monitored by the ECM. The level of voltage generated by the O_2S directly corresponds to the oxygen levels in the exhaust stream.

The O_2S is installed in the turbocharger exhaust pipe, directly after the EBPV.

Humidity Sensor (HS)

The HS measures the moisture content of filtered air entering the intake system.

Using the HS, the ECM will adjust in order to prevent condensation of airborne water particles (moisture). The HS also houses the IAT sensor, which is used by the ECM for calculating fuel delivery.

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Standard Electronic Control Features

NOTE: For the latest complete feature operation, and parameter information, use the MaxxForce® 11 and 13 Engine Feature Documentation found under the Body Builder Website Link within Navistar® Service Portal. This includes parameter details of description, possible values, whether or not it is customer programmable, and recommended settings.

Aftertreatment (AFT) System

The AFT system, part of the larger exhaust system, processes engine exhaust so that it meets tailpipe emission requirements. The AFT system traps particulate matter (soot) and prevents it from leaving the tailpipe. The trapped particulate matter is then rendered to ash by heating the exhaust and injecting fuel through a process called regeneration. Regeneration reduces the frequency of AFT system maintenance without adversely affecting emissions.

For additional information, see Aftertreatment (AFT) System in the “Engine Systems” section of this manual.

Cold Ambient Protection (CAP)

CAP protects the engine from damage caused by prolonged idle at no load condition during cold weather.

CAP maintains engine coolant temperature by increasing engine rpm. CAP also improves cab warm-up.

CAP is standard on trucks without an Idle Shutdown Timer (IST).

Inlet Air Heater

The inlet air heater feature improves engine start-up in cold weather. The Engine Control Module (ECM) controls the Inlet Air Heater Relay (IAHR) and monitors the Engine Oil Temperature (EOT), Inlet Air Temperature (IAT) and Engine Coolant Temperature 2 (ECT2) sensors. When the key is turned to the ON position, the ECM monitors the ECT2 and IAT sensors. If either sensor is below 11°C (52°F), the ECM enables the IAHR. The IAHR energizes the Inlet Air Heater Fuel Igniter (IAHFI). When the IAHFI reaches the proper operating temperature, the wait to start lamp flashes. As the engine is cranked, the ECM energizes the Inlet Air Heater Fuel Solenoid (IAHFS) valve, introducing fuel into the IAHFI, which ignites and warms the air being drawn into the engine. Do not accelerate the engine until the wait to start lamp goes out.

For additional information, see Inlet Air Heater System in the “Engine Systems” section of this manual.

Coolant Temperature Compensation (CTC)

NOTE: CTC is disabled in emergency vehicles and school buses that require 100 percent power on demand.

CTC reduces fuel delivery if the engine coolant temperature is above cooling system specifications.

Before standard engine warning or optional warning/protection systems engage, the ECM begins reducing fuel delivery when engine coolant temperature reaches approximately 107°C (225°F). A rapid fuel reduction of 15 percent is achieved when engine coolant temperature reaches approximately 110°C (230°F).

Data Plate

The ECM stores data to help identify the vehicle and engine components. The data plate feature is used to display text data descriptions in order to assist with reports and make data tracking easier.

The parameters associated with this feature only need to be modified when a related component is replaced, and can only be updated through your authorized dealer.

Electronic Speedometer and Tachometer

The engine control system calibrates vehicle speed up to 157,157 pulses per mile. The calculated vehicle speed is a function of transmission tail shaft speed, number of teeth on the tail shaft, rear axle ratio, and tire revolutions per mile. Use the Electronic Service Tool (EST) with ServiceMaxx™ software to program new speed calibrations into the ECM.

The tachometer signal is generated by the ECM by computing the signals from the Camshaft Position (CMP) sensor and the Crankshaft Position (CKP) sensor. The calculated engine speed is then sent to the instrument cluster through the J1939 CAN Data Link.

Engine Crank Inhibit (ECI)

The ECI will not allow the starting motor to engage when the engine is running and the drivetrain is engaged.

The ECI will not allow the starting motor to engage with the engine running if the key is turned to START while the clutch pedal is pressed.

Engine Electronic Governor Control

The governor controls engine rpm within a safe and stable operating range.

The low idle governor prevents engine rpm from dropping below a stable speed to prevent stalling when various loads are demanded on the engine.

The high idle governor prevents engine rpm from going above a safe speed that would cause engine damage.

Engine Fan Control (EFC)

The engine fan control feature is designed to allow configuration of the engine for various fan control features on a particular vehicle application.

The primary purpose of the engine fan is to allow the engine to run at its regulated operating temperature increasing engine performance. It is also used to assist in cooling the refrigerant in the A/C condenser. Factory set parameters within the ECM provide engine fan control based on the fan type installed in the vehicle. Choosing whether the fan is engaged during engine speed control, commonly referred to as PTO, operation is a customer programmable parameter. For additional information, see EFC (Engine Fan Control) in the “Electronic Control Systems Diagnostics” section of this manual.

Event Logging System

The event logging system records vehicle operation above the maximum speed setting (overspeed) and engine operation above maximum rpm (overspeed), coolant temperature out of operational range, low coolant level, or low oil pressure. The readings for the odometer and hourmeter are stored in the ECM memory at the time of an event and can be retrieved using the EST.

Fast Idle Advance

The ECM monitors the Engine Coolant Temperature (ECT) sensor. If the engine coolant temperature is below 10 °C (50 °F), the ECM activates the fast idle advance.

Fast idle advance increases engine idle speed to 700 rpm for a period of up to 100 seconds to assist in faster warm-up to operating temperature. This occurs by the ECM monitoring the engine coolant temperature and adjusting the fuel injector operation accordingly.

Low idle speed is resumed when engine coolant temperature reaches temperatures above 10 °C (50 °F), or the 100 second period times out.

J1939 Datalink

The vehicle is equipped with an SAE standard J1939 CAN datalink:

- The J1939 datalink is used for diagnostics and calibration communications for the Engine Control Module (ECM).
- The J1939 datalink is used for communications between the ECM, Electronic Gauge Cluster (EGC), and Body Controller (BC).

The J1939 datalink is accessed through the cab diagnostic connector pins C and D. The datalink provides communication between the ECM and the Electronic Service Tool (EST).

The J1939 datalink supports:

- Transmission of engine parameter data
- Transmission and clearing of Diagnostic Trouble Codes (DTCs)
- Diagnostics and troubleshooting
- Programming engine and vehicle features
- Programming calibrations and strategies
- Inter-module communications between the:
    - Engine Control Module (ECM)
    - Body Controller (BC)
    - Electronic Gauge Cluster (EGC)
    - Automatic Transmission Controller
    - Electronic Service Tool (EST)

For additional information, see J1939 Datalink in the “Electronic Control Systems Diagnostics” section in this manual.

Password Protection

The ECM allows the vehicle to be configured to help the owner optimize fuel economy and reliability. The password protection feature provides protection to prevent unauthorized users from changing parameter values in the ECM. With the password set, the service tool will prompt for the current password and will not allow any parameter to be changed until that password is entered. The password parameter is customer programmable.

Service Diagnostics

The EST provides diagnostic information using the J1939 datalink.

Faults from sensors, actuators, electronic components, and engine systems are detected by the ECM. The faults are accessed by the EST through the Diagnostic Connector, and are displayed as Diagnostic Trouble Codes (DTCs) on the EST. Effective engine diagnostics require and rely on DTCs.

Trip Reporting

The trip reporting feature is designed to monitor, collect, and store engine related operational information. This information can be downloaded and organized into useful reports using a service tool. Trip reporting operational data is recorded in two ways: non-resettable cumulative data, which consists of running totals, and resettable trip data, which consists of data collected since the last trip reset.

Vehicle Setup

The vehicle setup feature consists of various parameters within the ECM, which are based on the vehicle configuration. Most parameters are pre-programmed by the original equipment manufacturer (OEM) and will not require any adjustment for the life of the vehicle.

Optional Electronic Control Features

NOTE: For the latest complete feature operation, and parameter information, use the MaxxForce® 11 and 13 Engine Feature Documentation found under the Body Builder Website Link within Navistar® Service Portal. This includes parameter details of description, possible values, whether or not it is customer programmable, and recommended settings.

Cruise Control

Cruise Control is a well-known feature that offers driving comfort by providing a method for an operator to set and maintain a constant vehicle speed without using the accelerator pedal. It is especially useful when the operator is required to drive on highways at a constant speed for many miles.

This cruise control feature is unique due to a parameter, which allows the cruise control set speed to be maintained in the ECM memory. Additional programming flexibility is included to allow a trade-off to be made between performance and fuel economy.

Driver Reward

The driver reward feature is designed to give the operator incentives for driving more efficiently. The feature accomplishes this by measuring the driver's habits based on fuel economy, time at idle, or both.

The rewards include higher maximum vehicle speed and higher cruise control speed limit. Lower maximum vehicle speed or cruise control speed limits may result as a penalty for failing to meet the standards.

Customer programmable parameters within the ECM provide driver reward related options that can be adjusted to suit the customer's needs.

MaxxForce® Engine Brake

The engine brake feature is a hydro-mechanical device designed to help decelerate the vehicle by providing additional engine load. It mounts under the engine valve cover and turns your power-producing diesel engine into a power-absorbing air compressor. This will reduce brake wear in vehicles which require frequent braking. This feature assumes the vehicle is equipped with a factory installed engine brake system; otherwise there may be engine components, additional switches, harnesses, and software modifications which may also be required.

Programmable parameters within the ECM provide engine brake related options that can be adjusted to suit the customer's needs. Choosing whether the engine brake is activated by pressing the service brake pedal or by releasing the accelerator pedal is one example. For a detailed feature description, see Engine Brake System in the "Engine Systems" section of this manual.

Engine Warning Protection System (EWPS)

NOTE: Emergency vehicles are not equipped with EWPS.

The Engine Warning and Protection System (EWPS) feature is designed to protect the engine from damage by monitoring critical engine data such as the engine speed, temperature, oil pressure, and coolant level. The EWPS feature will alert the operator by using a combination of visual and audible warnings if critical engine parameters are exceeded. Depending on the severity of the problem, there may be a reduction in power associated with the visual warnings. EWPS also visually alerts the operator with an amber warning lamp if the vehicle speed exceeds a threshold. The vehicle overspeed incidents are logged and can be downloaded into a report. Refer to the "Trip Reporting" feature for more information.

Customer programmable parameters within the ECM provide EWPS related options that can be adjusted to suit the customer's needs. For example the customer may choose that the EWPS feature activate a flashing red lamp and audible warning 30 seconds before engine shut down, to provide an additional level of engine protection.

Gear Down Protection (GDP)

The Gear Down Protection (GDP) feature is designed to encourage the driver to operate in the engine's most efficient range for fuel economy. This is done by limiting the vehicle speed until the driver shifts into a higher gear. This encourages the driver to upshift to the next highest gear, and helps to maintain the engine's most efficient speed range for fuel economy.

There are several customer programmable parameters for this feature.

Idle Shutdown Timer (IST)

The idle shutdown timer is used to limit the amount of engine idle time by automatically shutting down the engine after a pre-programmed time has expired. Programmable parameters within the ECM determine the time and conditions required before the engine shuts down. Some customer programmable parameters provide idle shutdown related options that can be adjusted to suit the customer's needs.

Thirty seconds before engine shutdown occurs, there will be an amber lamp illuminated in the instrument panel (if equipped) and an audible warning will sound. This will continue until the engine shuts down or the idle shutdown timer is reset. This feature shuts down the engine, but the vehicle electrical system and accessories will remain active until the key switch is turned off.

Progressive Shift

The progressive shift feature is designed to limit the engine speed to encourage the driver to up-shift early, which in turn improves fuel economy. This feature provides engine speed limit parameters optimized for each transmission gear, to encourage the use of the higher gears during cruise control and low engine load operations.

Customer programmable parameters within the ECM provide progressive shift related options that can be adjusted to suit the customer’s needs.

Power Take Off (PTO) - In Cab

The engine speed control feature, commonly referred to as “PTO”, provides a method for an operator to set and maintain a constant engine speed without using the accelerator pedal. It is commonly used for powering auxiliary devices.

The in-cab engine speed control feature provides three conditions under which the operator may select PTO speeds:

- Stationary Preset - Permits the operator to select up to six preset speeds while the vehicle is stationary
- Stationary Variable Speed - Permits the operator to select any engine speed within the PTO boundaries
- Mobile Variable Speed - Permits the operator to select a desired variable speed for moving or stationary PTO operations

Customer programmable parameters within the ECM provide in-cab engine speed control related options that can be adjusted to suit the customer's needs. Choosing whether the operator is allowed to increase the engine speed using the accelerator pedal without disengaging the PTO is one example.

Power Take Off (PTO) - Remote

When control over engine speed is required from outside the vehicle’s cab, remote mounted switches must be used to turn on PTO engine speed control and select the desired engine speed. This functionality is referred to as Remote Engine Speed Control (RESC). The engine speed can be ramped up and down with RESC similar to the way the in cab PTO feature works; however, the RESC feature includes two additional switches (remote preset & remote variable), which allow the operator to choose the mode of engine speed control operation.

Customer programmable parameters within the ECM provide RESC related options that can be adjusted to suit the customer’s needs. Choosing whether a remote throttle pedal is used for PTO operation is one example.

Service Interval

The service interval feature is designed to provide a visual reminder to the operator of service interval information such as, oil change interval has expired, and that routine maintenance procedures should be performed. The term “interval” in this case is used to describe the distance, time, or fuel used between the last maintenance performed on the vehicle and the next maintenance, which is due.

Customer programmable parameters within the ECM provide options that can be adjusted to suit the customer’s needs. For example, the engine hours, fuel used, and vehicle distance can be used individually or in combination to determine the service interval.

It is essential that operators are trained to know the maintenance schedules and instructions regarding the operation and reset functionality of the service interval for the feature to be effective. Refer to Integral Digital Display in Section 3 – Instruments, Indicators, and Switches of the MaxxForce® 11 and 13 *Engine Operation and Maintenance Manual* for more information.

Traction Control

Traction control is a system that identifies when a wheel is spinning faster than the other wheels during acceleration.

When a traction control condition occurs, a datalink message is sent to the ECM to limit fuel for the purpose of reducing engine torque.

Vehicles must have a transmission and an Antilock Brake System (ABS) that supports traction control.

Up-Shift Indicator

The up-shift indicator feature provides an indication to the operator that the transmission should be shifted into a higher gear. This helps to maintain the engine’s most efficient speed range for fuel economy.

The feature is commonly used on manual transmissions and automated manuals in manual mode.

Road Speed Limiter

Road Speed Limiter (RSL) is a feature with customer programmable parameters designed to regulate the maximum vehicle speed as controlled by the accelerator pedal.

The following additional features are available with RSL:

- **Adjustable RSL:** Provides a customer programmable secondary vehicle speed limit, lower than the limit provided by RSL, useful for spreader applications and construction, etc.
- **RSL Override:** Raises the vehicle speed limit provided by the RSL feature to a customer programmable speed when the driver identifies a "passing situation."
- **RSL Anti-Tampering:** Customer selectable option, which checks whether the vehicle speed signal (VSS) input is valid or if it has been subject to tampering.

These options can be enabled by programmable parameters within the ECM.

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Session Files

A Session file is a window into the Engine Control Module (ECM). Sessions can display vehicle and engine information, such as module calibration, sensor signals, and actuator command signals. Special engine and vehicle features can also be programmed using these sessions.

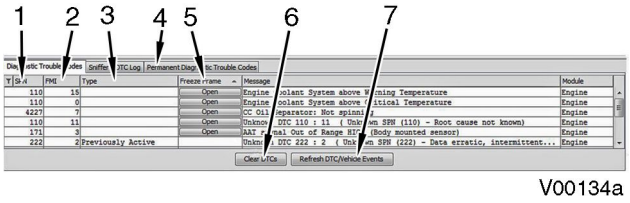
ServiceMaxx™ software has many default sessions, that load automatically when running any Service Bay Test or Service Tool Procedure. Users are not limited to any default session. Users are able to build their own session and save or load it at anytime. See the *ServiceMaxx™ Users Guide* for details.

ServiceMaxx™ software has a few added sessions that do not load automatically, but can be selected from the Sessions drop-down menu. These sessions are available to help diagnose common systems and program special features:

- Hard Start No Start
- Performance
- Programming

Diagnostic Trouble Code (DTC)

NOTE: 2010 model year vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the DTC Window.



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Figure 32 DTC window

1. Suspect Parameter Number (SPN)
2. Failure Mode Indicator (FMI)
3. Fault Code Type
4. Permanent Diagnostic Trouble Codes tab
5. Freeze Frame
6. Clear DTCs button
7. Refresh DTC/Vehicle Events button

Suspect Parameter Number (SPN)

The SPN identifies the individual component causing the DTC.

Failure Mode Indicator (FMI)

The FMI identifies the fault or condition effecting the individual component.

Pending

Pending DTCs are possible emission faults that were detected on the first drive cycle.

Active

Active DTCs are codes that are active now.

Previously Active

Previously Active DTCs are historical faults that may be caused by intermittent signals, or an operating condition, which is not currently present.

Freeze Frame Data

Freeze Frame Data is a snapshot of all influencing signals at the time the code was set. This can help diagnose hard to duplicate failures. Freeze Frame Data is cleared as soon as the DTC is cleared.

ECM Programmable Features

Many features can be programmed into the Engine Control Module (ECM) to fit many different applications. To make programming changes using ServiceMaxx™ software, load the Programming session. See the Body Builder website for further details.

Connecting EST with ServiceMaxx™ Software to Engine

To connect the Electronic Service Tool (EST) with ServiceMaxx™ software to the engine, the NAVCoM or NAVLink Interface Cable must be connected between the EST and the Diagnostic Connector. The Diagnostic Connector is located inside the vehicle cab, above the clutch pedal.

Service Bay Tests

Engine Off Tests

Engine Off Tests can be selected in the Tests drop-down menu under Engine Off Tests.

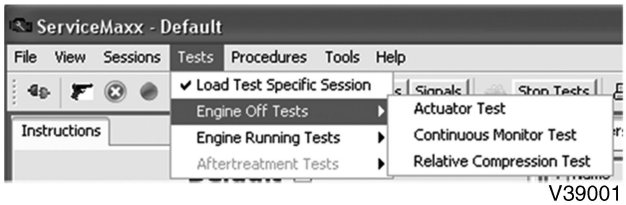


Figure 33 ServiceMaxx™ Test Menu – Engine Off Tests

Actuator Test

The Actuator Test enables the technician to cycle any selected actuator high and low and, if available, command any given duty cycle percent. A technician can use a Digital Multimeter (DMM) to measure changes in voltage or duty cycle, or visually monitor actuator movement while actuator is commanded.

Continuous Monitor Test

The Continuous Monitor Test helps detect intermittent circuit faults. During this test, signals are continuously monitored and faults are immediately logged. This test provides a graphical view of all signals and allows the technician to easily detect intermittent spiking or momentary loss of signal. Perform this test while manipulating connectors, wiring, and harnesses of the suspected faulty component.

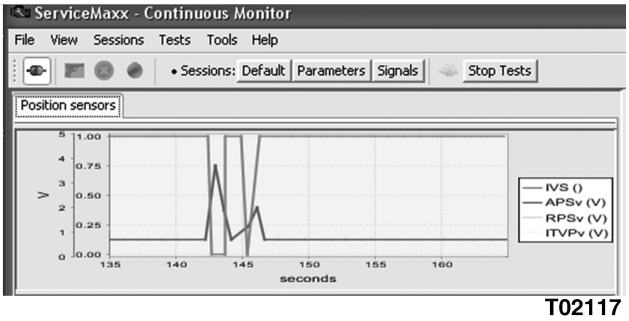


Figure 34 Continuous Monitor Test – Faulty Signal

NOTE: Run the Continuous Monitor Test while monitoring sensor voltages. Wiggle the wiring harness and connections while looking for signal spikes.

DPF Servicing

The DPF Servicing procedure is used to update the installation date and serial number (if replaced) of the Diesel Particulate Filter (DPF). This procedure should be run any time the DPF has been replaced or removed for cleaning. Follow on-screen instructions.

Relative Compression Test

The Relative Compression Test measures cylinder balance based on the compression stroke of each cylinder.

This test helps determine cylinder integrity. The ECM measures the time it takes for each piston to travel upward during the compression stroke. Timing is based on information from the Camshaft Position (CMP) sensor and Crankshaft Position (CKP) sensor. A cylinder with low compression allows the piston to travel faster during the compression stroke.

Test results are displayed by either numerical text or graphical display. Assuming there are no mechanical problems with the engine, the numbers or graphs displayed should be approximately the same value or height. A smaller number or lower level graph would indicate a problem with that particular cylinder.

NOTE: The Relative Compression Test must be run before running the Cylinder Cutout Test.

Engine Running Tests

Engine Running Tests can be selected in the Tests drop-down menu under Engine Running Tests.

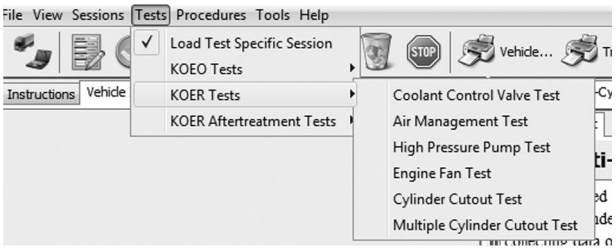


Figure 35 ServiceMaxx™ Tests Menu – Engine Running Tests

Air Management Test

The Air Management Test validates operation and performance of the Exhaust Gas Recirculation (EGR) valve, Turbocharger 2 Wastegate Control (TC2WC) valve, and Exhaust Backpressure Valve (EBPV), based on Intake Manifold Pressure (IMP). This test is unable to validate the performance of the turbocharger, due to the amount of engine load required.

High Pressure Pump Test

The High Pressure Pump Test validates performance of the Fuel Rail Pressure System. The test accelerates the engine in three steps while commanding a higher rail pressure on each step. When the test is complete, the ECM sends the test results to the Electronic Service Tool (EST).

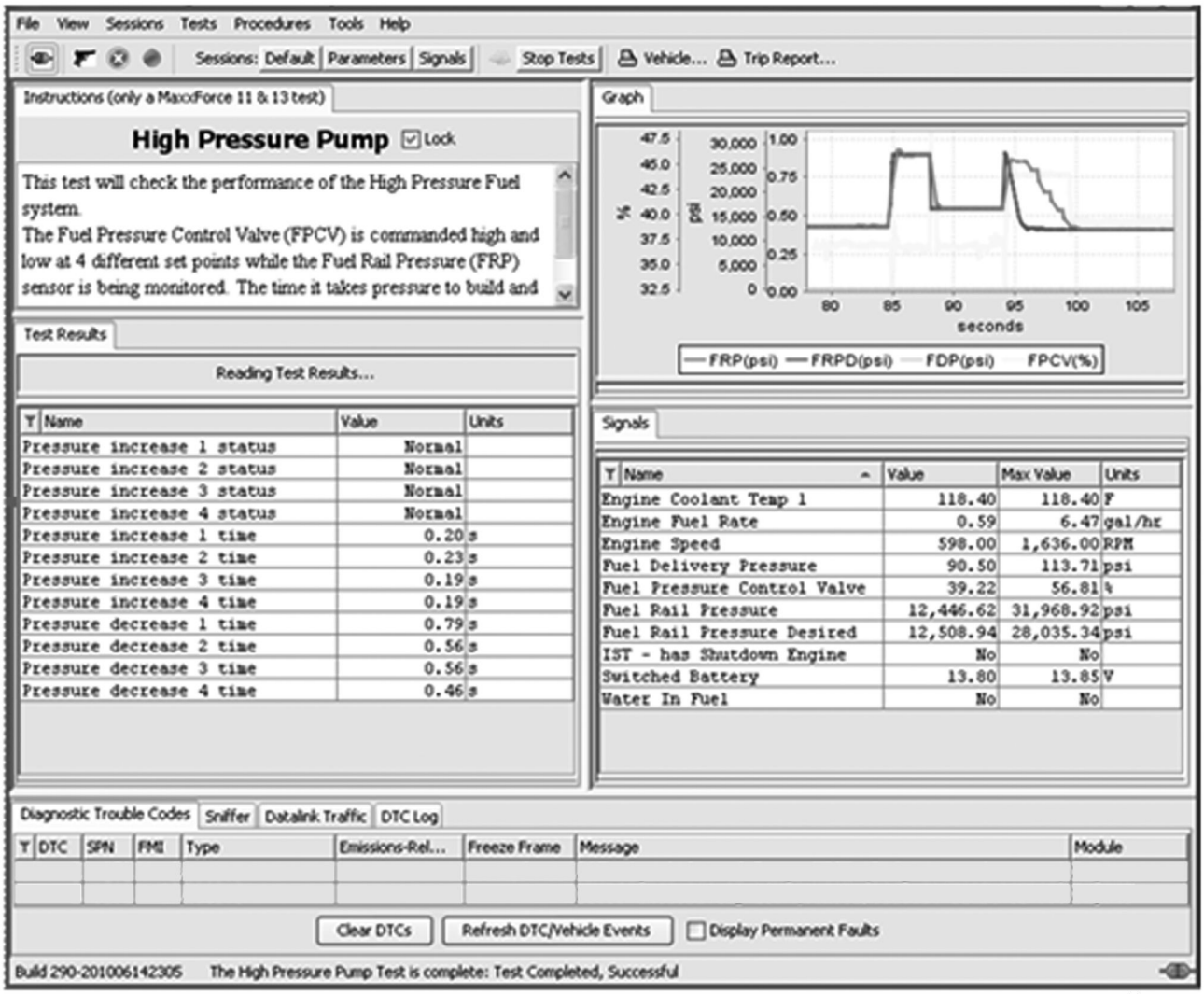


Figure 36 High Pressure Pump Test

Cylinder Cutout Test

The Cylinder Cutout Test isolates a low contributing cylinder due to an injector circuit fault.

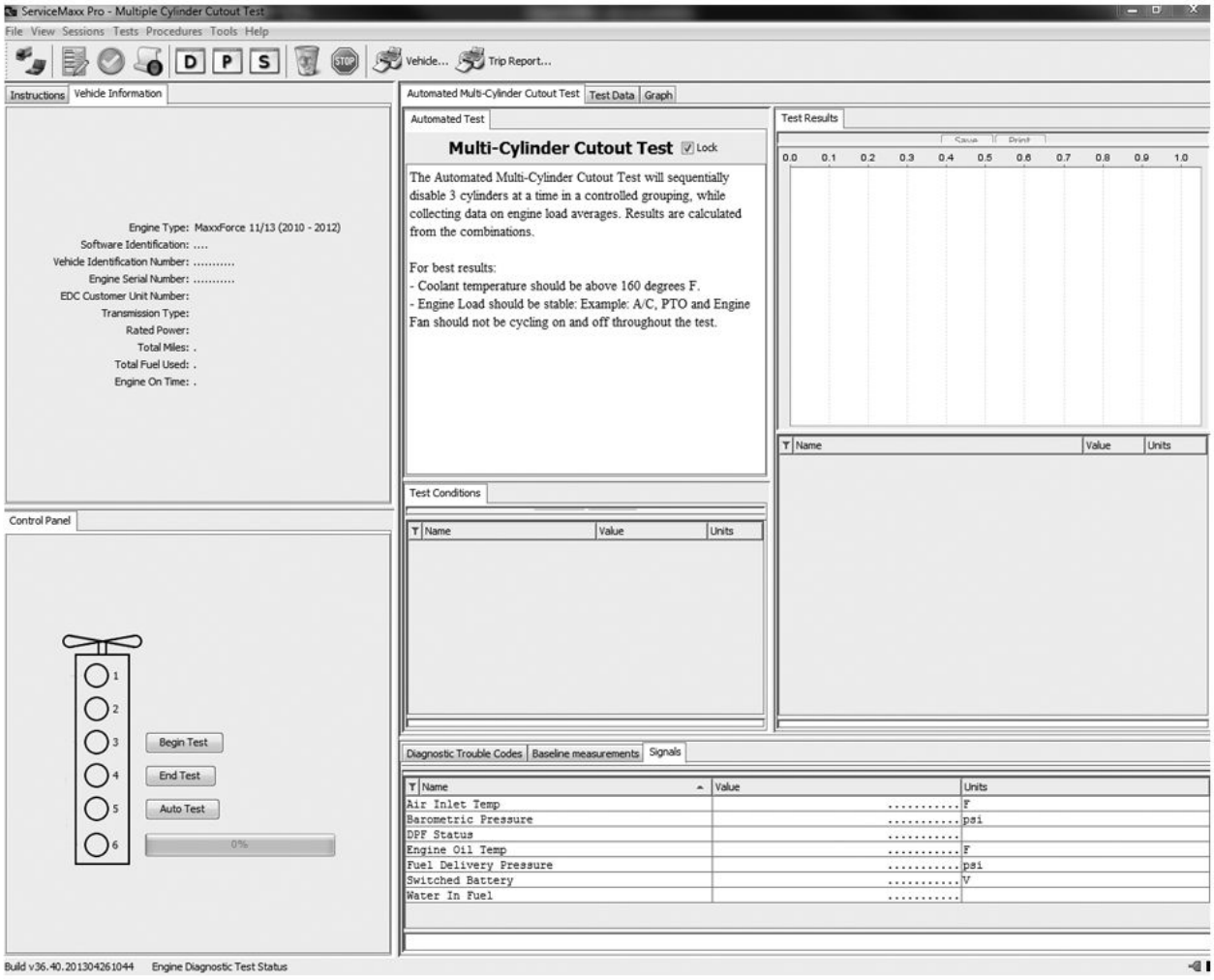
Before starting the Cylinder Cutout Test, follow the steps below:

1. Run Relative Compression Test.
2. Verify fuel system pressure is not below specification and fuel is not aerated.

Multi-Cylinder Cutout Test

The Multi-Cylinder Cutout Test is used to highlight an over- or under-performing cylinder. This test monitors engine load while disabling 3 cylinders at a time in a pre-determined sequence. The results of each combination are collected and used in calculating the end result.

NOTE: Before starting the Multi-Cylinder Cutout Test, coolant temperature should be above 160˚F (71˚C) and engine load should be stable (Example: A/C, PTO, and Engine Fan should not be cycling on and off throughout the test).



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Figure 37 Multi-Cylinder Cutout Test

Hot Run Sensor Comparison Test

Purpose

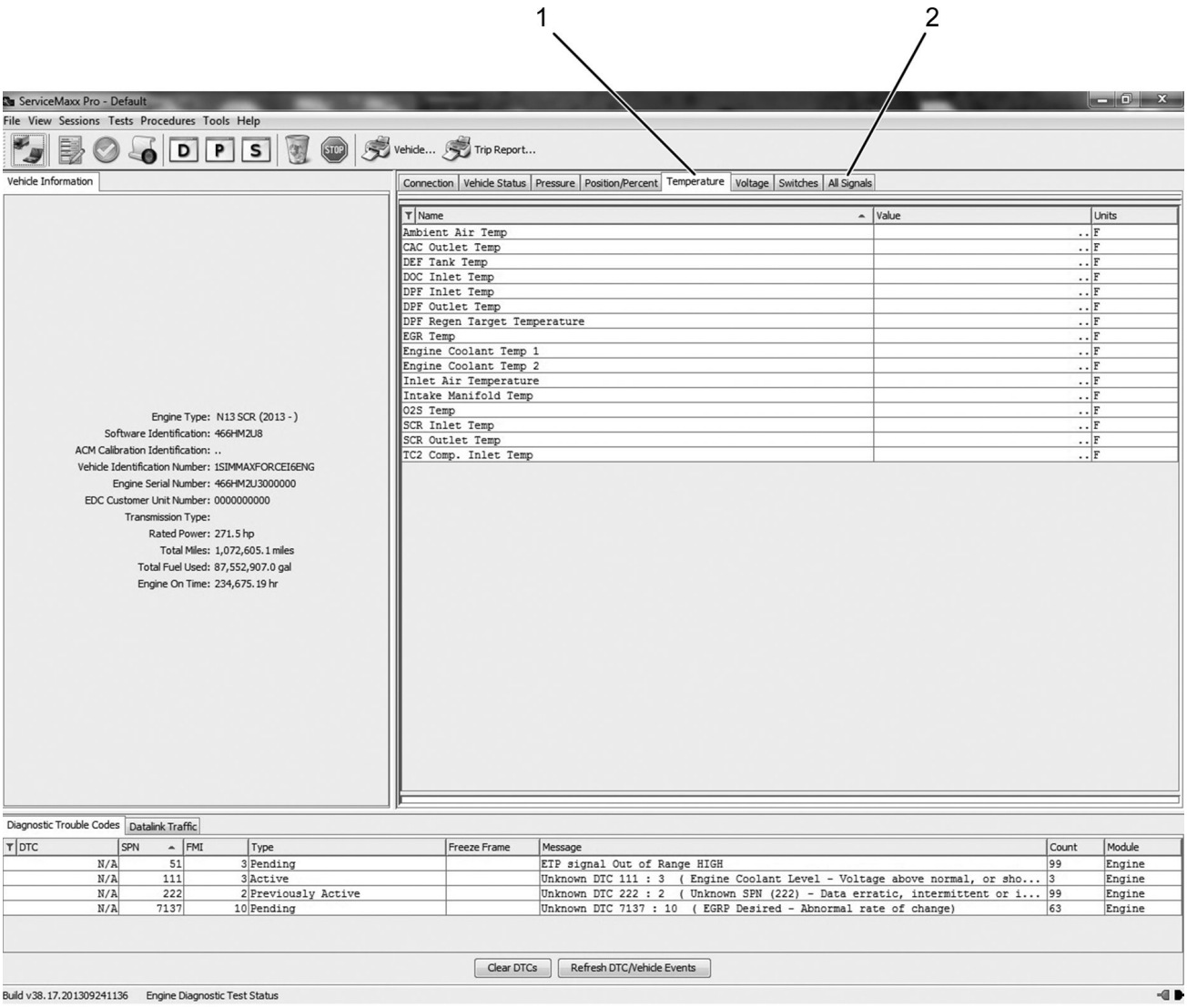
Check for failed aftertreatment system temperature sensor.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

NOTE: This test is not dependent on engine temperature.

1. Turn ignition switch to ON position.
2. Connect Electronic Service Tool (EST) with ServiceMaxx™ software to vehicle's diagnostic connector.



0000060730

Figure 38 Default Session

1. Temperature tab
2. All Signals tab

3. Go to Default Session: Sessions > Default > Temperature tab.

⚠ WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

4. Start and run engine at 1400 - 1500 rpm for 10 minutes.

5. Monitor the following signals in the All Signals tab:

   Compare the following three signals:

   - DOC Inlet Temp
   - DOC Outlet Temp
   - DPF Outlet Temp

   After 10 minutes, if any of these three aftertreatment temperature sensors are not within 77°F (25°C) of each other, diagnose appropriate sensor and / or circuit (see Electronic Control Systems Diagnostics).

Onboard Filter Cleanliness Test

The Onboard Filter Cleanliness Test increases engine speed to measure pressure differential across the Diesel Particulate Filter (DPF). This includes running a complete Parked Regen.

Service Tool Procedures

These procedures are not Service Bay Tests, but special ECM controls that allow the technician to perform specific procedures. MaxxForce® 11 and 13 engines have four special procedures: Inlet Air Heater, Oxygen Sensor Calibration, Engine Fan, and Injector Quantity Adjustment (IQA).

Engine Off Procedures can be selected in the Procedures drop-down menu.

Engine Off Procedures

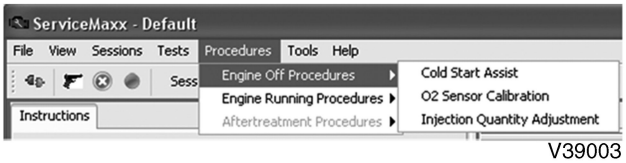


Figure 39 Engine Off Procedures

Inlet Air Heater

The Inlet Air Heater procedure gives the technician the ability to command the Inlet Air Heater to run at any temperature. Follow the on screen instructions when running ServiceMaxx™ software procedures.

Oxygen Sensor Calibration

The Oxygen Sensor Calibration procedure calibrates the Oxygen Sensor (O_2S). Anytime the O_2S is replaced, this procedure needs to be performed.

Injector Quantity Adjustment

Injector Quantity Adjustment (IQA) is a function that injects the correct amount of fuel for each individual injector, throughout the operating range of the engine. Injector mechanical tolerances, high flow to low flow, can be evenly balanced with ECM calibration. Each injector has an encrypted label and must be programmed into the ECM, whenever an injector has been replaced. IQA can be programmed using the Injector Quantity Adjustment procedure.

Engine Running Procedures

Engine Running Procedures can be selected in the Procedures drop-down menu.

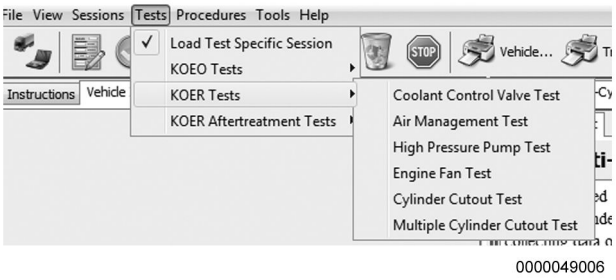


Figure 40 Engine Running Procedures

Engine Fan

The Engine Fan procedure commands the engine fan to different states and operating speeds to help diagnose fan failures. The viscous engine fan takes minutes to respond to changes in the commanded speed.

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Coolant System

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g., filters rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

Coolant Loss

Symptom

Consistent need to refill deaeration tank and active or previously active DTCs related to the cooling system.

Possible Causes

- External leaks
- Improper servicing
- Loose or failed coolant hoses
- Damaged or failed deaeration cap
- Damaged or failed deaeration tank
- Damaged or failed radiator
- Damaged or failed heater core
- Failed breather tube heater
- Failed Aftertreatment Fuel Injector (AFI)
- Failed Coolant Control Valve (CCV)
- Failed Coolant Flow Valve (CFV)
- Failed Low Temperature Radiator (LTR)
- Failed air compressor
- Failed Low Pressure Charge Air Cooler (LPCAC)
- Failed Exhaust Gas Recirculation (EGR) cooler
- Damaged or failed distributor housing
- Failed oil cooler
- Cracked cylinder head
- Porous or cracked cylinder liner

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- Surge Tank Cap Adaptor

Procedure

1. Check the service records to determine the frequency and quantity of coolant added.
   - If the vehicle's cooling system is being overfilled, there will be a small coolant loss everyday. Educate the driver on correct coolant level.
   - If the cooling system maintenance is correct, continue to next step.

NOTE: Before running engine, ensure engine oil and coolant are within normal operating ranges and there is no visible evidence of coolant on the oil level gauge (dipstick).

2. Start engine. With engine at operating temperature and operating at high idle speed, inspect for coolant overflow.
   - If coolant overflow is detected, go to Coolant Overflow (page 80).
   - If coolant overflow is not detected, continue to next step.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow engine to cool for 15 minutes or more.
- Wrap a thick cloth around radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn the cap counterclockwise to remove.

3. Remove deaeration tank cap. Check sealing surfaces of deaeration cap and deaeration tank for damage.
   - If sealing surfaces are damaged, install new components as necessary. Retest cooling system.
   - If sealing surfaces are not damaged, continue to next step.
4. Connect Radiator Pressure Testing Kit ZTSE2384 with Surge Tank Cap Adaptor to deaeration cap. Pressurize deaeration cap to its rated pressure.
   - If deaeration cap does not hold rated pressure, install a new deaeration cap. Retest cooling system.
   - If deaeration cap holds rated pressure, continue to next step.
5. Connect Radiator Pressure Testing Kit ZTSE2384 with Surge Tank Cap Adaptor to deaeration tank. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.
6. Visually inspect all components and hoses for external coolant leaks.
   - If an external coolant leak is identified, repair as necessary. Retest cooling system.
   - If no external leak is detected, continue to next step.
7. Obtain a fuel sample from the fuel tank and test for coolant contamination.
   - If fuel sample is contaminated with coolant, go to Coolant Leak to Fuel (page 84).
   - If fuel sample is not contaminated with coolant, continue to next step.
8. Inspect the intake manifold, Low Pressure Charge Air Cooler (LPCAC) outlet, and EGR Cooler for evidence of coolant.
   - If there is evidence of coolant in the intake manifold, LPCAC outlet, or EGR Cooler, go to Coolant Leak to Intake (page 84).

     NOTE: The EGR Cooler can be inspected by removing the cold side tubes at the intake.
   - If there is no evidence of coolant in the intake manifold or coolant is detected in the LPCAC outlet, continue to next step.
9. Obtain an oil sample from the engine and test for coolant contamination.
   - If oil sample is contaminated with coolant, go to Coolant Leak to Lube Oil (page 85).
   - If oil sample is not contaminated with coolant, go to Coolant Leak to Exhaust (page 82).

Coolant Overflow

Symptom

Coolant flowing or bubbling from the deaeration tank.

Possible Causes

- Failed air compressor
- Failed LPCAC
- Failed EGR cooler
- Cracked cylinder liner
- Cracked cylinder head
- Failed oil cooler

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- EGR Cooler Leak Detection Test Kit 12-892-02
- Surge Tank Cap Adaptor
- One inch pipe plug
- Suitable hose with one inch inside diameter
- Regulated air pressure
- Shut off valve

Procedure

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow engine to cool for 15 minutes or more.
- Wrap a thick cloth around radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn the cap counterclockwise to remove.

1. Partially drain cooling system.

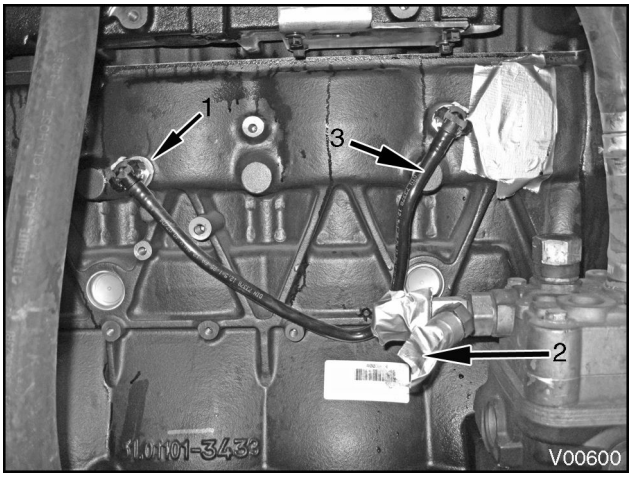


Figure 41 Air compressor coolant test

1. Rear coolant port
2. Air compressor connector
3. Front coolant line

2. Remove coolant line from rear coolant port (1).
3. Remove coolant line from air compressor connector (2).
4. Tape off both air compressor connectors.
5. Install front coolant line (3) into rear coolant port (1).
6. Refill cooling system to proper operating level.

CAUTION: To prevent engine damage, do not run the engine for more than one minute. This can overheat the air compressor.

7. Start and run engine for a maximum of one minute.
   - If coolant continues overflowing from deaeration tank, continue to next step.
   - If coolant stops overflowing from deaeration tank, install a new air compressor following procedures in the *Engine Service Manual*.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow engine to cool for 15 minutes or more.
- Wrap a thick cloth around radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn the cap counterclockwise to remove.

8. Remove deaeration tank cap.
9. Connect Radiator Pressure Testing Kit ZTSE2384 with Surge Tank Cap Adaptor to deaeration tank.
10. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.
11. Inspect intake manifold and LPCAC outlet for evidence of coolant.
    - If there is no evidence of coolant in intake manifold or coolant is detected in LPCAC outlet, go to Coolant Leak to Intake (page 84).
    - If there is no evidence of coolant in the intake manifold or coolant is detected in the LPCAC outlet, continue to next step.
12. Drain engine coolant.
13. Disconnect both coolant hoses from LPCAC.
14. Using a suitable hose with a one inch inside diameter and a plug, block off LPCAC coolant outlet port.

WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

15. Attach an air pressure regulator to a pressurized air source and regulate pressure to 207 kPa (30 psi).
16. Using a suitable hose with a one inch inside diameter and a shut off valve, connect air pressure regulator with pressurized air source to LPCAC coolant inlet port.
17. Pressurize LPCAC to 207 kPa (30 psi) and close shut off valve.
18. Remove air pressure source.
19. Monitor air pressure in LPCAC for a period of 5 minutes.
    - If air pressure in the LPCAC drops, install a new LPCAC following procedures in the *Engine Service Manual*.
    - If air pressure in the LPCAC remains constant, continue to next step.

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

20. Pressure test EGR cooler, in vehicle, following procedures in the *Engine Service Manual*.
    - If a leak is detected, install a new EGR cooler following procedures in the *Engine Service Manual*.
    - If a leak is not detected, go to Coolant Leak to Lube Oil (page 85).
    - If EGR cooler is leaking coolant internally, replace Oxygen Sensor (O_2S) following procedures in the *Engine Service Manual*. Perform O_2S Calibration Procedure (page 75) anytime O_2S is replaced.

Coolant Leak to Exhaust

Symptoms

Coolant leaks to the exhaust may be detected externally or internally. See the following list of symptoms for identification of coolant leaks to the exhaust.

- Coolant residue at exhaust manifold flanges
- Observation of coolant loss without engine overheating
- Coolant smell in exhaust
- Coolant leaking from exhaust
- Severe case - engine hydraulic lock
- Failed Aftertreatment Fuel Injector (AFI)
- Restricted Diesel Particulate Filter (DPF) or Diesel Oxidation Catalyst (DOC).

Possible Causes

- Failed EGR cooler
- Failed AFI
- Cracked cylinder head
- Cracked cylinder liner

NOTE: If a coolant leak to exhaust is determined from one of the listed possible causes, the Oxygen Sensor (O_2S) must be replaced. See the *Engine Service Manual* for O_2S replacement procedures. Perform O_2S Calibration Procedure (page 75) anytime O_2S is replaced.

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- Surge Tank Cap Adaptor
- EGR Cooler Leak Detection Test Kit 12-892-02

Aftertreatment Fuel Injector (AFI) Coolant Leak Inspection

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow engine to cool for 15 minutes or more.
- Wrap a thick cloth around radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

1. Remove deaeration tank cap.
2. Connect Radiator Pressure Testing Kit ZTSE2384 with Surge Tank Cap Adaptor to deaeration tank.

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

3. Disconnect exhaust pipe at Pre-DOC assembly.
4. Pressurize cooling system to 117 kPa (17 psi) for 15 minutes.

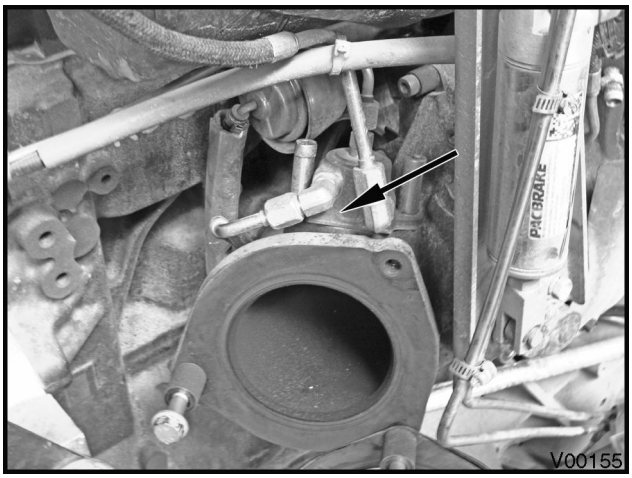


Figure 42 AFI nozzle

5. Inspect inside of exhaust pipe at AFI nozzle.
   - If coolant is evident at AFI nozzle inside exhaust pipe, install a new AFI following Hydrocarbon Injector installation procedure in the *Engine Service Manual* and retest.
   - If no coolant is evident at AFI nozzle inside the exhaust pipe, continue to next test.

EGR Cooler Leak Inspection

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

1. Visually inspect EGR cooler for cracks or leaks.
   - If an external leak or crack is identified, install a new EGR cooler following procedures in the *Engine Service Manual* and retest.
   - If no external leaks or cracks are identified, continue to next step.

2. Pressure test EGR cooler, in vehicle, following procedures in the *Engine Service Manual*.
   - If a leak is detected, install a new EGR cooler following procedures in the *Engine Service Manual*.
   - If a leak is not detected, go to Cylinder Head Leak Test (page 87).

Coolant Leak to Fuel

Symptom

Noticeable coolant separation in fuel sample.

Possible Causes

- Coolant heater auxiliary fuel filter (if equipped)
- Failed AFI
- Cracked cylinder head

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- Surge Tank Cap Adaptor

Procedure

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow engine to cool for 15 minutes or more.
- Wrap a thick cloth around radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

1. Remove deaeration tank cap.
2. Connect Radiator Pressure Testing Kit ZTSE2384 with Surge Tank Cap Adaptor to deaeration tank.
3. Pressurize cooling system to 117 kPa (17 psi).
4. Disconnect fuel line from AFI. Inspect AFI for coolant leaking from fuel inlet.
   - If coolant is leaking, install a new AFI following Hydrocarbon Injector installation procedure in the *Engine Service Manual*.
   - If coolant is not leaking, continue to next step.
5. Restore fuel system to proper operating condition.
6. Remove fuel return port at rear of cylinder head.
7. Pressurize cooling system to 117 kPa (17 psi) for a minimum of 30 minutes.
8. Monitor fuel return port in cylinder head for coolant.

   NOTE: It may take 12-24 hours for a coolant leak to become visible.
   - If coolant is present in the fuel return port, install a new cylinder head following procedures in the *Engine Service Manual*.
   - If no coolant is present in the fuel return port, fuel in the fuel tank may have been contaminated. Drain contaminated fuel from supply tanks and replace fuel filters following procedures in the *Engine Operation and Maintenance Manual*.

Coolant Leak to Intake

Symptom

Coolant overflowing from deaeration tank or air bubbles in coolant.

Possible Causes

- Failed LPCAC
- Failed EGR cooler
- Cracked cylinder head

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- Surge Tank Cap Adaptor
- EGR Cooler Leak Detection Test Kit 12-892-02

Procedure

1. Determine location of coolant leakage.
   - If coolant is leaking from LPCAC outlet, continue to next step.
   - If the coolant leakage is from intake manifold, skip to step 5.
2. Drain cooling system.
3. The LPCAC can be left on the vehicle to be tested or removed as described in the *Engine Service Manual*.
4. Test LPCAC following procedures in the *Engine Service Manual*.
   - If LPCAC is leaking, install a new LPCAC following procedures in the *Engine Service Manual*.
   - If LPCAC is not leaking, continue to next step.
5. Visually inspect EGR cooler for cracks or leaks.
   - If an external leak or crack is identified, install a new EGR cooler following procedures in the *Engine Service Manual*.
   - If no external leaks or cracks are identified, continue to next step.
6. Remove front tubes from EGR cooler and pressure test EGR cooler, in vehicle, following procedures in the *Engine Service Manual*.
   - If a leak is detected, install a new EGR cooler following procedures in the *Engine Service Manual*.
   - If no leak is found, continue to next step.
7. Test cylinder head for coolant leaks in the intake area. Go to Cylinder Head Leak Test (page 87).
   - If a coolant leak is identified in cylinder head, install a new cylinder head following procedures in the *Engine Service Manual*.
   - If a coolant leak is not identified in cylinder head, restore engine to operational condition and retest cooling system.

Coolant Leak to Lube Oil

Symptom

Engine oil with a light gray and sludgy appearance. The crankcase may also be overfilled.

Possible Causes

- Failed oil cooler
- Failed air compressor
- Cracked cylinder head
- Cracked or cavitation in front cover
- Cracked cylinder liner
- Cracked crankcase
- Cracked oil cooler housing
- Missing/damaged oil module gasket
- Missing/damaged oil cooler gaskets
- Missing mounting bolts for the oil module to the crankcase

Tools

- ZTSE2384 – Radiator Pressure Testing Kit
- Surge Tank Cap Adaptor

Lube Oil Contamination Inspection

1. Check lube oil for proper level and visible contamination.
   - Oil contaminated with coolant generally causes the oil to thicken and coagulate, giving the oil a light gray sludgy appearance.
   - If contamination cannot be verified, take an oil sample for analysis.
2. Remove oil sump following procedures in the *Engine Service Manual*.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow engine to cool for 15 minutes or more.
- Wrap a thick cloth around radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

3. Remove deaeration tank cap.
4. Install Radiator Pressure Testing Kit ZTSE2384 with Surge Tank Cap Adaptor on deaeration tank.
5. Pressurize cooling system to 117 kPa (17 psi) for a minimum of 15 minutes.

NOTE: It may take 12-24 hours for a coolant leak to become visible.

6. Inspect the inside of the crankcase for evidence of coolant leakage.
   - If coolant leak is at the air compressor drain, install a new air compressor following procedures in the *Engine Service Manual*.
   - If coolant leak is from oil cooler, install a new oil cooler following procedures in the *Engine Service Manual*.
   - If coolant is evident at the front cover area, continue to next step.
   - If coolant is evident at the rear gear train area, inspect freeze plug on rear of cylinder head and repair as necessary.
   - If coolant is evident on the bottom edge of a cylinder liner(s), skip to step 10.
   - If coolant leak is from cracks in the crankcase, replace crankcase following procedures in the *Engine Service Manual*.
7. Remove water distributor housing following procedures in the *Engine Service Manual*.

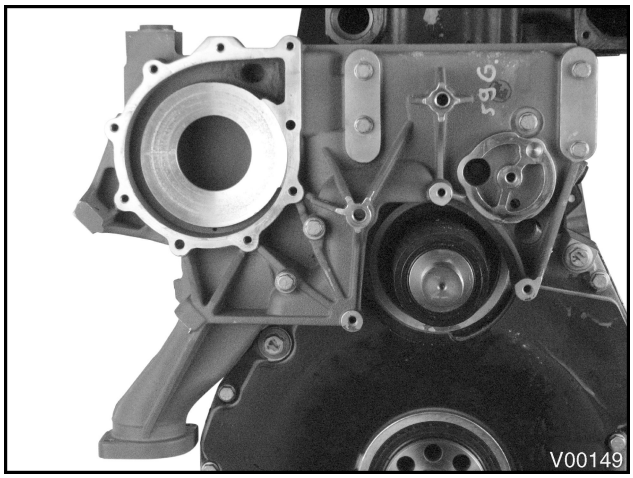


Figure 43 Water distributor housing

8. Inspect gear train area for coolant leaks.
   - If coolant is leaking into gear train area, inspect distributor housing for leak sources. Repair as necessary.
   - If no coolant is leaking into the gear train area, inspect water distributor housing and gasket for leak sources. Repair as necessary.
   - If no coolant is leaking from water distributor housing or gasket, continue to next step.
9. Inspect lower edges of cylinder liners for coolant leaks. Note cylinder number(s) where coolant leakage is identified.
   - If coolant is leaking on the outside of a cylinder liner, install new cylinder liner O-rings following procedures in the *Engine Service Manual*.
   - If coolant is leaking inside of cylinder liner, continue to next step.
10. Remove front and rear tubes from EGR cooler and pressure test EGR cooler, in vehicle, following procedures in the *Engine Service Manual*.
    - If a leak is detected, install a new EGR cooler following procedures in the *Engine Service Manual*.
    - If no leak is found, continue to next step.
11. Test cylinder head for coolant leaks. Go to Cylinder Head Leak Test.
12. Test cooling system again to validate repair.

Cylinder Head Leak Test

Procedure

1. Drain oil and remove oil pan see *Engine Service Manual*.
2. Pressure test cooling system to 117 kPa (17 psi).
3. Inspect all cylinder liners and crankcase coolant passages following procedures in the *Engine Service Manual*.
    - If cylinder liners are damaged, repair or replace as necessary following procedures in the *Engine Service Manual*.
    - If crankcase is damaged or cracked, repair or replace as necessary following procedures in the *Engine Service Manual*.
4. Test cooling system again to validate repair.

Coolant Over-Temperature

Symptom

Coolant over-temperature is identified by the water temperature gauge amber indicator illuminating and flashing and the audible alarm sounding, or the cooling system setting Diagnostic Trouble Codes (DTCs).

Possible Causes

- Wrong parts installed
- Low engine coolant level
- External coolant leaks
- Damaged fan belt
- Broken/worn accessory drive belt
- Accessory belt tensioner failure
- Damaged fan shroud
- Cooling fan blade assembly wrong or damaged
- Slipping cooling fan drive clutch
- Inoperative cooling fan
- Electronic gauge cluster error
- Engine Coolant Temperature (ECT) sensor biased
- Incorrect or damaged radiator
- Internal or external radiator blockage
- Winter front installed
- Water pump failure
- One or both coolant thermostats stuck (closed)
- Internal coolant leak
- Coolant Mixer Valve (CMV) failure
- EGR cooler failure
- LPCAC failure
- Chassis effects, transmission, or aftermarket equipment

Tools

- ZTSE2384 - Radiator Pressure Testing Kit
- Surge Tank Cap Adaptor
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- Digital Multimeter (DMM)
- Hose pinch off pliers

Coolant Over-Temperature Conditions Inspection

1. Connect Electronic Service Tool (EST) with ServiceMaxx™ software to vehicle's Diagnostic Connector.
2. Check for active and previously active DTCs related to coolant over-temperature.
3. Correct any sensor DTCs before proceeding. See “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS."
4. If engine has not been operated for eight to 12 hours, use Electronic Service Tool (EST) with ServiceMaxx™ software to compare Engine Coolant Temperature 1 (ECT1), Engine Coolant Temperature 2 (ECT2), and Engine Oil Temperature (EOT) with Key ON, Engine OFF (KOEO). All of the sensors should read within 5 °C (10 °F) of each other.
5. Check deaeration tank for correct fill level.
    - If coolant level is low and a coolant leak is suspected, fill cooling system and repair leak. See Coolant Loss (page 79).

- If coolant level is low and other over-temperature conditions are still suspected, refill cooling system and continue to next step.

6. Inspect cooling fan blade, shroud, accessory drive belt(s), accessory drive belt tensioner(s), and radiator for damage. Inspect Cooling fan drive clutch for free rotation. Key OFF does fan free wheel in both directions?
   - If fan drive is damaged, replace fan drive following procedures in the *Engine Service Manual*.
   - If vehicle is new or recently repaired, verify correct part number for any replaced component related to the cooling system.
   - Verify cooling fan blade, cooling fan drive clutch, and radiator are clean of debris and dirt build-up. Clean areas as required.

   WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:
   - Allow engine to cool for 15 minutes or more.
   - Wrap a thick cloth around radiator cap or deaeration cap.
   - Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
   - Pause for a moment to avoid being scalded by steam.
   - Continue to turn cap counterclockwise to remove.
7. Remove deaeration tank cap.
8. Connect Radiator Pressure Test Kit ZTSE2384 with Surge Tank Cap Adaptor to deaeration tank cap. Pressurize deaeration cap to its rated pressure.
   - If deaeration cap does not hold rated pressure, install a new deaeration cap.
   - If deaeration cap holds rated pressure, continue to next step.
9. Connect Radiator Pressure Testing Kit ZTSE2384 with Surge Tank Cap Adaptor to deaeration tank. Run engine at elevated idle. Monitor pressure in system using Radiator Pressure Testing Kit gauge.
   - If pressure is higher than pressure rating of the cap, go to Coolant Overflow (page 80).
   - If pressure is below rating of cap, continue to next step.
10. Using EST with ServiceMaxx™ do Tests > KOER Tests > Engine Fan Test.

- If fan does not operate properly, verify air or electrical supply to fan drive. If air or electrical supply to fan drive is damaged, repair as necessary.
- If fan operates properly, continue to next step.

11. Start and run engine up to operating temperature. Verify cooling fan clutch engages at desired temperature.
    - If fan does not operate properly, verify air or electrical supply to fan drive. If air or electrical supply to fan drive is damaged, repair as necessary.
    - If fan operates properly, continue to next step.
12. Attempt to duplicate the operator's concern of coolant over-temperature.

    CAUTION: To prevent radiator damage, do not hold wand of high-pressure hose too close to radiator fins.
    - If concern cannot be duplicated, clean radiator fins (if not done previously). Flush radiator fins with water on cooling fan side of the radiator. Do not continue with diagnostics.
    - If coolant over-temperature is duplicated, continue to next step.
13. Using EST with ServiceMaxx™ software, monitor ECT1 and ECT2 sensor temperature readings.
    - If the temperature value for ECT2 sensor is below ECT1 sensor reading, continue with next test.
    - If the temperature value for ECT2 sensor is above ECT1 sensor reading, continue with Coolant Over-Temperature – Charge Air Cooling.

Coolant Over-Temperature – Engine Cooling

Procedure

⚠ WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow engine to cool for 15 minutes or more.
- Wrap a thick cloth around radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn cap counterclockwise to remove.

1. Remove deaeration tank cap.
2. Run engine and observe radiator and aeration lines for coolant flow.

   NOTE: Coolant flow cannot be seen unless thermostats are open.

   - If no coolant flow is observed in radiator and aeration lines, continue to next step.
   - If coolant flow is observed in radiator and aeration lines, go to step 6.
3. Drain engine coolant.
4. Remove water pump following procedures in the *Engine Service Manual*.
5. Visually inspect water pump for damage, such as broken vanes, damaged impeller, or a damaged shaft.

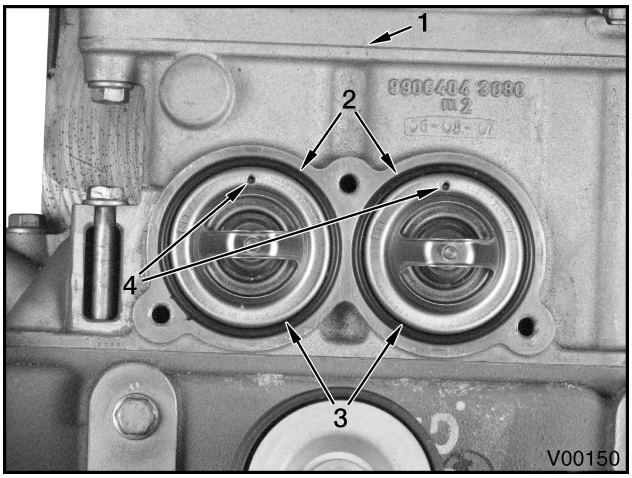


Figure 44 Thermostat elements

1. Thermostat housing assembly
2. 60 x 4 O-ring (2)
3. Thermostat element (2)
4. Ball valves (part of thermostat elements)

6. Remove and inspect thermostats following procedures in the *Engine Service Manual*. Ensure the opening temperature on both thermostats match the rating of the thermostats.
   - Replace thermostats as needed. Retest to validate repair.
   - If both thermostats pass test, continue to next step.
7. If the vehicle is equipped with an automatic transmission, use appropriate vehicle service/diagnostics manual to review automatic transmission diagnostics.
8. If over-temperature condition remains, remove radiator and have flow checked at radiator repair facility. Retest engine for over-temperature condition with repaired or replaced radiator.

Cooling System Components

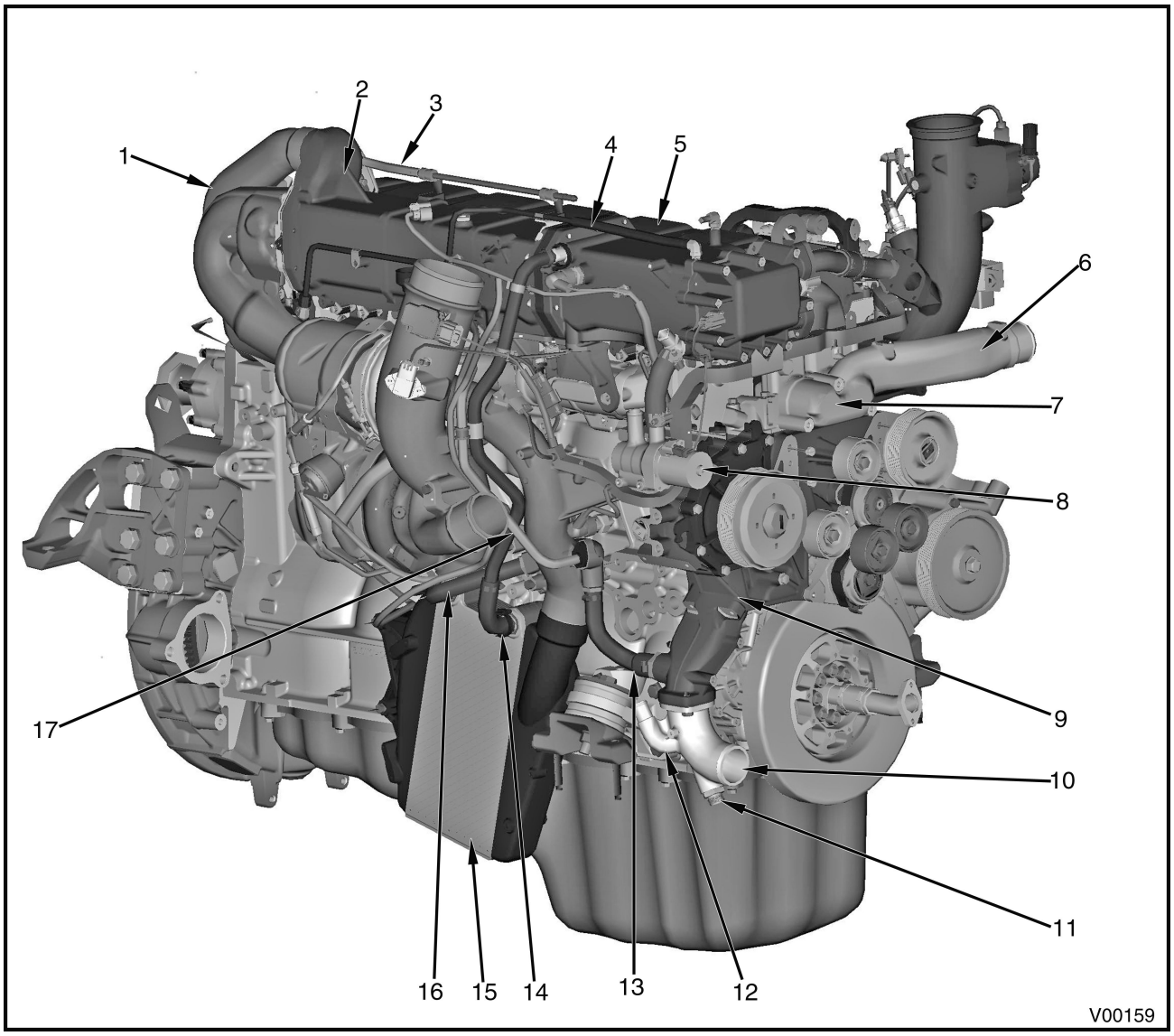


Figure 45 Cooling System Components

1. Coolant manifold
2. High-temperature EGR cooler
3. EGR coolant return
4. EGR coolant supply
5. Low-temperature EGR cooler
6. Coolant manifold outlet
7. Dual thermostats
8. CMV and CFV
9. Water Pump
10. Water inlet
11. Heater coolant
12. Surge tank line connector
13. LTR coolant return line
14. LTR coolant supply line
15. LPCAC
16. LTR coolant return line
17. Coolant return (cab heater)

Cooling System Flow

The water pump is located on the distributor case and draws coolant from the radiator through the coolant inlet at the lower right side of the distributor case. The engines have no coolant passages between the crankcase and cylinder head through the cylinder head gasket. This design eliminates the possibility of coolant leaks at the cylinder head gasket. Coolant in and out of the crankcase and cylinder head is directed through external passages. Coolant flows through the crankcase and cylinder head from front to rear. This coolant flows around the cylinder liners and combustion chambers to absorb heat from combustion.

Coolant exiting the crankcase and cylinder head at the rear of the engine is directed through an external coolant elbow to the Exhaust Gas Recirculation (EGR) module. Coolant passes between the EGR cooler plates, travels parallel to the exhaust flow, and exits into the distributor case. A deaeration port on the top of the EGR module directs coolant and trapped air towards the coolant deareation tank.

Coolant from the pump also flows through the air to air and the Low Pressure Charge Air Cooler (LPCAC) to regulate the charge air temperature. Coolant flow through the charge air coolers is controlled by the Coolant Mixer Valve (CMV) and Coolant Flow Valve (CFV). Depending on the coolant temperature, CMV sends coolant through the LPCAC, or indirectly to the LPCAC, after going through the Low Temperature Radiator (LTR) located in front of the main coolant radiator. When the charge air temperature is too low, CMV bypasses the LTR and directs all the coolant through the LPCAC. When the charge air temperature increases, CMV directs a percentage of the coolant to the LTR before it enters the LPCAC to cool the charge air. If the engine coolant temperature is too high, CMV sends all of the coolant flow through the LTR and through the LPCAC to help cool the engine faster.

Both coolant valves are controlled by the Engine Control Module (ECM) based on signals from the Engine Coolant Temperature 1 (ECT1) sensor, ECT2 sensor, and the Intake Manifold Pressure/Turbocharger 2 Compressor Inlet Sensor (IMP/TC2CIS) sensors. The ECT1 sensor is located in the underside of the EGR coolant crossover manifold, at the back of engine.

Coolant flow to the radiator is controlled by two thermostats. When the thermostats are closed, coolant flowing out of the EGR cooler is directed through a bypass port inside the front cover into the water pump. When the thermostats are open, the bypass port is blocked, and coolant is directed from the engine into the radiator.

Coolant passes through the radiator and is cooled by air flowing through the radiator from ram air and operation of the coolant fan. The coolant returns to the engine through the inlet elbow.

The air compressor is cooled with coolant supplied by a hose from the left side of the crankcase. Coolant passes through the air compressor cylinder head and returns through a passage inside the crankcase to the distributor case.

The oil module receives coolant from a passage in the crankcase. Coolant passes between the oil cooler plates and returns back to the water pump suction passage located in the front cover.

Thermostat Operation

The engines are fitted with two thermostats in a common housing to ensure sufficient coolant flow in all operating conditions. The thermostats are located at the top of the distributor case.

The thermostat housing assembly has two outlets. One directs coolant to the radiator when the engine is at operating temperature. The second outlet directs coolant to the water pump until the engine reaches operating temperature. The thermostats begin to open at 83 °C (181 °F) and are fully open at 91 °C (196 °F).

When engine coolant is below the 83 °C (181 °F), the thermostats are closed, blocking coolant flow to the radiator. Coolant is forced to flow through a bypass port back to the water pump.

When coolant temperature reaches the opening temperature of 83 °C (181 °F), the thermostats open allowing some coolant to flow to the radiator. When coolant temperature exceeds 91 °C (196 °F), the lower seat blocks the bypass port directing full coolant flow to the radiator.

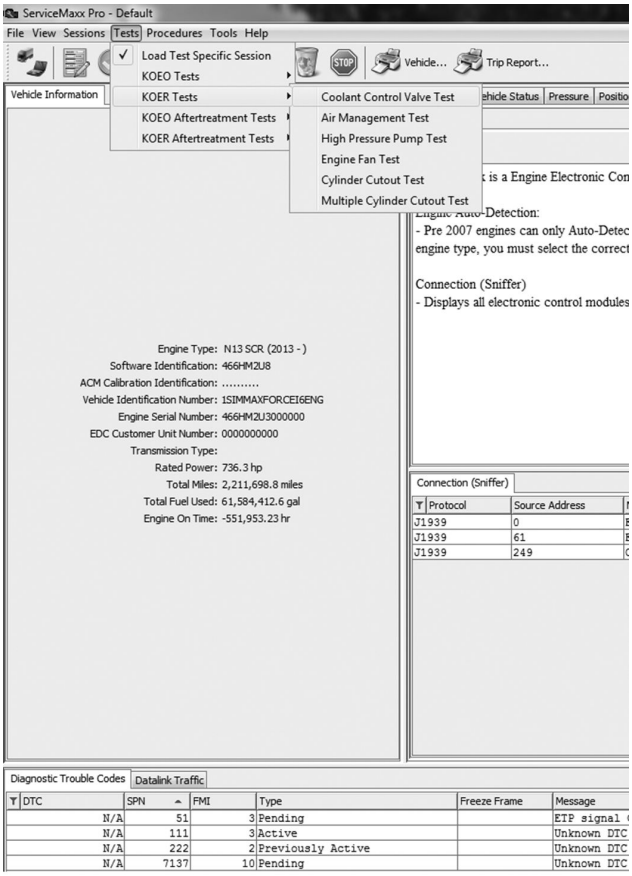
Coolant Control Valve (CCV) Assembly and Coolant Mixer Valve (CMV) Operation

The CCV assembly is installed on the upper right side of the distributor housing. The CCV has two separate solenoid actuated valves; CMV, and CFV. The CMV and the CFV are part of the CCV assembly and cannot be serviced separately. CFV controls the coolant flow through the CACOTs while the CMV controls the coolant flow through the LTR. The CMV and CFV solenoids are controlled by two separate Pulse Width Modulated (PWM) signals from the ECM. The PWM signal duty cycles vary between 0% and 100% depending on the coolant and charge air temperature. The CMV is installed on the upper side of CCV and controls the coolant flow through the LTR. The CFV is installed on the lower side of CCV and controls the amount of coolant flow through the LTR and LPCAC. The CFV helps protect the LTR circuit from over-pressure at high engine speeds. If the engine coolant temperature is too low, the CFV closes to reduce the coolant flow through the LPCAC.

When the temperature of the charge air and coolant coming out of the LPCAC is low, the CMV directs the coolant through a LTR bypass directly into the LPCAC. This helps the engine reach its normal operating temperature faster. If the temperature of the charge air and coolant coming out of the LPCAC is high, the CMV directs the coolant flow through the LTR. This prevents an overheating of the charge air cooler which can result in failure of the LPCAC.

Coolant Control Valve (CCV) Test

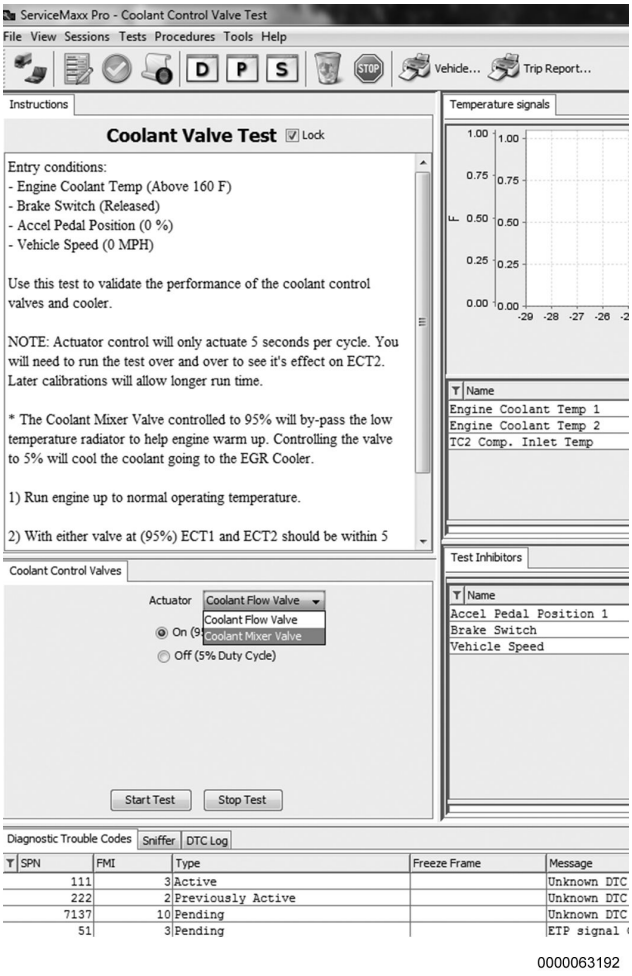
1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.



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Figure 46 Key-On Engine-Running Tests

4. Select Test > KOER Tests > Coolant Control Valve Tests.
5. Start engine and allow to reach operating temperature.



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Figure 47 Coolant Control Valve Test

6. Select Coolant Mixer Valve or Coolant Flow Valve from Actuator drop-down menu.

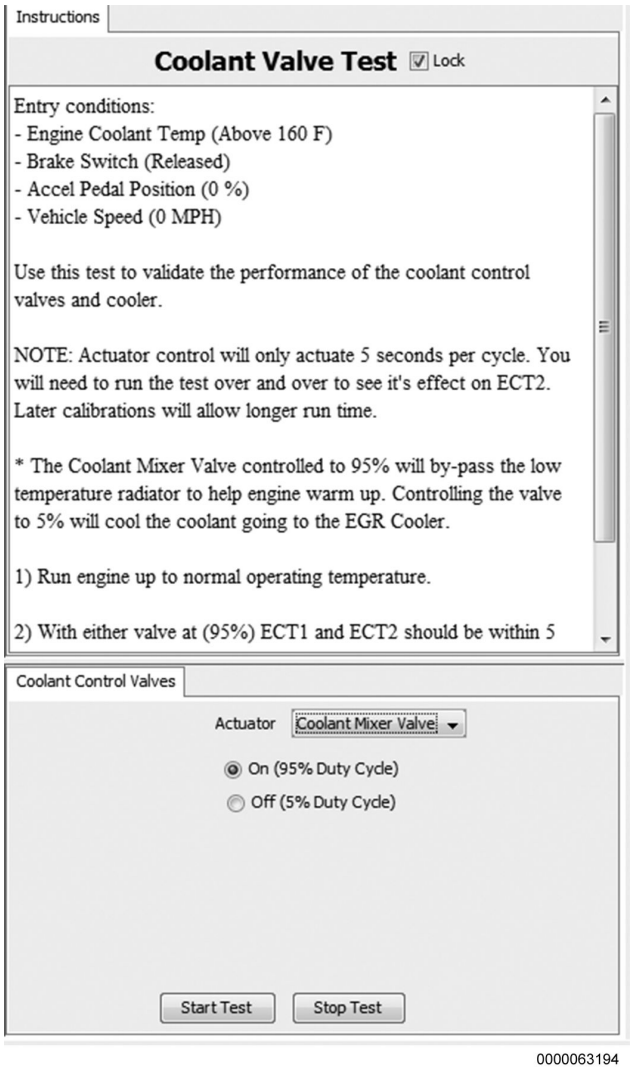


Figure 48 Coolant Mixer Valve actuator session

7. Set actuator to ON (95% Duty Cycle) and click on the Start Test button.
8. Using an infrared thermometer, measure and record coolant inlet and outlet temperatures at the secondary radiator.
9. Using EST with ServiceMaxx™ software, monitor and record temperature readings from ECT, TC2CIS, and ECT2 sensors. Record readings on Performance Diagnostics Form.
10. Calculate secondary radiator cooling by subtracting coolant inlet temperature from coolant outlet temperature. Record this number as secondary radiator difference.
11. Calculate LPCAC cooling by subtracting TC2CIS sensor temperature from ECT2 sensor temperature. Record this number as cooler temperature difference.
12. Use recorded data to determine if CFV and CMV are operating correctly.
    - If cooler difference is higher than secondary radiator difference, or is within 3 ˚C (5 ˚F) of secondary radiator difference, the Coolant Flow Valve (CFV) is stuck in the fully closed position. Install a new Coolant Control Valve (CCV) assembly following procedures in the *Engine Service Manual*.
    - If the ambient temperature is lower than 4 ˚C (40 ˚F), add 2 ˚C (4 ˚F) to ECT and ECT2.

      If ECT sensor reading is higher than ECT2 sensor reading by less than 11 ˚C (20 ˚F), the Coolant Mixer Valve (CMV) is stuck in the fully closed position. Install a new CCV assembly following procedures in the *Engine Service Manual*.
    - If cooler difference is lower than secondary radiator difference and ECT sensor reading is higher than ECT2 reading by 11 ˚C (20 ˚F), the CCV is functioning normally. Continue to next step.
13. If over-temperature condition remains, remove secondary radiator and have flow checked at radiator repair facility. Retest engine for over-temperature condition with repaired or replaced secondary radiator.

Lubrication System

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g., filters rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

Visual Oil Level Inspection

NOTE: If engine has been running, allow a 15 minute oil drain down period before checking oil level.

Park vehicle on level ground and use oil level gauge (dipstick) to check oil level.

Incorrect Maintenance

1. Check service maintenance records and discuss with customer to determine if the lube oil has been overfilled unintentionally.
    - If maintenance is unknown, change engine oil and filter and retest to see if complaint reoccurs.

Dilution from Coolant

Lube oil with coolant dilution can be described different ways, depending on the quantity of coolant that has been introduced into the oil.

- A milky substance left under the valve cover and in the oil fill tube is the result of ethylene glycol based coolant which has not had the moisture evaporated from the coolant/oil mixture.
- When the moisture has evaporated from the coolant contaminated oil, a light gray, thick, sludgy consistency is present. If lube oil exhibits signs of coolant dilution, go to Coolant Leak to Lube Oil (page 85).

Power Steering Fluid Leak to Lube Oil

Symptom

Oil level increases while power steering fluid level decreases.

Possible Causes

- Power steering pump leak

Procedure

1. Adjust oil level to full range.
2. Adjust power steering fluid to full range.
3. Start and run engine for a minimum of 10 minutes.
4. Stop engine and inspect lube oil and power steering fluid levels.
    - If power steering level is decreasing and lube oil level is increasing, install a new power steering pump following procedures in the *Engine Service Manual*.
    - If power steering level is not decreasing and lube oil level is not increasing, power steering fluid is not leaking into lube oil.

Lube Oil to Coolant

Symptom

An oily residue in engine coolant, that is apparent in the deaeration tank.

Possible Causes

- Oil cooler
- Oil module
- Cracked oil module housing
- Missing/damaged oil module gasket
- Missing/damaged oil cooler gaskets
- Missing mounting bolts for the oil module to the crankcase

Tools

Oil drain pan

Procedure

1. Verify coolant is contaminated by inspecting deaeration tank for presence of oil residue.
   - If coolant is contaminated, continue to next step.
   - If no contamination is found, no repairs are necessary.
2. Place a drain pan under oil module.
3. Remove oil module from engine following procedures in the *Engine Service Manual*.
4. Remove oil cooler from oil module following procedures in the *Engine Service Manual*.
5. Pressure test oil cooler following procedures in the *Engine Service Manual*.
   - If oil cooler fails pressure test, install a new oil cooler following procedures in the *Engine Service Manual* and reinstall oil module.
   - If oil cooler passes pressure test, replace both oil cooler gaskets following procedures in the *Engine Service Manual*.

Lube Oil to Intake

Symptom

Customer complaint of high lube oil consumption.

Possible Causes

- High pressure turbocharger
- Low pressure turbocharger
- High crankcase pressure

Procedure

1. Verify volume of lube oil entering intake system.
   - If residue of lube oil is present at intake air inlet, continue to next step.
   - If no lube oil residue is present at intake air inlet, the system is operating as designed and no repair is necessary.
2. Remove Low Pressure Charge Air Cooler (LPCAC) assembly following procedures in the *Engine Service Manual*.
3. Inspect for lube oil at LPCAC inlet and CAC.
   - If lube oil residue is present at LPCAC inlet, check and repair low-pressure turbocharger assembly following procedures in the *Engine Service Manual*.
   - If lube oil residue is present at CAC and not the LPCAC, check and repair high-pressure turbocharger assembly following procedures in the *Engine Service Manual*.

Lube Oil to Exhaust

Symptom

High lube oil consumption or restricted Diesel Particulate Filter (DPF) or Diesel Oxidation Catalyst (DOC). If the complaint is “wet exhaust” or leakage of exhaust system joints, verify Aftertreatment Fuel Injector (AFI) and/or system is functioning properly.

Possible Causes

- High-pressure turbocharger
- Low-pressure turbocharger
- Internal engine damage

NOTE: If lube oil to exhaust is determined from one of the listed possible causes, the Oxygen Sensor (O_2S) must be replaced. See the *Engine Service Manual* for O_2S replacement procedures. Perform O_2S Calibration Procedure (page 75) anytime O_2S is replaced.

Procedure

1. Remove exhaust manifold with butterfly from low-pressure turbocharger following procedures in the *Engine Service Manual*. Identify if lube oil is present at turbine side of low-pressure turbocharger.
   - If no oil is present at exhaust outlet of low-pressure turbocharger, the leak into the exhaust is most likely fuel. Verify the AFI and Downstream Injection (DSI) system is functioning properly. Go to Fuel to Exhaust (page 103).

- If oil is present at exhaust outlet of low-pressure turbocharger, remove low-pressure turbocharger following procedures in the *Engine Service Manual* and continue to next step.

2. Inspect turbine housing on high-pressure turbocharger and identify if lube oil is present at turbine side of high-pressure turbocharger.
   - If no oil is present, the leak into exhaust is from the low-pressure turbocharger. Install a new low-pressure turbocharger following procedures in the *Engine Service Manual*.
   - If oil is present, remove high-pressure turbocharger following procedures in the *Engine Service Manual* and continue to next step.
3. Inspect the inside of the high-pressure turbine inlet and exhaust manifold for presence of lube oil.
   - If no oil is present, the leak into exhaust is from the high-pressure turbocharger. Install a new high-pressure turbocharger following procedures in the *Engine Service Manual*.
   - If oil is present, remove exhaust manifolds from cylinder head following procedures in the *Engine Service Manual*. Pinpoint the power cylinder of concern and continue to next step.
4. Repair power cylinder following procedures in the *Engine Service Manual* for repair of specific component.

Low Oil Pressure

NOTE: Oil pressure depends on oil temperature and on engine speed (and thus, oil pump speed). To check oil pressure differences, unless there is a dramatic change, you have to know the oil temperature and engine speed. A typical engine speed is idle. A typical warm oil temperature is 110 °C (230 °F).

Symptom

Oil pressure indicator lamp will illuminate and an alarm will sound if oil pressure is less than 48 kPa (7 psi) with engine running at or above 325 rpm.

Possible Causes

- Low oil level
- High oil level/oil contamination
- Incorrect oil viscosity
- Inaccurate Engine Oil Pressure (EOP) sensor or circuit
- Restricted oil filter
- Oil sump/oil suction line damage
- Scored or damaged oil pump
- Oil pressure regulator wear/damage
- Broken, missing, or loose piston cooling tube(s)
- Internal engine bearing wear/damage
- Camshaft bearing wear/damage
- Missing oil gallery cup plugs (front or rear)
- Missing oil filter
- Clogged oil filter
- Damaged oil cooler
- No rotor in the centrifuge
- Soot in centrifuge filter

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- ZTSE4409 – Pressure Test Kit
- Oil pressure test coupler (obtain locally)
- Clean oil drain pan

Procedure

WARNING: To prevent personal injury or death, make sure the parking brake is set, the transmission is in neutral or park, and the wheels are blocked when running the engine in the service bay,

WARNING: To prevent personal injury or death, when routing test leads, do not crimp leads, run leads too close to moving parts, or let leads touch hot engine surfaces.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

NOTE: Engine oil level varies depending on temperature of engine.

NOTE: If engine has been running, allow a 15 minute oil drain down period before checking oil level.

1. Park vehicle on level ground and use oil level gauge (dipstick) to check oil level.
   - If lube oil is contaminated with coolant, go to Coolant Leak to Lube Oil (page 85).
   - If lube oil is contaminated with fuel, go to Fuel in Lube Oil (page 102).
   - If oil level is in specification and oil is not contaminated, but oil pressure remains low, continue to next step.
2. Verify low engine oil pressure complaint by checking oil pressure gauge on vehicle's dashboard.
   - If oil pressure is within specification, no repair is necessary.
   - If oil pressure is below specification, continue to next test.
3. Turn ignition switch to ON, engine OFF.
4. Connect EST to vehicle's Diagnostic Connector.
5. Start ServiceMaxx™ software.
6. Using EST, verify Engine Oil Pressure (EOP), Engine Oil Temperature (EOT) , and engine speed differences.
   - If EOP is within specification, investigate failed or malfunctioning oil pressure gauge on vehicle's dashboard. See appropriate chassis service manual for diagnosing oil pressure gauge.
   - If EOP is below specification, continue to next step.

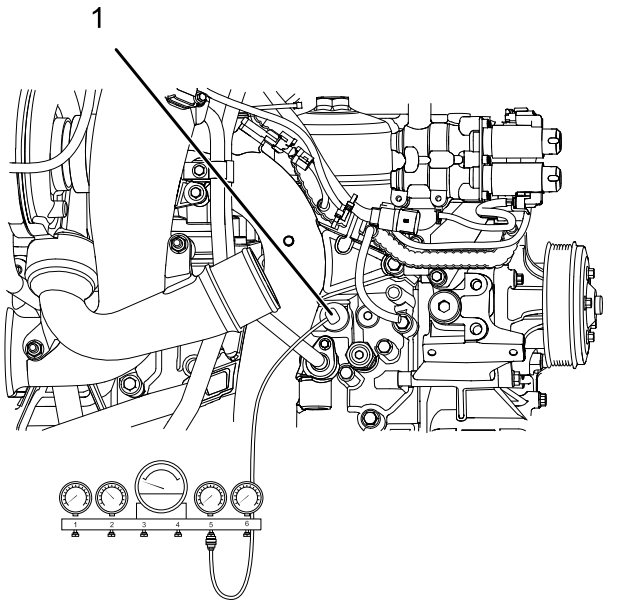


Figure 49 Oil pressure gauge connection

1. Oil pressure test coupler.

7. Remove EOP sensor and install oil pressure test coupler (obtain locally).
8. Connect test line between oil pressure test coupler and 0 to 160 psi gauge on Pressure Test Kit ZTSE4409.

9. Start engine and run to operating temperature. Measure oil pressure at both low and high idle, and under no load conditions.
    - If oil pressure is within specifications listed in ”APPENDIX: A PERFORMANCE SPECIFICATIONS” and the oil pressure gauge indicates low pressure, perform Engine Oil Pressure (EOP) Sensor (page 635) diagnostics in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS."
    - If oil pressure is not within specification, continue to next step.
10. Remove oil filter and inspect for debris.
    - If oil filter has debris, install a new oil filter. Inspect oil bypass valve located in oil module housing. If debris is present in oil bypass valve, clean bypass valve and retest system.
    - If oil filter does not have debris, install new oil filter and retest system.
    - If engine fails test, continue to next step.
11. Drain oil from engine using a clean drain pan. Inspect oil drain plug magnet and drained oil for debris. An oil sample can be taken to determine level of engine wear and contaminants in oil.
12. Remove oil sump following procedures in *Engine Service Manual*.
13. Inspect oil suction line for damage.
    - If oil suction line is damaged, install a new oil suction line following procedures in the *Engine Service Manual*. Retest the engine for correct oil pressure.
    - If oil suction line is not damaged, install a new oil sump following procedures in the *Engine Service Manual*. Continue to next step.
14. Visually inspect for missing, loose, or damaged O-rings, piston cooling tubes, and bearing inserts.
    - If visual inspection identifies any concerns, repair as necessary and retest system.
    - If visual inspection does not identify any concerns, proceed to next step.
15. Connect regulated shop air line to the oil filter module diagnostic coupling assembly.
16. Slowly apply air pressure in 34.5 kPa (5 psi) increments up to 345 kPa (50 psi).

NOTE: There will be loss of air at many lube points; however, the amount of loss should not be excessive.

17. Check for audible loss of air pressure. If air loss is identified in the following areas, inspect and repair the associated components as necessary:
    - Front of engine right side – oil pressure regulator, oil galley plugs
    - If a continuous flow of lube oil is coming out of the oil return port, remove and replace oil pressure relief valve.
    - Rear of engine – oil galley plugs
    - Main and rod bearings
    - Upper engine – camshaft bearings (removal of the valve cover is required)
    - If no leak has been found, remove front cover of engine and inspect oil pump following procedures in the *Engine Service Manual*.

Fuel System

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

Excessive Fuel Consumption

Symptom

More fuel is required to perform the same task.

Possible Causes

Operator effects

- Inaccurate record keeping or tank filling
- Winter blend, kerosene, or number one diesel fuel
- Unrealistic expectations
- Excessive transient behavior

Application effects

- Heavy loading Gross Vehicle Weight (GVW)
- Low rear axle ratio
- Large frontal area
- Accessory usage (such as Power Takeoff)
- Additional equipment drawing fuel from vehicle fuel tanks
- Extended idle applications
- Tire size, tire condition, or air pressure

Chassis effects

- Brake drag
- Cooling fan clutch locked ON
- Transmission slippage/shifting
- Fuel tank plumbing or venting
- Intake or exhaust restriction
- Aftertreatment restriction
- Clutch slipping

Engine effects

- Incorrect or inoperative thermostat(s)
- Failed turbocharger control system
- Fuel system performance loss
- Fuel system leaks
- Base engine performance loss
- Exhaust Gas Recirculation (EGR) system failure
- Engine Throttle Valve (ETV) system failure

Procedure

1. Review operator records and fueling procedures. Measurement errors are common. Fuel consumption taken only from one tank of use is susceptible to significant error because of filling procedures and vehicle application differences during operation. Accurate fuel consumption must be measured over time with a record of what the vehicle was doing during the measurement period.

NOTE: Loss of fuel economy is normal if winter blend fuel, kerosene, or number one diesel fuel is being used.

2. Review vehicle specifications to determine if fuel consumption is normal for type of application and use of vehicle. Compare consumption with similar vehicles in the same application and TCAPE report.

3. Do all tests on Performance Diagnostics form or in “PERFORMANCE DIAGNOSTICS” section (page 147).

   These tests verify the operating condition of the following engine and chassis systems:

   - Intake system
   - Exhaust system
   - Fuel delivery and filtration
   - High pressure fuel system
   - Injector operation
   - EGR system operation
   - ETV system operation
   - Boost pressure actuator operation
   - Base engine condition
   - Electronic control system condition

   If all tests are passed, engine is operating normally.

Fuel in Coolant

Symptom

Coolant has a diesel fuel odor.

Possible Causes

- Leaking coolant heated auxiliary fuel filter (if equipped)
- Cracked or porous cylinder head casting in fuel return area
- AFI

Tools

- ZTSE4409 – Pressure Test Kit
- Regulated air pressure

Procedure

1. Isolate and test any add-on coolant heated auxiliary fuel filter per manufacturer's instructions.
   - If leak is found, install a new coolant heated auxiliary fuel filter per manufacturer's instructions.
   - If no leak is detected, continue to next step.

WARNING: To prevent personal injury or death, do the following when removing the radiator cap or deaeration cap:

- Allow engine to cool for 15 minutes or more.
- Wrap a thick cloth around radiator cap or deaeration cap.
- Loosen cap slowly a quarter to half turn counterclockwise to vent pressure.
- Pause for a moment to avoid being scalded by steam.
- Continue to turn the cap counterclockwise to remove.

2. Remove deaeration tank cap.
3. Fill deaeration tank with coolant to a level above deaeration tank inlet.

NOTE: Do not reinstall deaeration cap at this time.

4. Disconnect electrical connector to Aftertreatment Fuel Injector (AFI).
5. Disconnect fuel supply line from AFI.
6. Connect a regulated air pressure source to fuel inlet of AFI and pressurize to 207 kPa (30 psi) for up to 20 minutes.
   - If air bubbles are observed at deaeration tank, install a new AFI following Hydrocarbon Injector installation procedure in the *Engine Service Manual*.
   - If no air bubbles are present at deaeration tank, continue to next step.

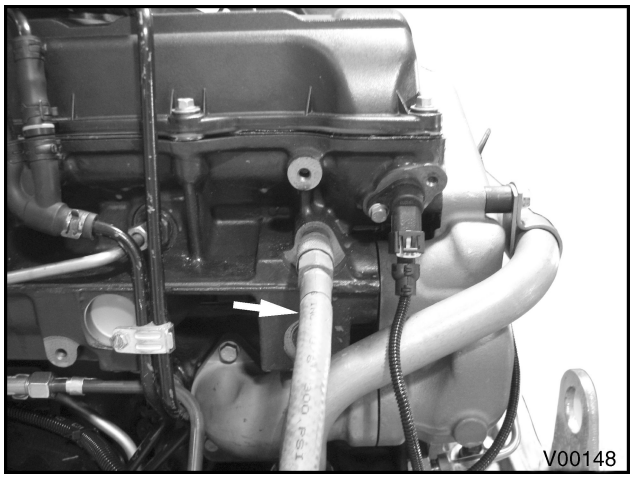


Figure 50 Compressed air source connected to cylinder head

7. Remove hollow screw at the rear of cylinder head and adapt compressed air source to cylinder head.
8. Pressurize cylinder head to 550 to 690 kPa (80 to 100 psi) for up to 20 minutes.
9. Observe deaeration tank for air bubbles or loss of pressure at gauge. If air bubbles are observed at deaeration tank, install a new cylinder head following procedures in the *Engine Service Manual*.

Fuel in Lube Oil

Symptom

Oil has a diesel fuel odor and engine oil level in consistently increases.

Possible Causes

- Fuel injector(s)
- Cylinder misfire (wash down)
- High pressure fuel lines

Tools

- ZTSE4618 – UV Leak Detection Kit
- 15-637-01 – Clean Fuel Source Tool
- UV Leak Detection Fluorescent Dye Cartridge

Procedure

1. If engine has a misfire, see Special Test Procedures (page 165) in ”PERFORMANCE DIAGNOSTICS." Use procedures in the *Engine Service Manual* for repair of specific components.
2. Verify oil contamination by performing a white paper test or oil analysis. Place one drop of suspected diluted oil on a clean sheet of printer or copier paper.
   - If oil wicks away rapidly into the paper, there is fuel contamination.
   - If oil maintains a uniform and slow expanding stain, there is no fuel contamination.
3. Inspect fuel system for leaks.

NOTE: The UV Leak Detection Kit ZTSE4618 requires warm-up time. Turn on UV Leak Detection Kit.

NOTE: Before starting dye test, verify there is no dye in oil.

4. Using Clean Fuel Source Tool 15-637-01, supply engine with an alternate supply of clean diesel fuel with dye mixed to manufacturers specification.
5. Start and run engine at high idle for a maximum of 5 minutes. Turn engine OFF.
6. Using the UV Leak Detection Kit ZTSE4618, inspect for leaks in the following areas:
   - High-pressure pump front seal. If a leak is found, replace fuel pump following procedures in the *Engine Service Manual*. To prevent damage to a newly installed fuel pump and to verify high back pressure did not cause fuel pump to fail, perform HP Pump Fuel Return Pressure Test (page 139) any time fuel pump is replaced.
   - Injector body. Remove valve cover following procedures in the *Engine Service Manual*. If a leak is found, replace fuel injector and pressure pipe neck following procedures in the *Engine Service Manual*.
   - If no leaks are found, take an oil sample for analysis and monitor engine oil level.

Fuel to Intake

Symptom

Fuel leaking into the intake results in black smoke and eventual Diesel Particulate Filter (DPF) Diagnostic Trouble Codes (DTCs).

Possible Causes

- Inlet Air Heater Fuel Solenoid (IAHFS) valve
- IAHFS valve control

Procedure

1. If engine has a misfire, see Special Test Procedures (page 165) in “PERFORMANCE DIAGNOSTICS."
2. Disconnect electrical connector from IAHFS valve.
3. Disconnect fuel supply line from Inlet Air Heater Fuel Igniter (IAHFI).
4. Pump fuel primer pump while checking IAHFS valve for fuel leakage.
5. Start engine and run at low idle. Check for fuel leakage from IAHFS valve.
   - If leakage is observed, install a new IAHFS valve following procedures in the *Engine Service Manual*.
   - If no leakage is observed, check the IAHFS valve control circuit. See IAHFS (Inlet Air Heater Fuel Solenoid) (page 421) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS”.

Fuel to Exhaust

Symptom

Wet exhaust system and possible damage to the Diesel Particulate Filter (DPF).

Possible Causes

- AFI
- Internal engine damage

Tools

Regulated air pressure source with shut off valve

Procedure

1. Disconnect fuel line from AFI.

⚠ WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

2. Connect regulated air pressure with a shut off valve to fuel inlet of AFI and pressurize to 207 kPa (30 psi).
3. Close shut off valve and monitor air pressure for two minutes.
   - If air pressure drops, install a new AFI following Hydrocarbon Injector installation procedure in the *Engine Service Manual*.
   - If pressure remains constant, continue to next step.
4. If engine has a misfire, see Special Test Procedures (page 165) in “PERFORMANCE DIAGNOSTICS”.
5. Remove exhaust manifold from cylinder head following procedures in the *Engine Service Manual* and pinpoint the power cylinder of concern.

Fuel Pressure and Aeration

Symptom

Fuel aeration exhibits one or more of the following characteristics:

- Engine stall during operation
- Rough running engine
- Extended engine crank time (hard start)
- Fuel pressure slow to build while cranking
- Excessive fuel pressure while cranking
- Pulsating fuel pressure during crank or engine running at idle.
- Difficulty priming fuel system

Possible Cause

- Leaks in fuel supply to fuel pump
- Loose fuel injector hold down
- Missing/damaged fuel injector sealing washer

Procedure

If aeration is suspected, go to Fuel System (page 126) in “HARD START AND NO START DIAGNOSTICS.”

Water in Fuel

Symptoms

Water in fuel exhibits one or more of the following characteristics:

- Water in fuel shown in Integral Digital Display
- Low power
- Engine stall during operation
- Rough running engine
- No start if water has frozen

Possible Causes

- Water in fuel supply system
- Ice in fuel lines

Tools

Clean, flat drain pan with a wide opening

Procedure

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

WARNING: To prevent personal injury or death, do not mix gasoline, gasohol, or alcohol with diesel fuel. An open heat source, spark, cell phone, or electronic device can ignite these fuel mixtures. This creates a fire hazard and possible explosion.

1. Place drain pan under filter housing.
2. Drain water separator following procedures in the *Engine Operation and Maintenance Manual*.
3. Check fuel in drain pan for engine coolant or other contamination. Dispose of the contents in the drain pan in accordance with local requirements.
   - Excessive water or contaminants may indicate the tank and fuel system need to be flushed and cleaned.
   - Some sediment and water may be present if fuel filter has not been replaced for a long period of time, or if sediment and water have not been drained recently.
   - Fuel should be clear and not cloudy. Cloudy fuel indicates that fuel is not a suitable grade for cold temperatures.
   - The fuel should not be dyed red or blue, these colors indicate off-highway fuel.
   - Fuel should not show evidence of waxing or gelling. Waxing or gelling of some fuels in cold weather could clog fuel filters and fuel pump and cause restrictions or low fuel pressure.
4. If fuel sample indicates water in fuel, obtain a fuel sample from fuel tanks.
   - If fuel sample indicates water in fuel, drain fuel tanks, and refill tanks with clean fuel.

Priming the Fuel System

⚠ WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

⚠ WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

CAUTION: To prevent engine damage, do not manually actuate the Fuel Pressure Control Valve (FPCV) to build fuel rail pressure, if the engine will not start. This can damage internal parts in the high-pressure pump.

CAUTION: To prevent damage to engine, plug component connections immediately after each fuel line is removed using clean fuel system caps.

NOTE: If fuel system will not prime during diagnosis and engine exhibits pulsating fuel pressure, see Low Pressure Fuel System (page 127) in "HARD START AND NO START DIAGNOSTICS".

Procedure

Prime fuel system when the following conditions occur:

- Fuel tank is drained or runs dry
- Primary fuel filter is removed or replaced
- Any fuel connection between fuel tank and secondary fuel filter is broken
- Secondary fuel filter is removed or replaced
- High-pressure fuel system is serviced

1. Ensure all fuel system connections are secure and proper fuel filters are installed.
2. Ensure battery is fully charged or install battery charger.
3. Turn ignition switch to ON, engine OFF.
4. Connect EST to vehicle's Diagnostic Connector.
5. Start ServiceMaxx™ software.
6. Prime suction side of low-pressure fuel system:
   a. Tighten primary fuel filter components that were removed (canister filter element, seals, or bowl) to specified torque values.
   b. Unscrew piston knob on fuel primer pump assembly and start pumping until fuel pressure builds up on delivery side of fuel primer pump. Pressure build up is indicated by higher pumping force on piston knob.
   c. Fully screw piston knob back in when priming is complete.

CAUTION: To prevent damage to the starter, if engine fails to start within 20 seconds, release ignition switch and wait two to three minutes to allow starter motor to cool.

7. Engage starter for 20 seconds and allow starter to cool for two minutes.
8. If engine does not fire during the first two cranking attempts, use EST to monitor Fuel Delivery Pressure (FDP) during third cranking attempt.
   a. If pressure does not build up during third cranking attempt, unscrew primary filter cap and separate filter element from filter cap.
   b. Ensure filter element is fully seated on standpipe.
   c. Reassemble primary fuel filter assembly.
9. Engage starter for 20 seconds and monitor FDP sensor using EST with ServiceMaxx™ software.
   - If engine does not start and there is no increase in pressure, allow starter to cool for two minutes, then repeat steps 6 and 7.

10. Using EST with ServiceMaxx™ software, prime fuel system. If engine does not fire after five crank events, using EST with ServiceMaxx™ software, select Tests > KOEO Tests > Actuator Test. Then select Fuel Pressure Control Valve from the drop down menu, de-energize the FPCV in the high-pressure pump by setting the duty cycle to 5%.

NOTE: De-energizing the FPCV closes the valve and controls the valve at the lower limit of 6.7% Pulse Width Modulation (PWM) signal. This allows all fuel delivered by the internal transfer pump to go to the high-pressure pump and allows for minimum high-pressure pump outlet pressure, making refilling easy.

11. Engage starter for 20 seconds to purge any trapped air from high-pressure pump. Allow starter to cool for two minutes.
12. Reenergize FPCV. Engage starter for 20 seconds and allow starter to cool for two minutes.

Engine Brake System

Engine Brake Inspection

Symptom

Engine exhibits no de-accelerator in vehicle performance.

WARNING: To prevent personal injury or death, read all safety instructions in the *Engine Service Manual*.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, make sure that the engine has cooled before removing components.

WARNING: To prevent personal injury or death, do not let engine fluids stay on the skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

Possible Causes

The engine brake exhibits one or more of the following characteristics:

- ON/OFF switch malfunctioning
- Engine Brake lash adjustment (one or more cylinders out of adjustment)
- Low engine oil pressure (insufficient supply of oil pressure to operate engine brake)
- Engine boost pressure is low while braking, below 20 psi @ 2100 rpm with the engine brake on high
- Lubricating oil is too cold or thick
- Improper slave piston adjustment or slave piston binding in bore
- Master piston not moving in bore
- Control valves defective or binding in housing bore
- Engine brake housing plugs leaking
- Outer control valve springs broken or engine oil pressure extremely high
- Housing pipe plug(s) missing
- Aeration in lubricating oil
- Lubricating oil being diluted by fuel oil
- Low engine oil level
- Worn engine rocker lever bushings
- Restrictions in the engine oil passages leading to engine brake

Tools

- ZTSE4357 – Digital Multimeter (DMM)
- ZTSE6076–5A – Lash Gauge (0.50mm)
- ZTSE6076–7A – Lash Gauge (0.80mm)

Preliminary Steps

WARNING: To prevent personal injury or death, wear safely glasses with side shields.

1. Before starting engine brake troubleshooting procedures, check the following:
   a. Check engine oil level on dipstick. Over or under filled condition in crankcase will cause aeration in the engine brake hydraulic system.
   b. Check the condition of engine lubricating oil for presence of fuel, water, or both. This indicates engine problems and must be corrected.
   c. Check turbocharger, air cooler, piping, and intake manifold leakage. Any loss of pressure will cause a reduction in engine brake power output.
2. Before inspecting engine brake housing, remove over-engine equipment such as air intake, turbocharger crossover pipes, and valve mechanism upper covers. Follow procedures in the *Engine Service Manual*.
   a. Inspect pipe plugs on housing ends where applicable, to make sure none are missing. Use Jacobs pipe plugs, Part Number 028317 torqued to 11 N•m (100 lb-in).
   b. Remove upper valve cover, following procedures in the *Engine Service Manual*.

c. Check for cracks in engine brake housing.

d. Check for loose, damaged, brittle, or cracked wiring, or connections at engine brake solenoid.

e. Check for loose or damaged hold down bolts.

f. Check exhaust bridges and actuator pins. Actuator pins should move freely with no signs of distress.

g. Check engine brake slave piston setting of 0.8 mm and engine valve settings.

NOTE: When operating the engine brake with the valve cover removed, be aware that there will be a significant amount of oil spray in this area. This engine brake has separate drilling to lubricate the master piston roller area. This adds to the oil spray in the area, but does not indicate leakage or a problem with the oil supply needed for engine brake operations. These are two separate systems within the engine brake housing.

WARNING: To prevent personal injury or death, wear safely glasses with side shields.

WARNING: Whenever engine is running and valve cover is removed, lubrication oil splashing in the engine brake could cause personal injury.

Engine Brake does not Turn on/Slow to Turn On

3. If supplied voltage to engine brake solenoids is 8.4 V DC or lower, check ECM input sensors.

   a. Harness failure: Check continuity from each engine brake solenoid to engine ground. Must be “open” (no connection). Repair harness as required.

   b. Engine brake solenoid resistance: Between 8.7 and 10 Ω at 25 °C (77 °F). If resistance is out of specifications, replace engine brake solenoid assembly.

Engine Brake Solenoid Specifications

Engine Temperature	Ohms
Cold: 25 °C (77 °F)	8.7 – 10
Hot: 121 °C (250 °F)	12 – 15.5

4. Check resistance from ECM 96-pin to ECB harness connector.

5. Check resistance from Engine Compression Brake 1 (ECB1) and Engine Compression Brake 2 (ECB2) to ECB harness connector.

6. Check resistance from each terminal to engine brake solenoid can. This should be an "open circuit." If a resistance is measured, replace engine brake solenoid assembly.

7. Check continuity from each engine brake solenoid to engine ground. Must be “open circuit” (no connection). Repair harness if required.

8. Check upper and lower engine brake solenoid seal rings for leaks or damage. Replace if necessary.

9. Check engine brake solenoid valve, screen, and engine brake solenoid seal rings. Replace if necessary.

   • Shake the engine brake solenoid, a distinct rattle should be heard. This will indicate free component movement. Move poppet stem (the pin exposed on the bottom of the engine brake solenoid) to confirm it moves freely. If poppet stem does not move freely or a distinct rattle can not be heard, replace engine brake solenoid.

Engine Brake does not Turn Off/Slow to Turn Off

10. Check ECM input sensors, repair if necessary.

11. Check undercover wiring and engine brake solenoid connectors for short(s).

   • Check continuity from each engine brake solenoid to engine ground. Must be “open circuit” (no connection). Replace wiring harness or engine brake solenoid if required.

12. Check for low Engine Oil Pressure (EOP).

   • Determine oil pressure at engine brake housing using procedures given in this section. If EOP is below specifications, but engine brake housing oil pressure is 138 kPa (20 psi) and engine is at operating temperature, engine should be repaired before proceeding to next step.

Engine Fails to Start

13. If engine brake solenoid valve is stuck in the ON position, see diagnostics above.

Engine Brake Weak in Effect or Low on Engine Brake Power

14. Check engine boost pressure while braking. If boost pressure is below 138 kPa (20 psi) @ 2100 rpm with the engine brake on high, check engine brake adjustment. If out of specification, see procedure below.

    NOTE: To get boost pressure, the vehicle has to be road tested.

15. Check turbocharger for proper output. Inspect Charge Air Cooler (CAC) and piping for any exhaust leakage or intake restrictions.

Engine Brake Slow to Operate or Weak in Effect

NOTE: Allow engine to warm before operating engine brakes.

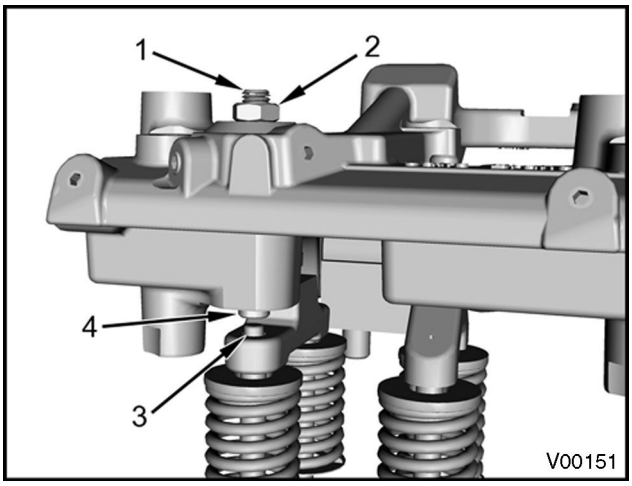


Figure 51 Engine Brake Assembly

1. Adjusting screw
2. Jam nut
3. Actuator pin (in exhaust valve bridge)
4. Slave piston

16. Check for improper slave piston adjustment or slave piston binding in bore.

    - If slave piston adjustment is incorrect or slave piston is binding in bore, readjust slave piston clearance lash setting to 0.8 mm. Ensure slave piston responds smoothly to the adjusting screw by loosening jam nut and moving adjusting screw through its full travel and for a full slave piston motion. Ensure piston travels full range without any binding or sticking.

NOTE: Master Piston Assembly – This is not a serviceable group. No attempt should be made to disassemble this group from the brake housing.

17. Check control valves for binding in housing bore.

    - Remove control valve. If body is scored, replace control valve. Check for contaminants in lube oil. Clean housing and control valve. If binding continues, replace housing.

18. Check control valve for defects.

    - Remove control valve. Ensure check ball is seated in bore and can be moved off seat. Ensure there is spring pressure against ball. Flush in cleaning solvent. Replace if necessary.

19. Check engine brake housing plugs for leakage.

    - If leaks are present, remove plug, clean threads, and install at 11 N•m (100 lbf-in).

20. Check outer control valve springs for damage.

Oil Pressure Dropping Below Minimum Required for Engine Brake Operation

Engine Brake Oil Pressure Requirements

Model	Control Valve	Control Valve Spring	Full Flow PSI	Over Pressure PSI
5783	11930	037215 / 019632	20-55	80

NOTE: For proper engine brake operation, oil pressure at engine brake housing must be 138 to 172 kPa (20 to 25 psi) with engine at operating temperature and running between 1000 rpm and governed engine speed.

21. Check for missing housing pipe plug(s).
    - Check all housing pipe plugs, replace as needed, and torque to 11 N•m (100 lbf-in).
22. Aeration of lubricating oil.
    - Check for aeration, activate, and then deactivate engine brake. Watch escape oil coming from control valve cover. If there are air bubbles in the oil, or if the oil is white and foamy, air is present in system. Aeration can be caused by the crankcase being too full of oil, too low on oil, or a problem with the engine oil pump or pick up tube.
23. Lubricating oil being diluted by fuel oil.
    - Obtain an oil sample to determine if fuel is present. See *Engine Operation and Maintenance Manual* for procedures on obtaining an oil sample.
24. Check engine oil level. See Visual Oil Level Inspection (page 95).
25. Check for worn engine rocker lever bushings. Replace if necessary.
26. Check for restrictions in engine oil passages leading to engine brake. Inspect all passageways. Repair if necessary.

One or More Cylinders Fail to Stop Braking or Engine Stalls

27. Check control valve inner spring for damage. Replace if necessary.
28. If one or more control valves are stuck in the ON or UP positions, check control valves for binding.
    - Remove, clean, or replace if necessary.
    - Inspect lubricating oil for contaminants.

Engine Misses or Loses Power

29. If slave piston adjustment is tight, readjust slave piston clearance to lash setting of 0.8 mm.
30. If engine brake solenoid is stuck in ON position, see procedure above.
31. If control valve is sticking or dragging in bore, clean control valve and bore. Replace if necessary.
32. Check control valve spring for damage. Replace if necessary.

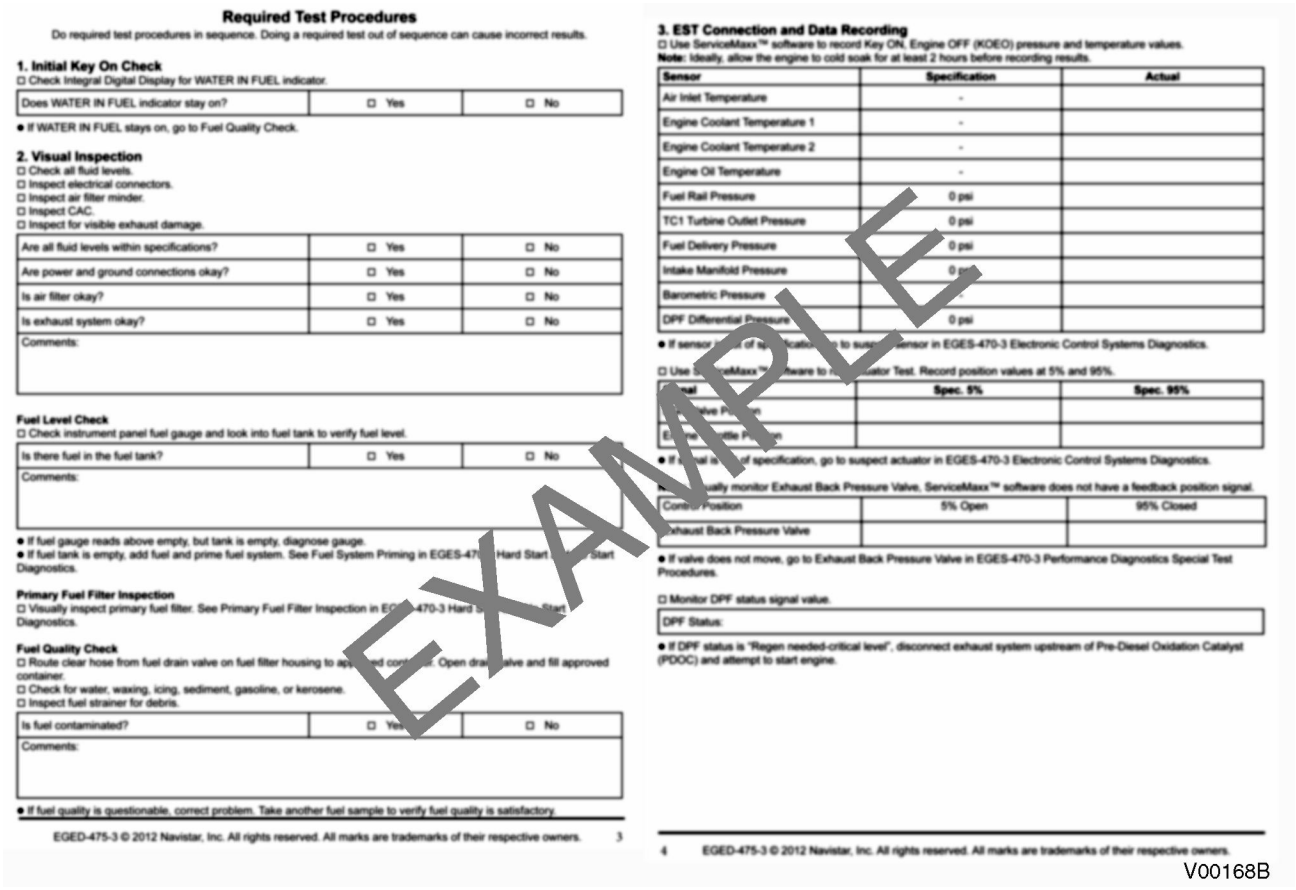
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Diagnostics Form EGED-475



Required Test Procedures

Do required test procedures in sequence. Doing a required test out of sequence can cause incorrect results.

1. Initial Key On Check

☐ Check Integral Digital Display for WATER IN FUEL indicator.

Does WATER IN FUEL indicator stay on?	☐ Yes	☐ No

● If WATER IN FUEL stays on, go to Fuel Quality Check.

2. Visual Inspection

☐ Check all fluid levels.
☐ Inspect electrical connectors.
☐ Inspect air filter minder.
☐ Inspect CAC.
☐ Inspect for visible exhaust damage.

Are all fluid levels within specifications?	☐ Yes	☐ No
Are power and ground connections okay?	☐ Yes	☐ No
Is air filter okay?	☐ Yes	☐ No
Is exhaust system okay?	☐ Yes	☐ No
Comments:		

Fuel Level Check

☐ Check instrument panel fuel gauge and look into fuel tank to verify fuel level.

Is there fuel in the fuel tank?	☐ Yes	☐ No
Comments:		

● If fuel gauge reads above empty, but tank is empty, diagnose gauge.
● If fuel tank is empty, add fuel and prime fuel system. See Fuel System Priming in EGES-47[illegible] Hard Start [illegible] Start Diagnostics.

Primary Fuel Filter Inspection

☐ Visually inspect primary fuel filter. See Primary Fuel Filter Inspection in EG[illegible]-470-3 Hard S[illegible] Start Diagnostics.

Fuel Quality Check

☐ Route clear hose from fuel drain valve on fuel filter housing to app[illegible]d cont[illegible]. Open drain valve and fill approved container.
☐ Check for water, waxing, icing, sediment, gasoline, or kerosene.
☐ Inspect fuel strainer for debris.

Is fuel contaminated?	☐ Yes	☐ No
Comments:		

● If fuel quality is questionable, correct problem. Take another fuel sample to verify fuel quality is satisfactory.

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3. EST Connection and Data Recording

☐ Use ServiceMaxx™ software to record Key ON, Engine OFF (KOEO) pressure and temperature values.
Note: Ideally, allow the engine to cold soak for at least 2 hours before recording results.

Sensor	Specification	Actual
Air Inlet Temperature	-	
Engine Coolant Temperature 1	-	
Engine Coolant Temperature 2	-	
Engine Oil Temperature	-	
Fuel Rail Pressure	0 psi	
TC1 Turbine Outlet Pressure	0 psi	
Fuel Delivery Pressure	0 psi	
Intake Manifold Pressure	0 psi	
Barometric Pressure	-	
DPF Differential Pressure	0 psi	

● If sensor [illegible] of specification, go to suspect sensor in EGES-470-3 Electronic Control Systems Diagnostics.

☐ Use ServiceMaxx™ software to [illegible]ator Test. Record position values at 5% and 95%.

Signal	Spec. 5%	Spec. 95%
[illegible]ve Pressure		
[illegible]ve Position		

● If signal is [illegible] of specification, go to suspect actuator in EGES-470-3 Electronic Control Systems Diagnostics.

● To visually monitor Exhaust Back Pressure Valve, ServiceMaxx™ software does not have a feedback position signal.

Control Position	5% Open	95% Closed
Exhaust Back Pressure Valve		

● If valve does not move, go to Exhaust Back Pressure Valve in EGES-470-3 Performance Diagnostics Special Test Procedures.

☐ Monitor DPF status signal value.

DPF Status:

● If DPF status is "Regen needed-critical level", disconnect exhaust system upstream of Pre-Diesel Oxidation Catalyst (PDOC) and attempt to start engine.

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V00168B

EXAMPLE

Figure 52 Diagnostics Form EGED-475 (Hard Start and No Start)

The Hard Start and No Start Diagnostics Form directs technicians to systematically troubleshoot a hard start or no start condition and avoid unnecessary repairs.

This Diagnostic Manual section shows detailed instructions of the tests on the form. The manual should be used with the form and referenced for supplemental test information. Use the form as a worksheet to record test results.

Do Required Test Procedures in sequence, and do Special Test Procedures when needed. Doing a test out of sequence can cause incorrect results. If the customer complaint is found and corrected, it is not necessary to complete the remaining tests.

See appropriate section of this manual for Diagnostic Trouble Codes (DTC's) and engine specifications.

To order technical service literature, contact your International dealer.

Diagnostics Form Vehicle Information and Complaint Page

Note: This form must be completed before calling for technical assistance.		
Technician:	Date:	Rated Power:
Software Identification:	Total Miles:	Engine On Time:
Vehicle Identification Number:		
Engine Serial Number:		
EDC Customer Unit Number:		
Transmission Type (select one): ☐ Manual ☐ Automatic		
Complaint:		

EXAMPLE

0000047998

1. Fill in the following information:
   - Technician
   - Date
   - Vehicle Identification Number (VIN)
   - EDC Customer Unit Number
   - Complaint (driver interview)

NOTE: Remaining information will be filled in later using information from the Electronic Service Tool (EST) with ServiceMaxx™ software.

Required Test Procedures

NOTE: The engine requires a starting aid when temperatures are below 11°C (52°F). If this is an inlet air heater problem, verify that the Inlet Air Heater is working before continuing. See Inlet Air Heater System Test (page 140).

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, provide proper ventilation when operating an engine in a closed area. Inhalation of exhaust gas can be fatal.

1. Initial Key ON Check

Purpose

Determine if Engine Control Module (ECM) is powered up and if water is in fuel supply.

Tools

None

Procedure

NOTE: Water in Fuel (WIF) sensor is optional.

1. Turn ignition switch to ON, engine OFF. Observe the following:
   - Wait to Start Lamp
   - Water In Fuel Lamp
2. Record results on Diagnostics Form.
   - If Water In Fuel Lamp stays ON, go to Fuel Quality Check (page 120).

2. Visual Inspection

Purpose

Check all fluid levels and inspect engine systems for problems such as leaks, open connections, and harness chaffing.

Tools

None

Engine Oil

1. Park vehicle on level ground and check oil level.

   NOTE: API CJ-4 oils are recommended for high speed diesel engines with advanced exhaust aftertreatment systems that meet 2007 and beyond on-highway exhaust emission standards.

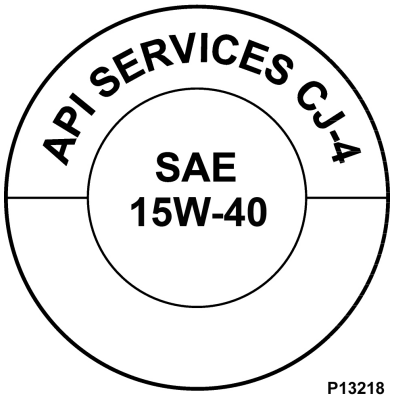


Figure 54 Lube oil requirements label

2. Use oil level gauge (dipstick) to verify engine oil level.
3. Check engine oil quality. Check for contamination or fuel dilution.

NOTE: If oil is contaminated or diluted, oil and filter must be replaced.

4. Record results on Diagnostics Form.
   - If level is below specification, inspect for leaks, oil consumption, or improper servicing. If engine oil level is low, fill to specification.
   - If level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing. If engine oil level is above specification, drain to proper level and diagnose contamination.

Engine Coolant Level

1. Park vehicle on level ground.

NOTE: Turn engine OFF and allow to cool. Ensure coolant temperature has stabilized to safe temperature and pressure.

2. Check coolant level that is indicated on deaeration tank level window.

NOTE: Coolant in the exhaust could damage the DPF. Inspect DPF for damage. See AFT System (page 217) in "ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS" for inspection of the DPF.

3. Record results on Diagnostics Form.
   - If coolant level is above or below deaeration tank fill level, inspect for leaks, coolant in oil, coolant in combustion exhaust, or improper servicing.
   - If coolant is contaminated, replace coolant.

Electrical System

1. Inspect batteries and electrical system (engine and vehicle) for poor or loose connections, corroded terminals, or broken and damaged wires.
2. Record results on Diagnostics Form.
   - If electrical system problem is found, make necessary repairs.

Intake Air

NOTE: Intake air restriction should be less than 172.3 kPa (51 in Hg) at full load, rated speed.

1. Inspect air filter gauge, located on air filter housing or dashboard.
2. Record results on Diagnostics Form.
   - If gauge indicates air filter requires replacement, verify there are no other restrictions in the air inlet or filter housing before replacing air filter.

Charge Air Cooler (CAC) System

1. Inspect CAC, interstage cooler, and all piping for leaks.

2. Inspect all CAC connections and clamps.
    - If CAC system problem is found, make necessary repairs. See Coolant Over-Temperature Conditions Inspection (page 87) in “ENGINE SYMPTOMS DIAGNOSTICS.”

Exhaust System

1. Inspect exhaust system (engine and vehicle) for restrictions, leaks, or damage.
2. Record results on Diagnostics Form.
    - If exhaust system problem is found, make necessary repairs.

Air Tanks

1. Inspect vehicle air tanks for water.
    - If water is found, drain water from air tanks.

Fuel Level

⚠ WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

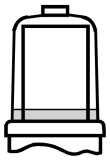
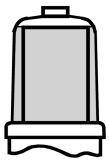
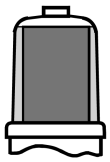
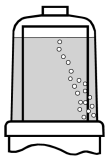
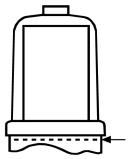
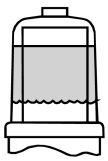
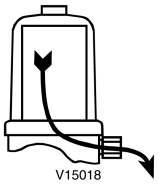
1. Park vehicle on level ground.
2. Check instrument panel fuel gauge, look into fuel tanks to verify fuel level, and make sure fuel levels are equal in both tanks.
3. Record results on Diagnostics Form.
    - If fuel gauge reads above empty, but fuel tanks are empty, diagnose fuel gauge. Verify sufficient fuel level before diagnosing a pressure problem.
    - If fuel tanks is empty, add fuel and prime fuel system. See Fuel System Priming (page 128).
    - If fuel level is within specification, go to Primary Fuel Filter Inspection.

Fuel Line Routing and Condition

1. With engine OFF, visually inspect the condition and routing of fuel lines.
    - If fuel lines are damaged or routed incorrectly, repair or replace as necessary.
    - If fuel lines are in good condition and routed correctly, go to Primary Fuel Filter Inspection.

Primary Fuel Filter Inspection

Visually inspect primary fuel filter condition following the inspection table on next page.

Fuel Level	Visual Indication	Possible Solution
 V15021	Fuel level below top of fuel filter.	Normal - no repair necessary.
 V15013	Fuel level above top of fuel filter. May cause loss of power complaint.	Change primary fuel filter element.
 V15014	Fuel level is to top of fuel filter and looks to be full of wax.	1. Change primary fuel filter element 2. Run engine for a minimum of 25 minutes at idle. Do not run at high idle.
 V15015	Bubbles are seen flowing within fuel.	1. Check all fittings and lines from between fuel tank and chassis fuel filter assembly. 2. Check upper and lower connector O-rings.
 V15016	Loss of power complaint. Fuel level is below fuel filter housing collar.	1. Check for missing grommet at lower end of filter. 2. Check for missing or broken spring at top of primary fuel filter element.
 V15017	Water is seen (noticeable separation) in fuel filter assembly.	1. Inspect fuel tank(s) for water contamination. 2. Drain a full cup of fuel from chassis fuel filter assembly. **NOTE: Do not drain with engine running.** 3. Restart engine. Shut off engine and drain chassis fuel filter assembly. 4. Repeat step 3 until ALL water is removed.
 V15018	Fuel drains back to fuel tank when changing fuel filter or draining water separator.	1. Remove and inspect check valve assembly. 2. Repair (clean) or replace as necessary, and retest.

Fuel Quality Check

Purpose

Check for poor fuel quality or contaminants.

Tools

- Clear diesel fuel container
- Clear plastic hose

Procedure

NOTE: Ultra Low Sulfur Diesel (ULSD) fuel is required for MaxxForce® 11 and 13 diesel engines used with advanced aftertreatment systems.



Figure 55 Fuel requirements label

NOTE: WATER IN FUEL indicator illuminates ON, then OFF, on the Integral Digital Display if there is no water in the system. If WATER IN FUEL indicator stays ON, water is detected.

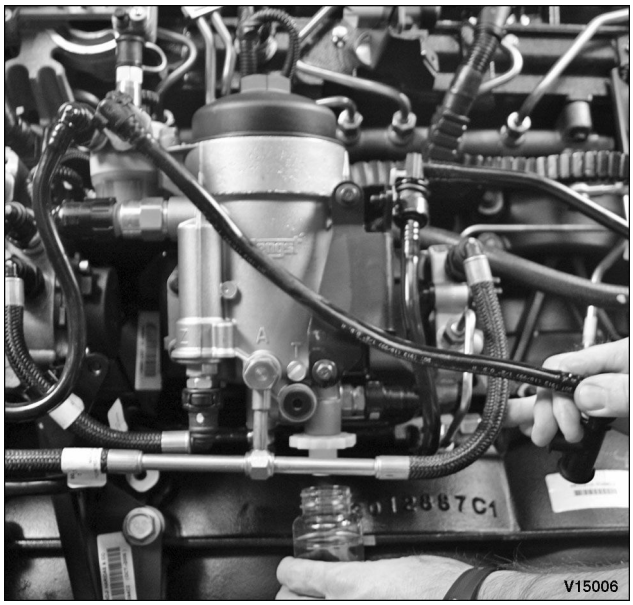


Figure 56 Fuel sample

1. Install clear plastic hose on fuel drain valve.
2. Route clear plastic hose into clear diesel fuel container.
3. Open fuel drain valve to fill container.

NOTE: If fuel does not flow, crank engine.

4. Check for water, waxing, icing, sediment, gasoline, kerosene, or Diesel Exhaust Fluid (DEF) by shaking fuel sample container and letting contents settle. Record results on Diagnostics Form.

   NOTE: Do not continue diagnostic procedures with contaminated fuel.

   - Sediments will fall to bottom of fuel sample container.
   - Gasoline and kerosene will separate from diesel fuel.
   - Waxing or icing will prevent diesel fuel from flowing out of fuel drain valve.
   - If fuel quality is questionable, repair as necessary. Take another sample to verify fuel quality is satisfactory.
   - If fuel quality is satisfactory, continue to Electronic Service Tool (EST) Connection and Data Recording test.

5. Inspect fuel strainer for debris. The fuel strainer is located in the fuel primer pump assembly.

3. Electronic Service Tool (EST) Connection and Data Recording

Purpose

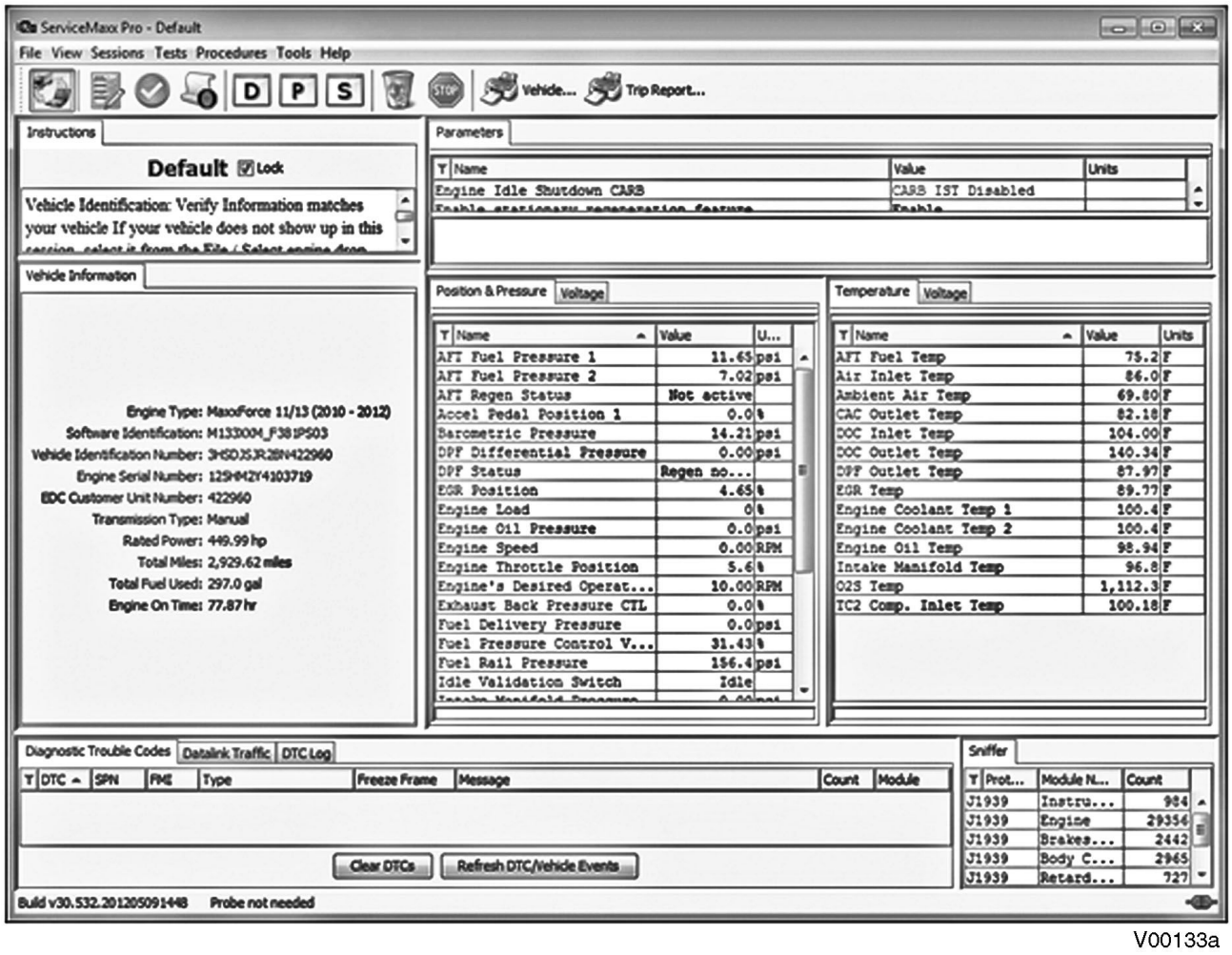
Check Engine Control Module (ECM) software, sensor signals and DTCs, and to record additional vehicle information on Diagnostics Form.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
    - If unable to communicate with the ECM, see the *ServiceMaxx™ Users Guide*.
    - If unable to communicate with the ECM and no problems are found using the *ServiceMaxx™ Users Guide*, go to J1939 Data Link (page 804) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”



V00133a

Figure 57 ServiceMaxx™ startup screen – vehicle connected

4. Verify the following vehicle information matches the displayed information in ServiceMaxx™ software and record on Diagnostics Form:
   - Software Identification
   - Vehicle Identification Number (VIN)
   - Engine Serial Number (ESN)
   - Transmission Type
   - Rated Power
   - Total Miles
   - Engine On Time

NOTE: The engine serial number is located on the front left side of the crankcase, below the cylinder head. It is also on the engine emission label on the valve cover.

5. Record the following Key ON, Engine OFF (KOEO) temperature sensor values on Diagnostics Form:

   NOTE: If possible, allow the engine to cold soak for at least 8 hours before recording results.

   NOTE: The engine requires a starting aid when temperatures are below 11° C (52° F). If this is an inlet air heater problem, verify Inlet Air Heater is working before continuing. See Inlet Air Heater System Test (page 140).

   - Inlet Air Temperature (IAT)
   - Engine Coolant Temperature 1 (ECT1)
   - Engine Coolant Temperature 2 (ECT2)
   - Engine Oil Temperature (EOT)

6. Record the following KOEO pressure sensor values on Diagnostics Form:
   - Fuel Rail Pressure (FRP)
   - TC1 Turbine Outlet Pressure (TC1TOP)
   - Fuel Delivery Pressure (FDP)
   - Intake Manifold Pressure (IMP)
   - Barometric Pressure (BARO)
   - DPF Differential Pressure (DPFDP)

7. Look for sensor values that are out of specification. A sensor out of specification could cause abnormal operating behavior, incorrect fueling, and injection timing problems.
   - If sensor is out of specification, go to the suspect sensor in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If sensors are within specification, continue to next step.

8. Use ServiceMaxx™ software to run Actuator Test.

9. Record EGR Valve Position and Engine Throttle Position values at 5% (closed) and 95% (open) on Diagnostics Form.
   - If either signal is not within specification, go to the suspect actuator in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”

10. Look for sensor values that are not within specification. A sensor out of specification could cause air management problems.

11. Make sure vehicle air tanks are full before proceeding to next step.

12. Use ServiceMaxx™ software to run Actuator Test.

13. Visually monitor movement of Exhaust Back Pressure Valve (EBPV). Record results on Diagnostics Form.

    NOTE: ServiceMaxx™ software does not have an EBPV feedback position signal.

    - If EBPV does not move, go to Exhaust Back Pressure Valve (page 163) in “PERFORMANCE DIAGNOSTICS.”

14. Use ServiceMaxx™ software to monitor DPF status. Record results on Diagnostics Form.
    - If DPF status is Regen needed - critical level, disconnect exhaust system upstream of Pre-Diesel Oxidation Catalyst (PDOC) and attempt to start engine. If engine starts, go to AFT System (page 217) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.” If engine does not start, continue with Hard Start and No Start diagnostics.

4. Check for Diagnostic Trouble Codes (DTCs)

NOTE: 2010 model year vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI) are displayed in the DTC Window.

- **Suspect Parameter Number (SPN) – The SPN identifies the individual component causing the DTC.**
- **Failure Mode Indicator (FMI) – The FMI identifies the fault or condition affecting the individual component.**
- **Pending DTCs are possible emission faults that were detected on first drive cycle.**
- **Active DTC are faults that are present now or emission faults that were detected on two consecutive drive cycles.**
- **Previously Active or Healing DTCs are historical faults. These faults may have been cause by an intermittent or operating condition which is not currently present.**

Purpose

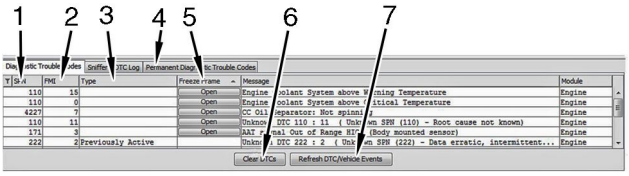
Identify DTCs.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.



V00134a

Figure 58 DTC window

1. Suspect Parameter Number (SPN)
2. Failure Mode Indicator (FMI)
3. Fault Code Type
4. Permanent Diagnostic Trouble Codes tab
5. Freeze Frame
6. Clear DTCs button
7. Refresh DTC/Vehicle Events button

4. Record DTCs and Freeze Frame Data on Diagnostics Form.
   - Correct any active DTCs. See “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - Investigate any previously active, pending, or healing DTCs for possible intermittent operating conditions in which the DTC was set.

NOTE: Freeze Frame Data is a snapshot of all influencing signals at the time the DTC was set. This can help diagnose hard to duplicate failures. Freeze Frame Data is cleared as soon as the DTC is cleared.

5. Engine Cranking

Purpose

Determine which system is causing the hard start or no start condition.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- Digital Multimeter (DMM)

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Hard Start - No Start session.

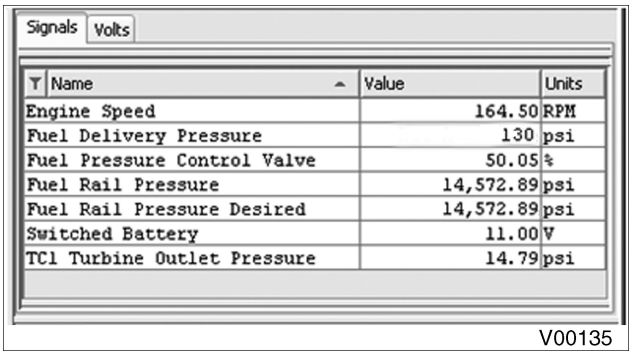


Figure 59 Hard Start - No Start session signals

NOTE: ServiceMaxx™ software displays Fuel Delivery Pressure (FDP) signal 15 psi below actual gauge pressure. See Appendix A (page 953) for specifications.

5. Monitor the following signals:
   - Switched Battery (SWBAT)
   - Engine Speed (RPM)
   - Fuel Delivery Pressure (FDP)
   - Fuel Rail Pressure (FRP)
   - TC1 Turbine Output Pressure (TC1TOP)

CAUTION: To prevent damage to the starter, if engine fails to start within 10 seconds, release ignition switch and wait 2 to 3 minutes to allow starter motor to cool.

6. Press the record button and crank engine for a maximum of 20 seconds.
7. Review engine cranking results and record on Diagnostics Form.
   - If FDP takes a long time to build during engine crank, but engine starts after starting pressure is met, check fuel supply line for fuel draining back to the remote-mounted primary fuel filter.
   - If SWBAT voltage drops below specification, continue to step 8.
   - If Engine Speed remains at 0.00 rpm with engine rotating, see CMP Sensor (page 393) and CKP Sensor (page 382) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If Engine Speed is below specification, check batteries and starting system.
   - If FDP is below specification, go to Low-pressure Fuel System (page 127).
   - If FDP is within specification, but FRP is below specification, go to Fuel Rail Pressure (FRP) Circuit Test (page 135).
   - If TC1TOP is above specification, disconnect exhaust just before Pre-Diesel Oxidation Catalyst (PDOC) and try to start engine. If engine starts, see AFT System (page 217) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”

   NOTE: If all values are within specification and the engine is normally subjected to temperatures below 10° C (50° F), go to Inlet Air Heater System Test (page 140).
8. Connect DMM to battery and monitor voltage during engine cranking.
   - If voltage stays within specification, go to ECM Power (page 589) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If voltage drops below specification, check batteries and starting system. Connect battery charger and repeat test.

Special Test Procedures

Fuel System

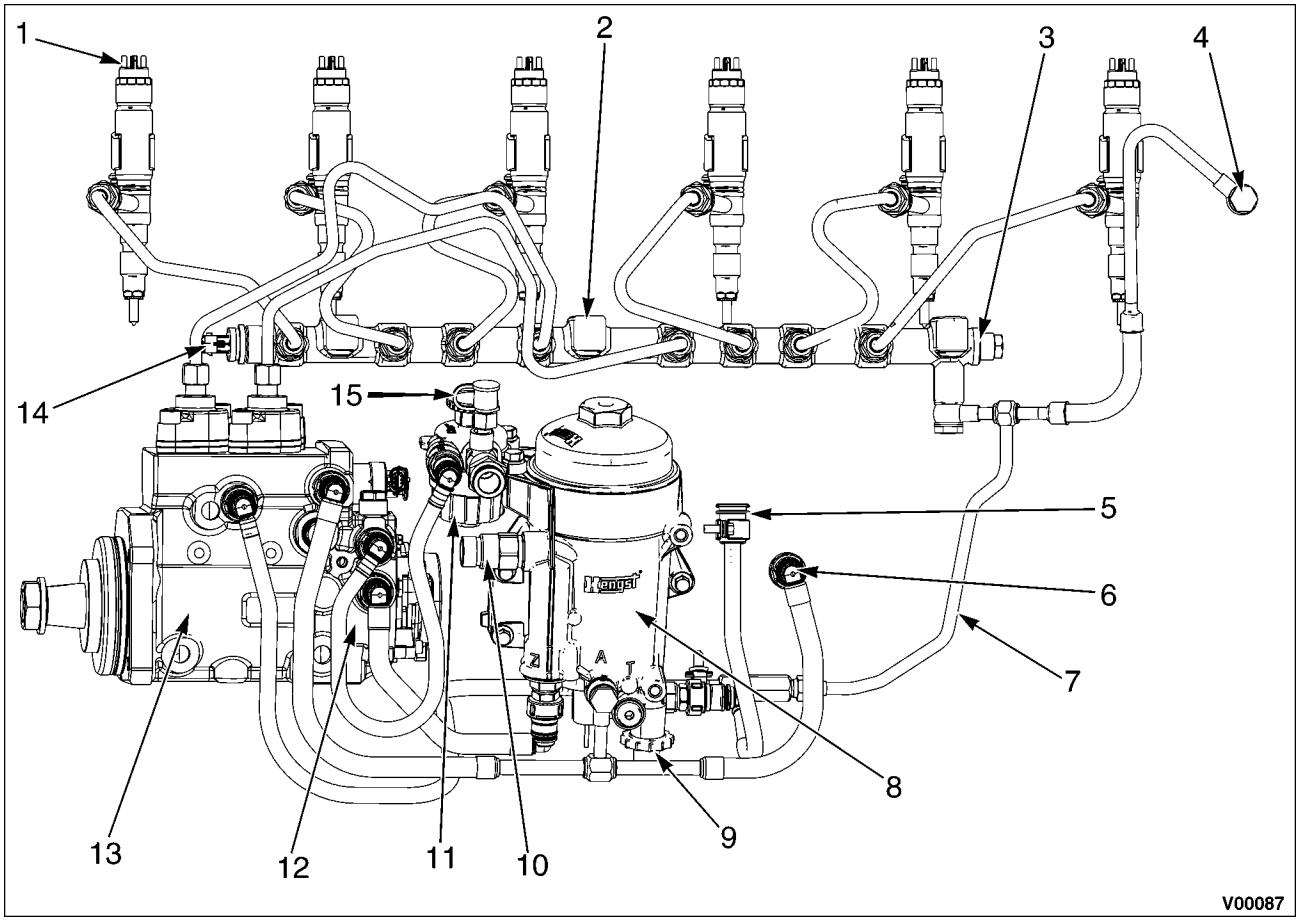


Figure 60 Fuel system

1. Injector (6)
2. Fuel Rail
3. Fuel rail pressure limiting valve
4. Fuel return from cylinder head
5. Engine fuel return connection (to chassis filter)
6. Fuel supply to DSI unit
7. Fuel return line
8. Fuel filter assembly
9. Drain screw
10. Fuel Delivery Pressure (FDP) sensor
11. Fuel strainer
12. LP fuel pump
13. HP fuel pump
14. Fuel Rail Pressure (FRP) sensor
15. Fuel primer pump

Low-pressure Fuel System

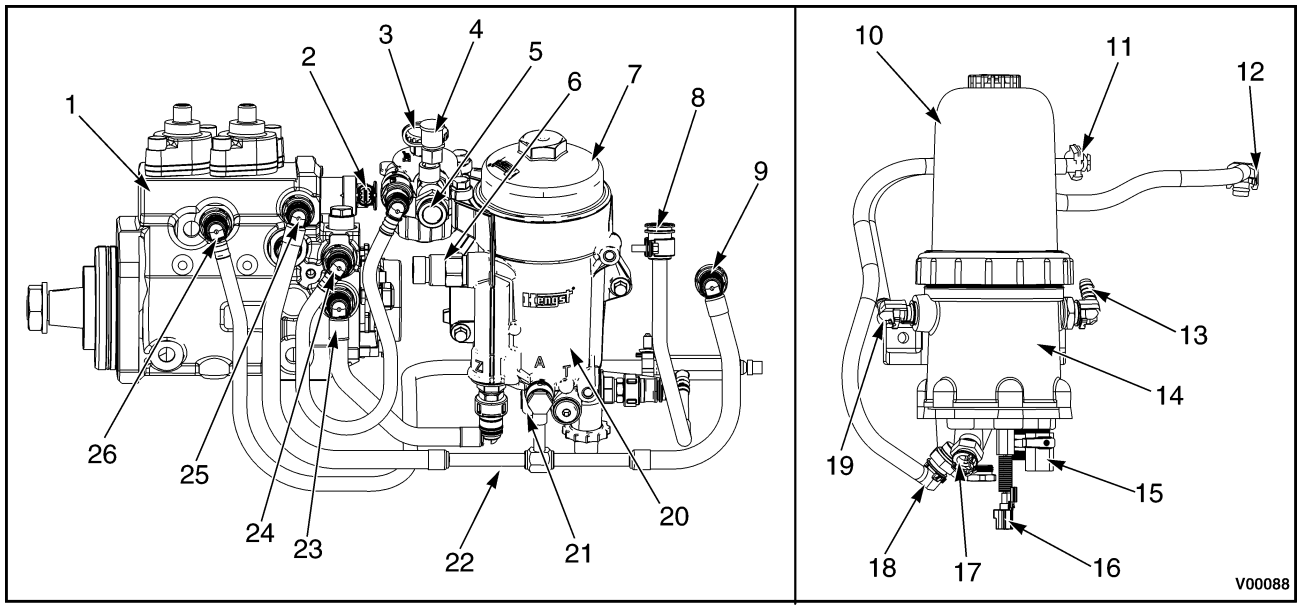


Figure 61 Low-pressure (LP) fuel system

1. HP fuel pump
2. Fuel Pressure Control Valve (FPCV)
3. Fuel primer pump assembly w/ fuel strainer element
4. Fuel pressure test port
5. Engine fuel supply connection
6. FDP sensor
7. Engine mounted secondary fuel filter access
8. Engine fuel return connection
9. Fuel supply to DSI unit
10. Chassis mounted primary fuel filter access
11. Fuel supply to engine
12. Fuel return from engine
13. Fuel supply from tank
14. Chassis mounted fuel filter/water separator
15. Fuel Heater
16. Water In Fuel (WIF) sensor
17. Fuel return to tank
18. Fuel return from engine
19. Fuel supply to engine
20. Engine mounted fuel module
21. Inlet air heater port
22. Low pressure fuel supply line
23. LP fuel pump outlet
24. LP fuel pump inlet
25. HP fuel pump inlet
26. HP fuel pump return

Fuel System Priming

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, store diesel fuel properly in an approved container designed for and clearly marked DIESEL FUEL.

Purpose

Prime the fuel system.

Tools

None

Procedure

1. Verify there is fuel in fuel tank.



Figure 62 Fuel primer pump

2. Pump fuel primer pump until fuel fills the system.
   - If fuel does not pull from fuel tank, go to Fuel Restriction Test (page 133).

Fuel Delivery Pressure (FDP) Test

NOTE: Perform this test if directed here from Engine Cranking test (page 125).

Purpose

Verify there is sufficient fuel pressure in low-pressure fuel system to start engine.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4891 – Air Cap, Fuel Cap, and Plug Kit

Procedure

CAUTION: To prevent damage to engine, plug component connections immediately after each fuel line is removed using clean fuel system caps.

NOTE: Ensure fuel lines are clear of heavy debris before breaking fuel line connections.

1. With the engine OFF, disconnect fuel supply line at low-pressure fuel pump inlet.
2. Use Air Cap, Fuel Cap, and Plug Kit ZTSE4891 to cap disconnected fuel supply line.

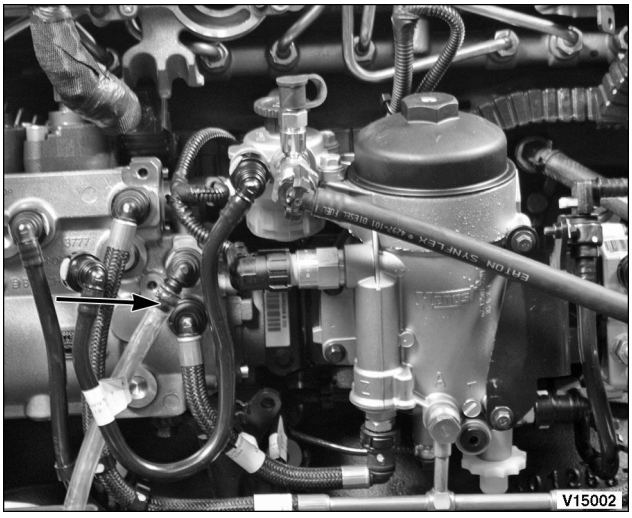


Figure 63 Clean Fuel Source Tool connected to low-pressure fuel pump inlet

3. Connect Clean Fuel Source Tool 15–637–01 to low-pressure fuel pump inlet.
4. Crank engine to remove air from fuel lines.
5. Turn ignition switch to ON, engine OFF.
6. Connect EST to vehicle's Diagnostic Connector.
7. Start ServiceMaxx™ software.
8. Select Hard Start - No Start session.

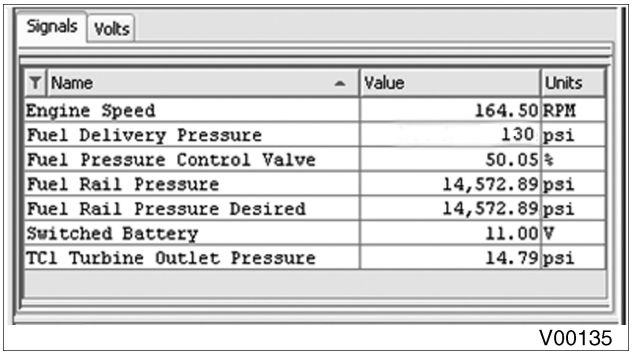


Figure 64 Hard Start - No Start session signals

9. Crank engine for 20 seconds while monitoring Fuel Delivery Pressure (FDP) signal. Record results on Diagnostics Form.

   NOTE: ServiceMaxx™ software displays Fuel Delivery Pressure (FDP) signal 15 psi below actual gauge pressure. See Appendix A (page 953) for specifications.

   - If FDP is below specification, go to Fuel Dead Head Test.
   - If FDP builds above specification, go to Fuel Aeration Test (page 131).

Fuel Dead Head Test

Purpose

Isolate fuel pump to determine if it is able to build proper pressure.

Tools

- ZTSE4526 - Compucheck Fitting
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool

Procedure

1. Retain connection between Clean Fuel Source Tool 15–637–01 and low-pressure fuel pump inlet from previous test.
2. Disconnect fuel line from low-pressure fuel pump outlet.

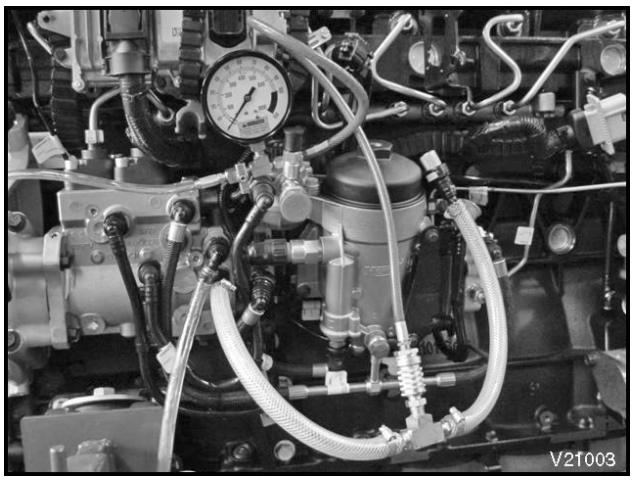


Figure 65 Fuel Inlet Restriction / Aeration Tool ZTSE4886 connected to low-pressure fuel pump outlet.

3. Connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 to low-pressure fuel pump outlet.
4. Use ZTSE4526 - Compucheck Fitting to connect Fuel Pressure Gauge to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
5. Connect Fuel Block Off Tool to Fuel Restriction / Aeration Tool ZTSE4886.
6. Crank engine to remove air from fuel lines.
7. Crank engine until fuel pressure stabilizes or up to a maximum of 20 seconds.
8. Record gauge pressure on Diagnostics Form.
   - If pressure is within specification, inspect secondary fuel filter, stand pipe, and housing for defects or damage. If no defect or damage is found, go to Fuel Rail Pressure (FRP) Return Flow Test.
   - If pressure is below specification, replace fuel pump following procedures in the *Engine Service Manual*. To prevent damage to a newly installed fuel pump and to verify high back pressure did not cause fuel pump to fail, perform HP Pump Fuel Return Pressure Test (page 139) any time fuel pump is replaced.

NOTE: Before installing a new fuel pump, ensure new fuel pump is the correct replacement part.

Fuel Aeration Test

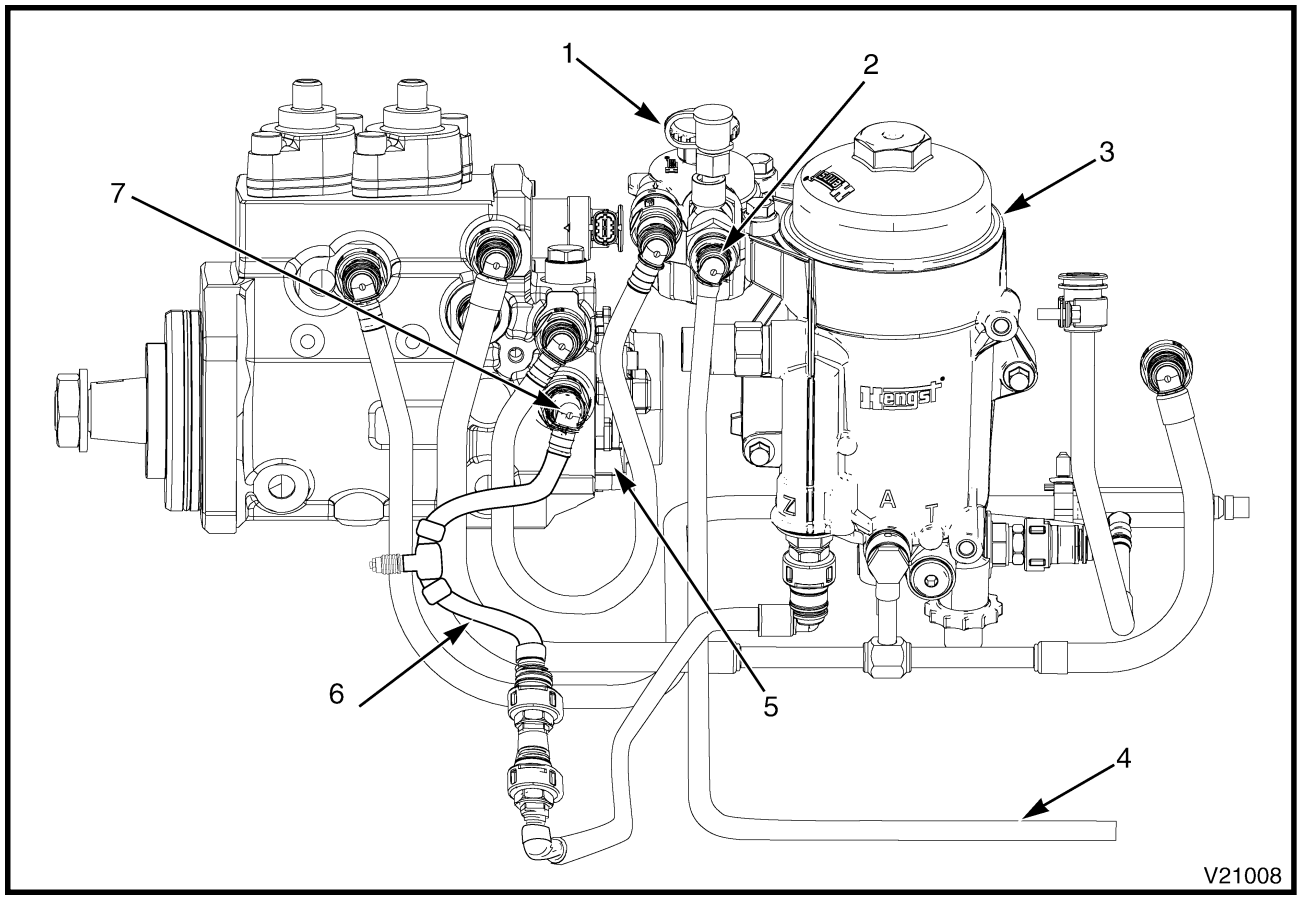


Figure 66 Fuel aeration test diagram

1. Strainer / primer pump
2. Aeration test point 2
3. Secondary fuel filter
4. Fuel supply from primary fuel filter
5. Low-pressure fuel pump
6. Fuel Inlet Restriction / Aeration Tool ZTSE4886
7. Aeration test point 1

Purpose

Check for fuel aeration.

Tools

- 15-637-01 – Clean Fuel Source Tool
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool
- ZTSE4906 – Fuel Line Coupler

Procedure

Aeration Test Point 1

1. Remove Clean Fuel Source Tool 15-637-01 from low-pressure fuel pump inlet.
2. Use Fuel Line Coupler ZTSE4906 to connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 between fuel supply line to secondary fuel filter and low-pressure fuel pump outlet.
3. Prime fuel system by pumping primer pump.
4. Crank engine while visually monitoring for fuel aeration (air bubbles passing through the clean line). Record results on Diagnostics Form.
    - If fuel is not aerated, go to Fuel Restriction Test.
    - If fuel is aerated, go to Aeration Test Point 2.

Aeration Test Point 2

1. Connect Clean Fuel Source Tool 15-637-01 to primer pump inlet.
2. Prime fuel system by pumping primer pump.
3. Crank engine while visually monitoring for fuel aeration (air bubbles passing through the clean line). Record results on Diagnostics Form.
    - If fuel is not aerated, repair open in fuel supply line between fuel primer pump and fuel tank.
    - If fuel is aerated, repair open in low-pressure fuel pump supply line or fuel primer pump.

Fuel Restriction Test

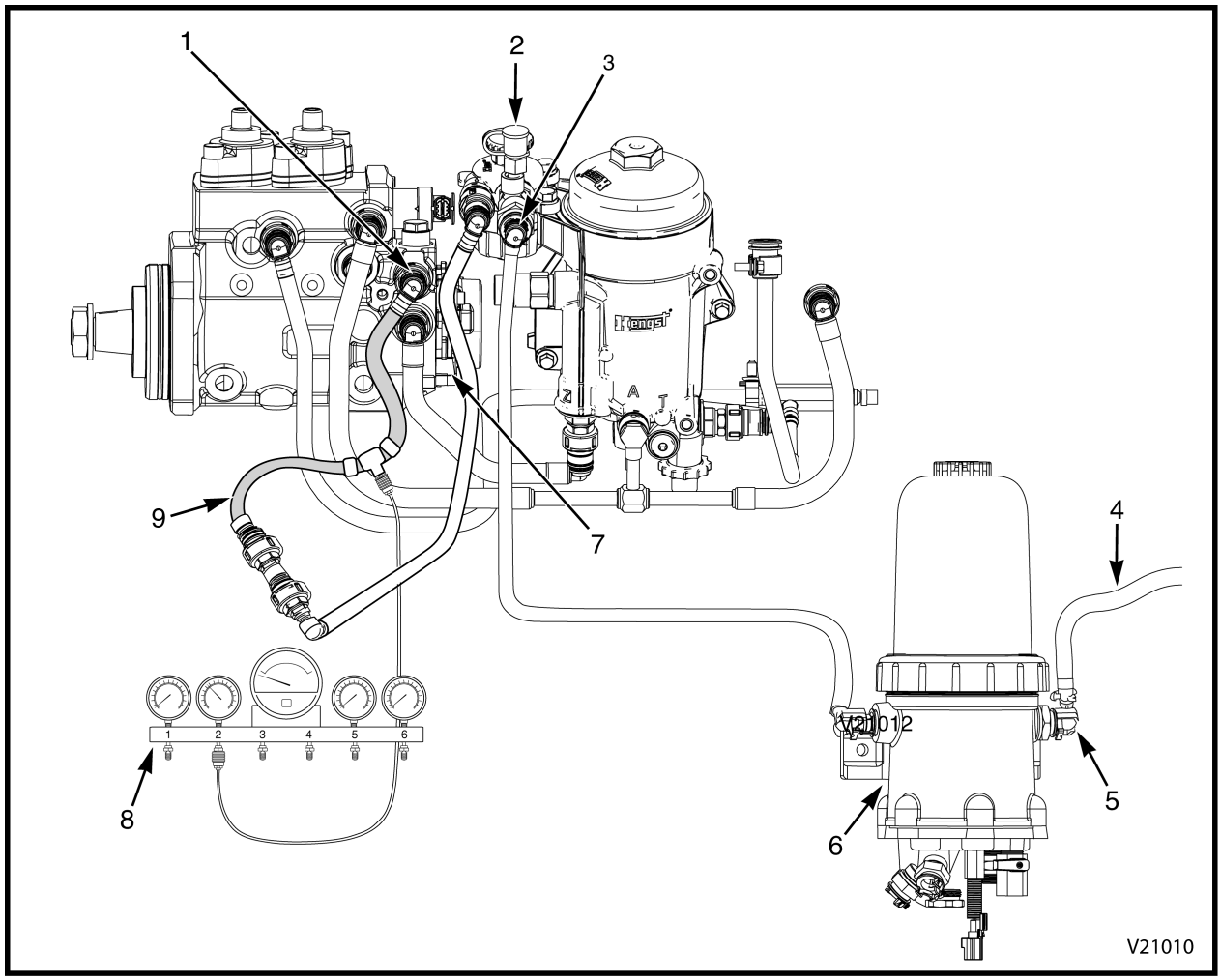


Figure 67 Fuel restriction test diagram

1. Fuel restriction test point 1
2. Strainer / primer pump
3. Fuel restriction test point 2
4. Fuel supply from tank
5. Fuel restriction test point 3
6. Primary fuel filter
7. Low-pressure fuel pump
8. Pressure Test Kit ZTSE4409 (vacuum gauge)
9. Fuel Inlet Restriction / Aeration Tool ZTSE4886

Purpose

Check for fuel supply restriction.

Tools

- ZTSE4526 - Compucheck Fitting
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4906 – Fuel Line Coupler

Procedure

Restriction Test Point 1

1. Use Fuel Line Coupler ZTSE4906 to connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 between low-pressure fuel pump supply line and low-pressure fuel pump inlet.
2. Connect Pressure Test Kit ZTSE4409 vacuum gauge to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
3. Prime fuel system by pumping primer pump.
4. Crank engine while monitoring Pressure Test Kit ZTSE4409 vacuum gauge. Record results on Diagnostics Form.
    - If restriction is within specification, verify Fuel Delivery Pressure (FDP) sensor reading with gauge. If FDP gauge reading is within specification, go to High-pressure Fuel System (page 135).
    - If restriction is above specification, go to Restriction Test Point 2.

Restriction Test Point 2

1. Connect Clean Fuel Source Tool 15-637-01 to primer pump inlet.
2. Prime fuel system by pumping primer pump.
3. Crank engine while monitoring Pressure Test Kit ZTSE4409 vacuum gauge. Record results on Diagnostics Form.
    - If restriction is within specification, go to Restriction Test Point 3.
    - If restriction is above specification, repair or replace fuel strainer and primer pump assembly, and check fuel lines.

Restriction Test Point 3

1. Connect Clean Fuel Source Tool 15-637-01 to primary fuel filter inlet.
2. Prime fuel system by pumping primer pump.
3. Crank engine while monitoring Pressure Test Kit ZTSE4409 vacuum gauge. Record results on Diagnostics Form.
    - If restriction is within specification, repair restriction between primary fuel filter and fuel tank.
    - If restriction is above specification, replace primary fuel filter, clean fuel strainer, and check fuel lines.

High-pressure Fuel System

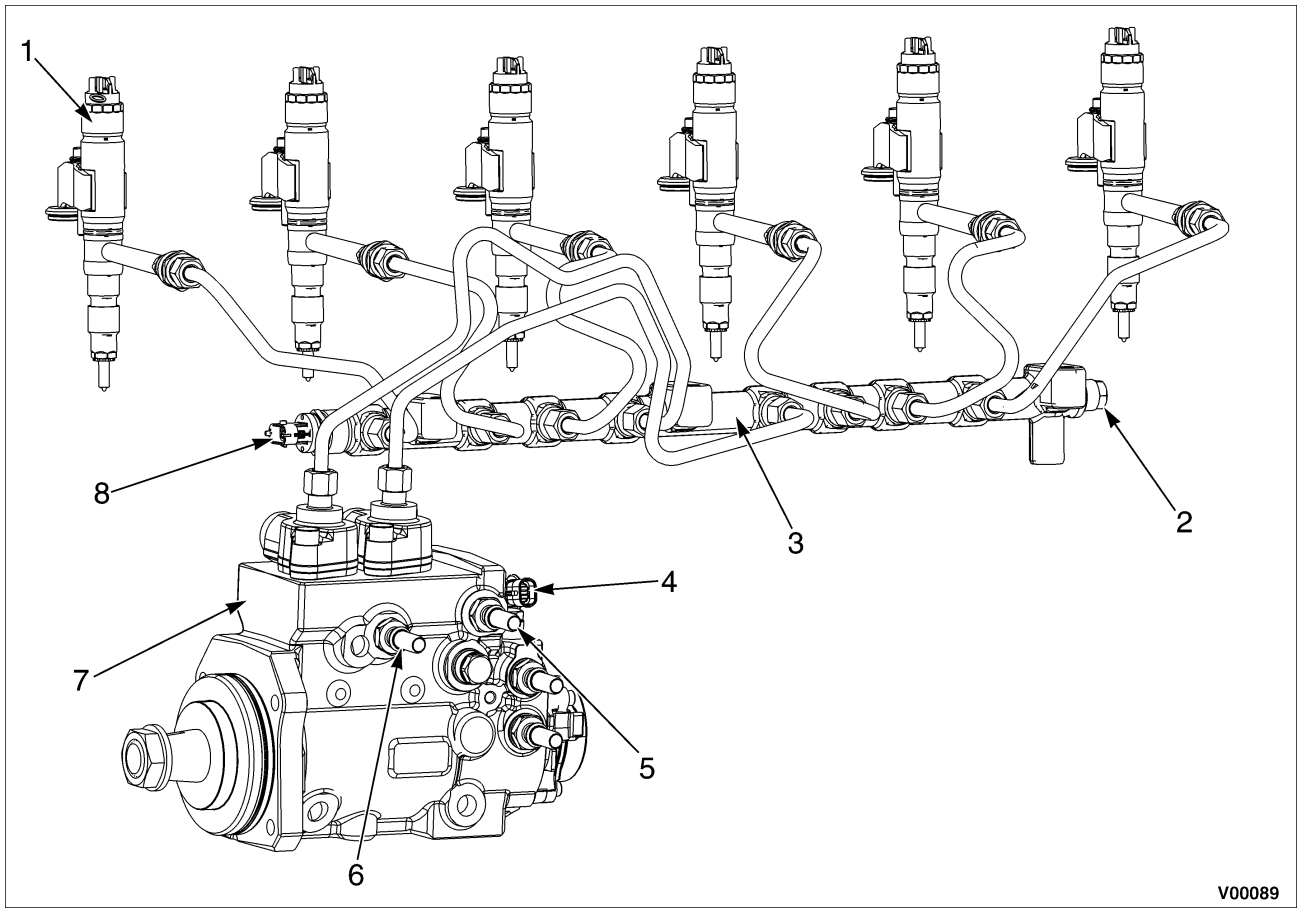


Figure 68 High-pressure (HP) fuel system

1. Injector (6)
2. Fuel rail pressure limiting valve
3. Fuel Rail
4. Fuel Pressure Control Valve (FPCV)
5. HP fuel pump inlet
6. HP fuel pump return
7. HP fuel pump
8. Fuel Rail Pressure (FRP) sensor

Fuel Rail Pressure (FRP) Circuit Test

Purpose

Verify whether FRP sensor is biased.

Tools

None

Procedure

1. Disconnect the FRP sensor electrical connector and attempt to start engine.
   - If engine starts, diagnose FRP sensor circuits. See FRP Sensor (page 683) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If the engine does not start, reconnect FRP sensor and go to High-pressure Pump Inlet Pressure Test.

High-pressure Pump Inlet Pressure Test

Purpose

Verify high-pressure fuel pump is receiving fuel.

Tools

- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool
- ZTSE4906 – Fuel Line Coupler

Procedure

1. Disconnect fuel supply to Down Stream Injection (DSI) valve assembly.
2. Use Fuel Line Coupler ZTSE4906 to connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 to DSI fuel supply line.

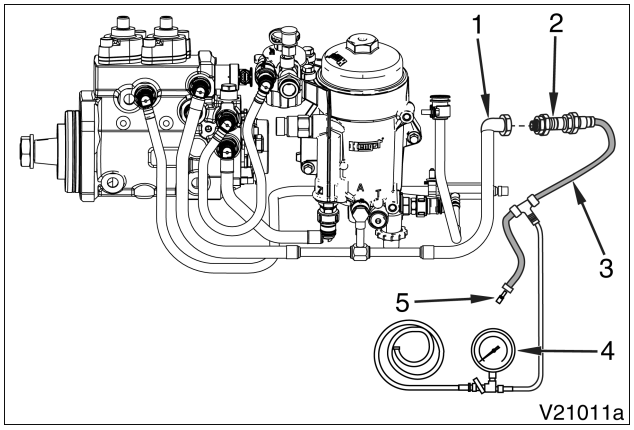


Figure 69 Fuel Pressure Gauge connected to DSI fuel supply line

1. DSI Fuel Supply Line
2. Fuel Line Coupler ZTSE4906
3. Fuel Inlet Restriction / Aeration Tool ZTSE4886
4. Fuel Pressure Gauge ZTSE4681
5. Fuel Block Off Tool ZTSE4905

3. Connect Fuel Block Off Tool ZTSE4905 to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
4. Connect Fuel Pressure Gauge ZTSE4681 to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
5. Crank engine while monitoring Fuel Pressure Gauge ZTSE4681. Record results on Diagnostics Form.
   - If gauge pressure is within specification, go to High-pressure Fuel Return Flow Test.
   - If gauge pressure is below specification, replace secondary fuel filter and go to HP Pump Return Flow Test (page 139).

Fuel Rail Pressure (FRP) Return Flow Test

Purpose

Verify return flow is within specifications.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- Diesel fuel container
- ZTSE4887 – High Pressure Return Line Tester

Fuel Rail Pressure (FRP) Return Flow Test Part 1

NOTE: Before running this test, ensure low-pressure fuel system is operating correctly.

1. Disconnect fuel drain tube assembly at rear of cylinder head.

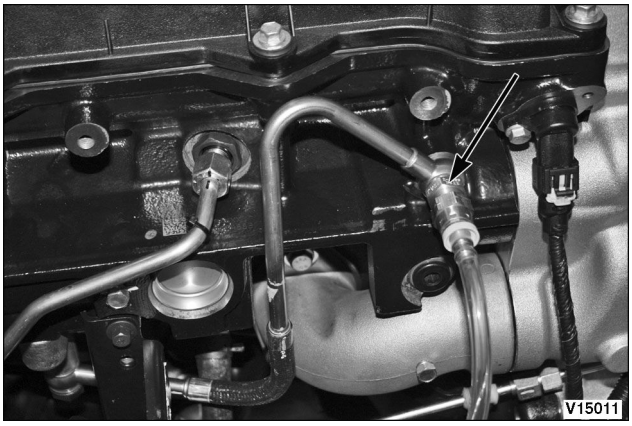


Figure 70 High Pressure Return Line Tester ZTSE4887 connected to cylinder head

2. Connect High Pressure Return Line Tester ZTSE4887-2 using 2 banjo ring seals to cylinder head fuel drain tube fitting. Thread ZTSE4887-3 to ZTSE4887-2 and route the end into a diesel fuel container.
3. Crank engine for 20 seconds while monitoring fuel return from High Pressure Return Line Tester ZTSE4887.
    - If fuel is returning, go to Fuel Rail Pressure (FRP) Leak Isolation.
    - If no fuel is returning, continue to next step.

Fuel Rail Pressure (FRP) Return Flow Test Part 2

NOTE: Before running this test, ensure low-pressure fuel system is operating correctly.

4. Reconnect fuel drain tube assembly disconnected in step 1.
5. Disconnect fuel rail return line at fuel rail.
6. Connect High Pressure Return Line Tester ZTSE4887-2 using 2 banjo ring seals to fuel rail return port. Thread ZTSE4887-3 to ZTSE4887-2 and route the end into a diesel fuel container.
7. Crank engine and monitor fuel return from High Pressure Return Line Tester ZTSE4887.
    - If fuel flows from High Pressure Return Line Tester ZTSE4887, replace fuel rail pressure relief valve.
    - If fuel does not flow from High Pressure Return Line Tester ZTSE4887, go to HP Pump Return Flow Test.

Fuel Rail Pressure (FRP) Leak Isolation

Purpose

Isolate pressure loss in high-pressure fuel system.

Tools

- Diesel fuel container
- ZTSE4887 – High Pressure Rail Return Line Tester
- ZTSE6098 – High Pressure Rail Plugs

Procedure

WARNING: The high-pressure fuel system may have extremely high pressure. Verify pressure is below 500 psi before cracking a line. Every time the engine is shut down and the key is in the OFF position, the ECM commands a blank shot injection process that drains the high-pressure fuel rail.

NOTE: Perform this procedure only if engine does NOT START because of low or nonexistent Fuel Rail Pressure (FRP).

1. Retain High Pressure Return Line Tester ZTSE4887 connection to cylinder head from previous test.

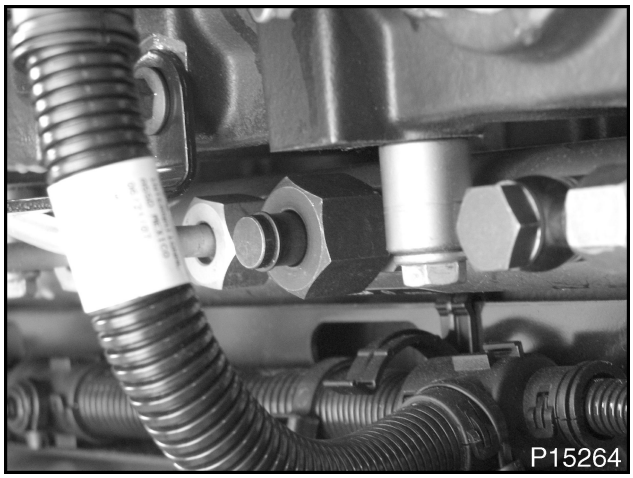


Figure 71 High Pressure Rail Plug installed on injector six

2. Disconnect number six injector fuel line and cap off rail with High Pressure Rail Plug ZTSE6098.
3. Crank engine while monitoring fuel leaking out of High Pressure Return Line Tester ZTSE4887.
   - If fuel is leaking out of High Pressure Return Line Tester ZTSE4887, leave High Pressure Rail Plug ZTSE6098 connected. Continue capping off one injector supply port at a time until fuel rail builds starting pressure. Once starting pressure is met, replace the removed injector tubes with new parts. Verify engine will start.
   - If fuel is not leaking out of High Pressure Return Line Tester ZTSE4887 and fuel rail builds starting pressure, replace number six injector tube and fuel pipe.

HP Pump Fuel Return Pressure Test

Purpose

Verify return flow is within specifications.

Tools

- ZTSE4526 - Compucheck Fitting
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4906 – Fuel Line Coupler

Procedure

NOTE: Prior to performing this test, ensure new fuel pump is the correct replacement part.

1. Restore fuel system to normal operating condition.
2. Disconnect high-pressure fuel pump return line.

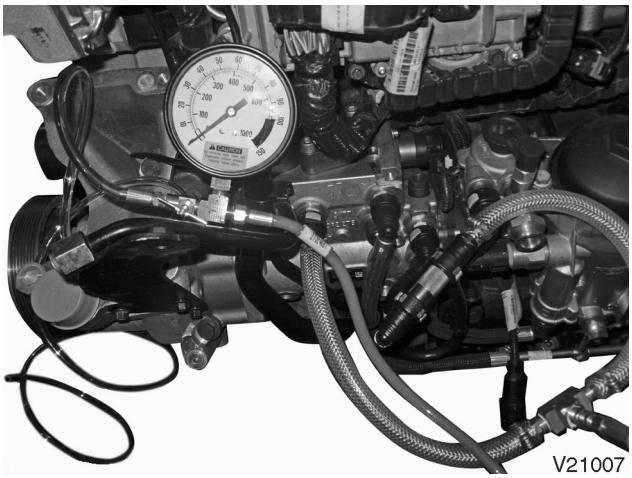


Figure 72 High-pressure fuel pump return line connected to Fuel Pressure Gauge ZTSE4681

3. Use Fuel Line Coupler ZTSE4906 to connect high-pressure fuel pump return line to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
4. Use ZTSE4526 - Compucheck Fitting to connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 to Fuel Pressure Gauge ZTSE4681.
5. Start engine and run high idle while monitoring Fuel Pressure Gauge ZTSE4681.
   - If pressure is above specification, inspect fuel return line between high-pressure fuel pump and fuel tank for restriction.
   - If pressure is below specification, no further action is required.

HP Pump Return Flow Test

Purpose

Verify fuel is flowing from high-pressure return.

Tools

- 15-637-01 - Clean Fuel Source Tool
- ZTSE4905 – Fuel Block Off Tool

Procedure

1. Disconnect high-pressure fuel pump return line, and connect Fuel Block Off Tool ZTSE4905 to the line.
2. Connect 15-637-01 Clean fuel source tool to the HP fuel pump fuel return port. Verify the shutoff valve is Open.
3. Crank engine for 20 seconds while monitoring fuel return from High Pressure Return Line Tester ZTSE4887.
   - If fuel is flowing from the return port into 15-637-01 Clean fuel source tool, replace Piston Overflow Valve (KUEV) valve.
   - If fuel does not flow from the return port into 15-637-01 Clean fuel source tool, replace fuel pump. Refer to the *Engine Service Manual* for replacement procedure and perform HP Pump Fuel Return Pressure Test to verify high back pressure did not cause fuel pump failure.

Inlet Air Heater System

⚠ WARNING: To prevent personal injury or death, do not smoke or park vehicle near open flames or sparks when taking a fuel sample.

⚠ WARNING: To prevent personal injury or death, make sure the parking brake is set, the transmission is in neutral or park, and the wheels are blocked when running the engine in the service bay.

Inlet Air Heater System Test

Purpose

Verify inlet air heater system is working correctly at any temperature.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

NOTE: Inlet Air Heater is commanded ON when Engine Coolant Temperature 1 (ECT1) is below 10 °C (50 °F).

Post production, ServiceMaxx™ software will have the ability to run Inlet Air Heater at higher temperatures.

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Hard Start - No Start session.
5. Monitor Engine Coolant Temperature 1 (ECT1).
   - If ECT1 is above 10 °C (50 °F), use ServiceMaxx™ software to run Inlet Air Heater procedure.
   - If ECT1 is below 10 °C (50 °F), continue to next step.

   NOTE: The ECM may take 15 seconds or longer to reset between ignition switch cycles.
6. Cycle ignition switch and monitor Wait to Start lamp in vehicle's dashboard.
7. When Wait to Start lamp begins flashing, crank engine while monitoring Intake Manifold Temperature (IMT) and Fuel Delivery Pressure (FDP). Record results on Diagnostics Form.
   - If IMT does not rise approximately 5.5 °C (10 °F) during engine crank, go to Inlet Air Heater Fuel Igniter (IAHFI) Test.
   - If IMT rises 5.5 °C (10 °F) during engine crank, the Inlet Air Heater system is working correctly.
   - If FDP is below specification, go to Low-pressure Fuel System (page 127).

Inlet Air Heater Fuel Igniter (IAHFI) Test

Purpose

Verify IAHFI is working properly.

Tools

- Digital Multimeter (DMM)
- EXP-1000 HD by Midtronics

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select 2010 BB Actuator session from the Sessions drop-down menu.

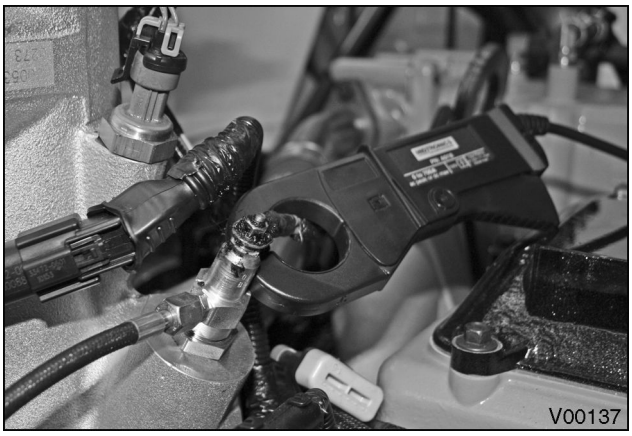


Figure 73 Current clamp on IAHFI

5. Connect EXP-1000 HD by Midtronics current clamp around IAHFI power circuit.
6. Select Inlet Air Heater Igniter from Actuator drop-down menu.
7. Press the Start Test button while monitoring current draw. Record results on Diagnostics Form.
   - If current draw is below specification, go to Inlet Air Heater Fuel Igniter (IAHFI) (page 411) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If current draw is above specification, IAHFI is working correctly. Continue to Fuel Supply at Inlet Air Heater Fuel Solenoid (IAHFS) Test.

Fuel Supply at Inlet Air Heater Fuel Solenoid (IAHFS) Test

Purpose

Verify sufficient fuel pressure is being supplied to the IAHFS.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE6059 – Inlet Air Heater Solenoid Test Adapter Kit

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Hard Start - No Start session.
5. Crank engine while monitoring Fuel Delivery Pressure (FDP).
   - If FDP is below specification, go to Fuel Delivery Pressure Test (page 129).
   - If FDP is within specification, continue to next step.
6. Disconnect fuel supply to IAHFS.

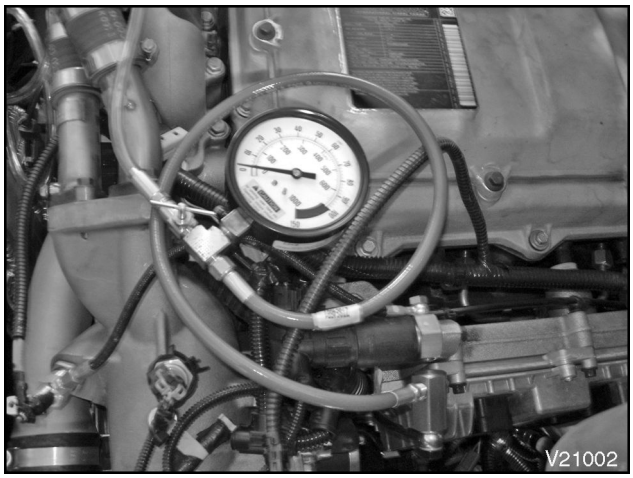


Figure 74 Fuel Pressure Gauge ZTSE4681 connected to IAHFS fuel supply line

7. Use Inlet Air Heater Solenoid Test Adapter Kit ZTSE6059 to connect Fuel Pressure Gauge ZTSE4681 to IAHFS fuel supply line.
8. Crank engine while monitoring Fuel Pressure Gauge ZTSE4681. Record results on Diagnostics Form.
   - If pressure is below specification, inspect IAHFS fuel supply line for restriction. If IAHFS fuel supply line is not restricted, replace fuel regulator in fuel filter housing.
   - If pressure is within specification, go to Fuel Supply at Inlet Air Heater Fuel Igniter (IAHFI) Test.

Fuel Supply at Inlet Air Heater Fuel Igniter (IAHFI) Test

Purpose

Verify sufficient fuel pressure is being supplied to the IAHFI.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE6059 – Inlet Air Heater Solenoid Test Adapter Kit

Procedure

NOTE: This test can only be run if ECT1 is below 10 °C (50 °F) or ServiceMaxx™ software can run the Inlet Air Heater procedure.

NOTE: Post production, ServiceMaxx™ software will have the ability to run Inlet Air Heater at higher temperatures.

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Hard Start - No Start session.
5. Reinstall fuel supply line to Inlet Air Heater Fuel Solenoid (IAHFS) disconnected in previous test.
6. Disconnect fuel supply to IAHFI.

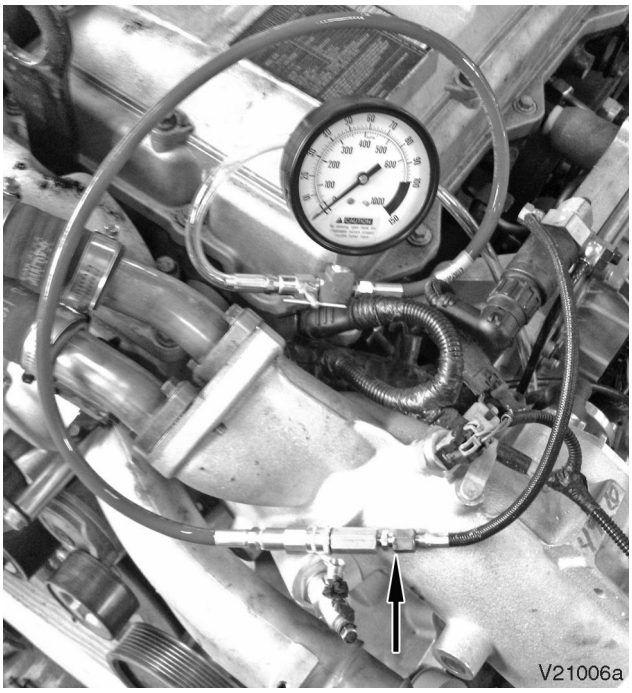


Figure 75 Fuel Pressure Gauge ZTSE4681 connected to IAHFI fuel supply line

7. Use Inlet Air Heater Solenoid Test Adapter Kit ZTSE6059 to connect Fuel Pressure Gauge ZTSE4681 to IAHFI fuel supply line.
8. Monitor Wait to Start lamp in vehicle's dashboard.
9. When Wait to Start lamp begins flashing, crank engine while monitoring Fuel Pressure Gauge ZTSE4681. Record results on Diagnostics Form.
   - If pressure is below specification, inspect IAHFI fuel supply line for restriction. If IAHFI fuel supply line is not restricted, see Inlet Air Heater Fuel Solenoid (page 411) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If pressure is within specification, replace IAHFI.

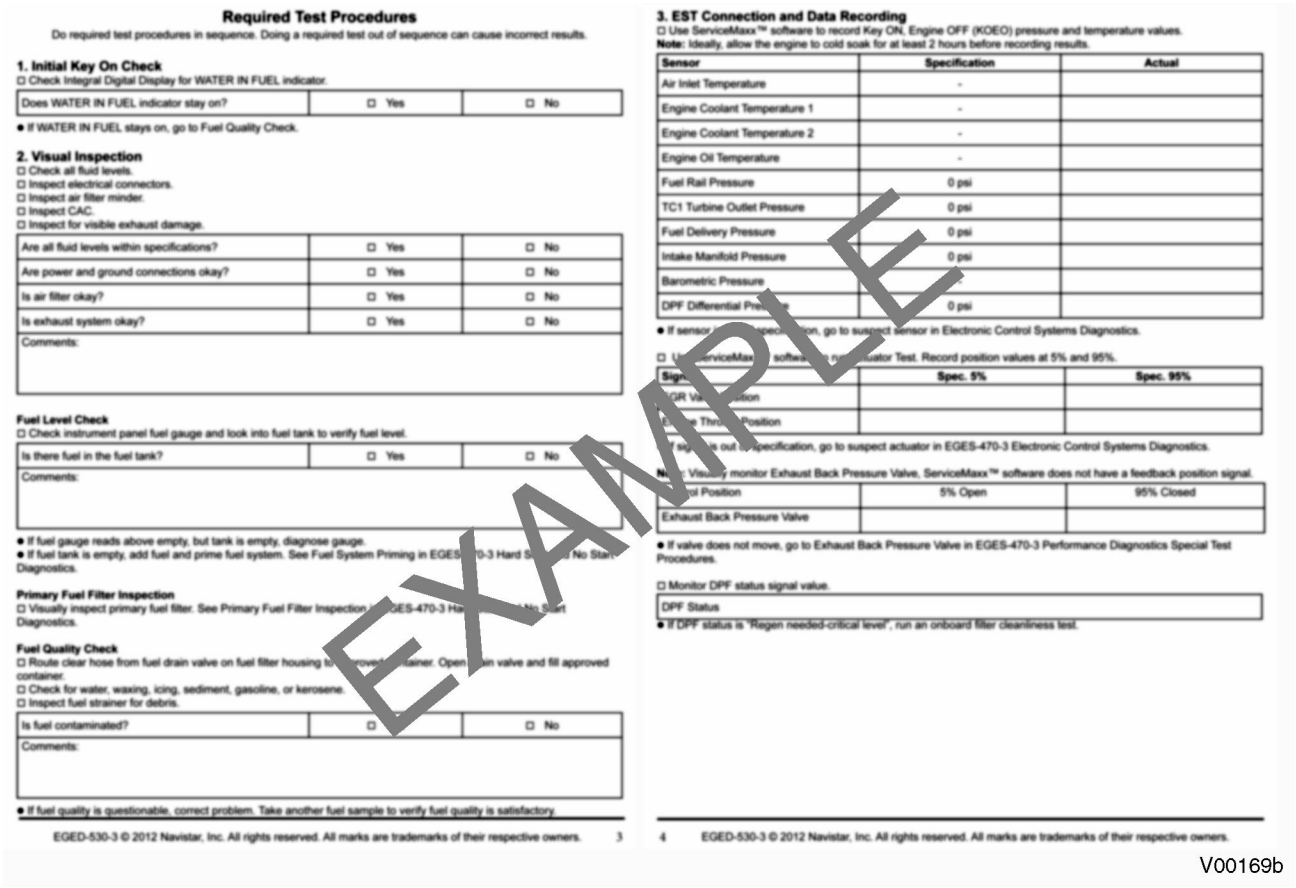
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Diagnostics Form EGED-530



Required Test Procedures

Do required test procedures in sequence. Doing a required test out of sequence can cause incorrect results.

1. Initial Key On Check

☐ Check Integral Digital Display for WATER IN FUEL indicator.

Does WATER IN FUEL indicator stay on?	☐ Yes	☐ No

● If WATER IN FUEL stays on, go to Fuel Quality Check.

2. Visual Inspection

☐ Check all fluid levels.
☐ Inspect electrical connectors.
☐ Inspect air filter minder.
☐ Inspect CAC.
☐ Inspect for visible exhaust damage.

Are all fluid levels within specifications?	☐ Yes	☐ No
Are power and ground connections okay?	☐ Yes	☐ No
Is air filter okay?	☐ Yes	☐ No
Is exhaust system okay?	☐ Yes	☐ No
Comments:		

Fuel Level Check

☐ Check instrument panel fuel gauge and look into fuel tank to verify fuel level.

Is there fuel in the fuel tank?	☐ Yes	☐ No
Comments:		

● If fuel gauge reads above empty, but tank is empty, diagnose gauge.
● If fuel tank is empty, add fuel and prime fuel system. See Fuel System Priming in EGES-470-3 Hard S... No Start Diagnostics.

Primary Fuel Filter Inspection

☐ Visually inspect primary fuel filter. See Primary Fuel Filter Inspection, EGES-470-3 Ha... No Start Diagnostics.

Fuel Quality Check

☐ Route clear hose from fuel drain valve on fuel filter housing t... container. Open drain valve and fill approved container.
☐ Check for water, waxing, icing, sediment, gasoline, or kerosene.
☐ Inspect fuel strainer for debris.

Is fuel contaminated?	☐	☐ No
Comments:		

● If fuel quality is questionable, correct problem. Take another fuel sample to verify fuel quality is satisfactory.

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3. EST Connection and Data Recording

☐ Use ServiceMaxx™ software to record Key ON, Engine OFF (KOEO) pressure and temperature values.
Note: Ideally, allow the engine to cold soak for at least 2 hours before recording results.

Sensor	Specification	Actual
Air Inlet Temperature	-	
Engine Coolant Temperature 1	-	
Engine Coolant Temperature 2	-	
Engine Oil Temperature	-	
Fuel Rail Pressure	0 psi	
TC1 Turbine Outlet Pressure	0 psi	
Fuel Delivery Pressure	0 psi	
Intake Manifold Pressure	0 psi	
Barometric Pressure		
DPF Differential Pressure	0 psi	

● If sensor ... specification, go to suspect sensor in Electronic Control Systems Diagnostics.

☐ Use ServiceMaxx™ software ... gurator Test. Record position values at 5% and 95%.

Sig...	Spec. 5%	Spec. 95%
EGR Valve Position		
... Throttle Position		

... out of specification, go to suspect actuator in EGES-470-3 Electronic Control Systems Diagnostics.

N...: Visually monitor Exhaust Back Pressure Valve, ServiceMaxx™ software does not have a feedback position signal.

...ol Position	5% Open	95% Closed
Exhaust Back Pressure Valve		

● If valve does not move, go to Exhaust Back Pressure Valve in EGES-470-3 Performance Diagnostics Special Test Procedures.

☐ Monitor DPF status signal value.

DPF Status

● If DPF status is "Regen needed-critical level", run an onboard filter cleanliness test.

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V00169b

EXAMPLE

Figure 76 Diagnostics Form EGED-530 (Performance Diagnostics)

The Performance Diagnostics Form directs technicians to systematically troubleshoot a performance condition and avoid unnecessary repairs.

This Diagnostic Manual section shows detailed instructions of the tests on the form. The manual should be used with the form and referenced for supplemental test information. Use the form as a worksheet to record test results.

Do all tests in sequence, unless otherwise stated. Doing a test out of sequence can cause incorrect results. If a problem was found and corrected, it is not necessary to complete the remaining tests.

See appropriate section for Diagnostic Trouble Codes (DTCs) and engine specifications.

To order technical service literature, contact your International dealer.

Diagnostics Form Vehicle Information and Complaint Page

Note: This form must be completed before calling for technical assistance.		
Technician:	Date:	Rated Power:
Software Identification:	Total Miles:	Engine On Time:
Vehicle Identification Number:		
Engine Serial Number:		
EDC Customer Unit Number:		
Transmission Type (select one): ☐ Manual ☐ Automatic		
Complaint:		

EXAMPLE

0000047998

1. Fill in the following information:
   - Technician
   - Date
   - Vehicle Identification Number (VIN)
   - EDC Customer Unit Number
   - Complaint (driver interview)

NOTE: Remaining information will be filled in later using information from the Electronic Service Tool (EST) with ServiceMaxx™ software.

Required Test Procedures

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, provide proper ventilation when operating an engine in a closed area. Inhalation of exhaust gas can be fatal.

Performance Specification Information See "APPENDIX A: PERFORMANCE SPECIFICATIONS" or "APPENDIX C: TECHNICAL SERVICE INFORMATION (TSI)" to obtain required specification information:

NOTE: Performance specifications may be periodically published in a Technical Service Information (TSI) format to support new model year products. Check service bulletin repository on Navistar® Service Portal for appropriate model year application.

1. Initial Key ON Check

Purpose

Determine if Engine Control Module (ECM) is powered up and if water is in fuel supply.

Tools

None

Procedure

1. Turn ignition switch to ON, engine OFF. Observe the following:
   - Wait to Start lamp
   - WATER IN FUEL indicator (Integral Digital Display)
2. Record results on Diagnostics Form.
   - If WATER IN FUEL indicator stays ON, go to Fuel Quality Check (page 154).

2. Visual Inspection

Purpose

Check all fluid levels and inspect engine systems for problems such as leaks, open connections, and harness chaffing.

Tools

None

Engine Oil

1. Park vehicle on level ground and check oil level.

   NOTE: Engine should be at normal operating temperature. Turn engine OFF. Wait 15 minutes for level to stabilize.

   NOTE: API CJ-4 oils are recommended for high speed diesel engines with advanced exhaust aftertreatment systems that meet 2007 and beyond on-highway exhaust emission standards.

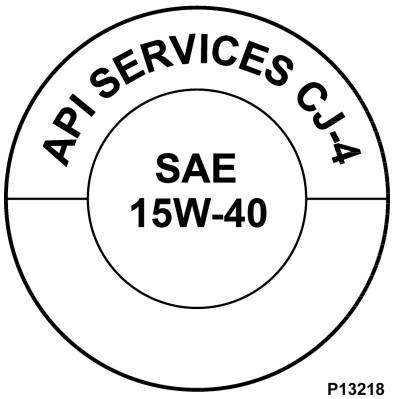


Figure 78 Lube oil requirements label

2. Use oil level gauge (dipstick) to verify engine oil level.

   NOTE: If oil is diluted or contaminated, oil and filter must be replaced.

3. Record results on Diagnostics Form.

   - If level is below specification, inspect for leaks, oil consumption, or improper servicing. If engine oil level is low, fill to specification.
   - If level is above specification, inspect for fuel dilution, coolant contamination, or improper servicing. If engine oil level is above specification, drain to proper level and diagnose contamination.

Engine Coolant Level

1. Park vehicle on level ground.

NOTE: Turn engine OFF and allow to cool. Ensure coolant temperature has stabilized to safe temperature and pressure.

2. Check coolant level as indicated on deaeration tank level window.

NOTE: Coolant in the exhaust could damage the DPF. Inspect DPF for damage. See AFT System (page 217) in "ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS" for inspection of the DPF.

3. Record results on Diagnostics Form.

   - If level is above or below deaeration tank fill level, inspect for leaks, coolant in oil, coolant in combustion exhaust, or improper servicing.
   - If coolant is contaminated, replace coolant.

Electrical System

1. Inspect batteries and electrical system (engine and vehicle) for poor or loose connections, corroded terminals, or broken and damaged wires.
2. Record results on Diagnostics Form.

   - If electrical system problem is found, make necessary repairs.

Intake Air

NOTE: Intake air restriction should be less than 172.3 kPa (51 in Hg) at full load, rated speed.

1. Inspect air filter gauge, located on air filter housing or dashboard.
2. Record results on Diagnostics Form.
   - If gauge indicates air filter requires replacement, verify there are no other restrictions in the air inlet or filter housing before replacing air filter.

Charge Air Cooler (CAC) System

1. Inspect CAC, interstage cooler, and all piping for leaks.
2. Inspect all CAC connections and clamps.
   - If CAC system problem is found, make necessary repairs. See Coolant Over-Temperature Conditions Inspection (page 87) in “ENGINE SYMPTOMS DIAGNOSTICS”.

Exhaust System

1. Inspect exhaust system (engine and vehicle) for restrictions, leaks, or damage.
2. Record results on Diagnostics Form.
   - If exhaust system problem is found, make necessary repairs.

Vehicle Air Tanks

1. Inspect vehicle air tanks for water.
   - If water is detected in air tanks, drain all water from air tanks.

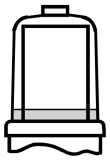
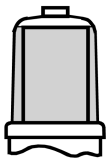
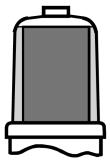
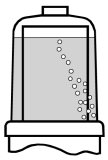
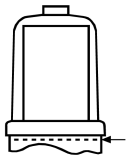
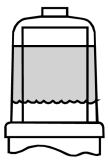
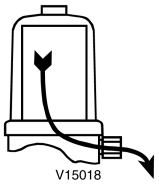
Fuel Level

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

1. Park vehicle on level ground.
2. Check instrument panel fuel gauge and look into fuel tank to verify fuel level.
3. Record results on Diagnostics Form.
   - If fuel gauge reads above empty, but tank is empty, diagnose instrument panel fuel gauge. Verify sufficient fuel level before diagnosing a pressure problem.
   - If fuel tank is empty, add fuel and prime fuel system. See Fuel System Priming (page 128) in “HARD START AND NO START DIAGNOSTICS.”

Primary Fuel Filter Inspection

Visually inspect primary fuel filter condition following the inspection table on next page.

Fuel Level	Visual Indication	Possible Solution
 V15021	Fuel level below top of fuel filter.	Normal - no repair necessary.
 V15013	Fuel level above top of fuel filter. May cause loss of power complaint.	Change primary fuel filter element.
 V15014	Fuel level is to top of fuel filter and looks to be full of wax.	1. Change primary fuel filter element 2. Run engine for a minimum of 25 minutes at idle. Do not run at high idle.
 V15015	Bubbles are seen flowing within fuel.	1. Check all fittings and lines from between fuel tank and chassis fuel filter assembly. 2. Check upper and lower connector O-rings.
 V15016	Loss of power complaint. Fuel level is below fuel filter housing collar.	1. Check for missing grommet at lower end of filter. 2. Check for missing or broken spring at top of primary fuel filter element.
 V15017	Water is seen (noticeable separation) in fuel filter assembly.	1. Inspect fuel tank(s) for water contamination. 2. Drain a full cup of fuel from chassis fuel filter assembly. **NOTE: Do not drain with engine running.** 3. Restart engine. Shut off engine and drain chassis fuel filter assembly. 4. Repeat step 3 until ALL water is removed.
 V15018	Fuel drains back to fuel tank when changing fuel filter or draining water separator.	1. Remove and inspect check valve assembly. 2. Repair (clean) or replace as necessary, and retest.

Fuel Quality Check

Purpose

Check for poor fuel quality or contaminants.

Tools

- Clear diesel fuel container
- Clear plastic hose

Procedure

NOTE: Ultra Low Sulfur Diesel (ULSD) fuel is required for MaxxForce® 11 and 13 diesel engines used with advanced aftertreatment systems.



Figure 79 Fuel requirements label

NOTE: WATER IN FUEL indicator illuminates ON, then OFF, on the Integral Digital Display if there is no water in the system. If WATER IN FUEL indicator stays ON, water is detected.

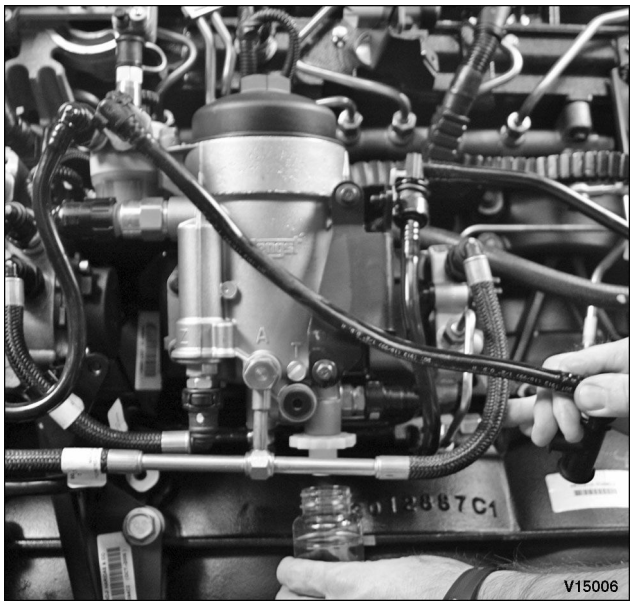


Figure 80 Fuel sample

1. Install clear plastic hose on fuel drain valve.
2. Route clear plastic hose into clear diesel fuel container.
3. Open fuel drain valve to fill container.

NOTE: If fuel does not flow, crank engine.

4. Check for water, waxing, icing, sediment, gasoline, Diesel Exhaust Fluid (DEF) or kerosene by shaking fuel sample container and letting contents settle. Record results on Diagnostics Form.
   - Sediments will fall to bottom of fuel sample container.
   - Gasoline and kerosene will separate from diesel fuel.
   - Waxing or icing will prevent diesel fuel from flowing out of fuel drain valve.
   - If fuel quality is questionable, repair as necessary. Take another sample to verify fuel quality is satisfactory.
   - If fuel quality is satisfactory, continue to Electronic Service Tool (EST) Connection and Data Recording test.

   NOTE: Do not continue diagnostic procedures if fuel is contaminated.
5. Inspect fuel strainer for debris. The fuel strainer is located in the fuel primer pump assembly.

3. Electronic Service Tool (EST) Connection and Data Recording

Purpose

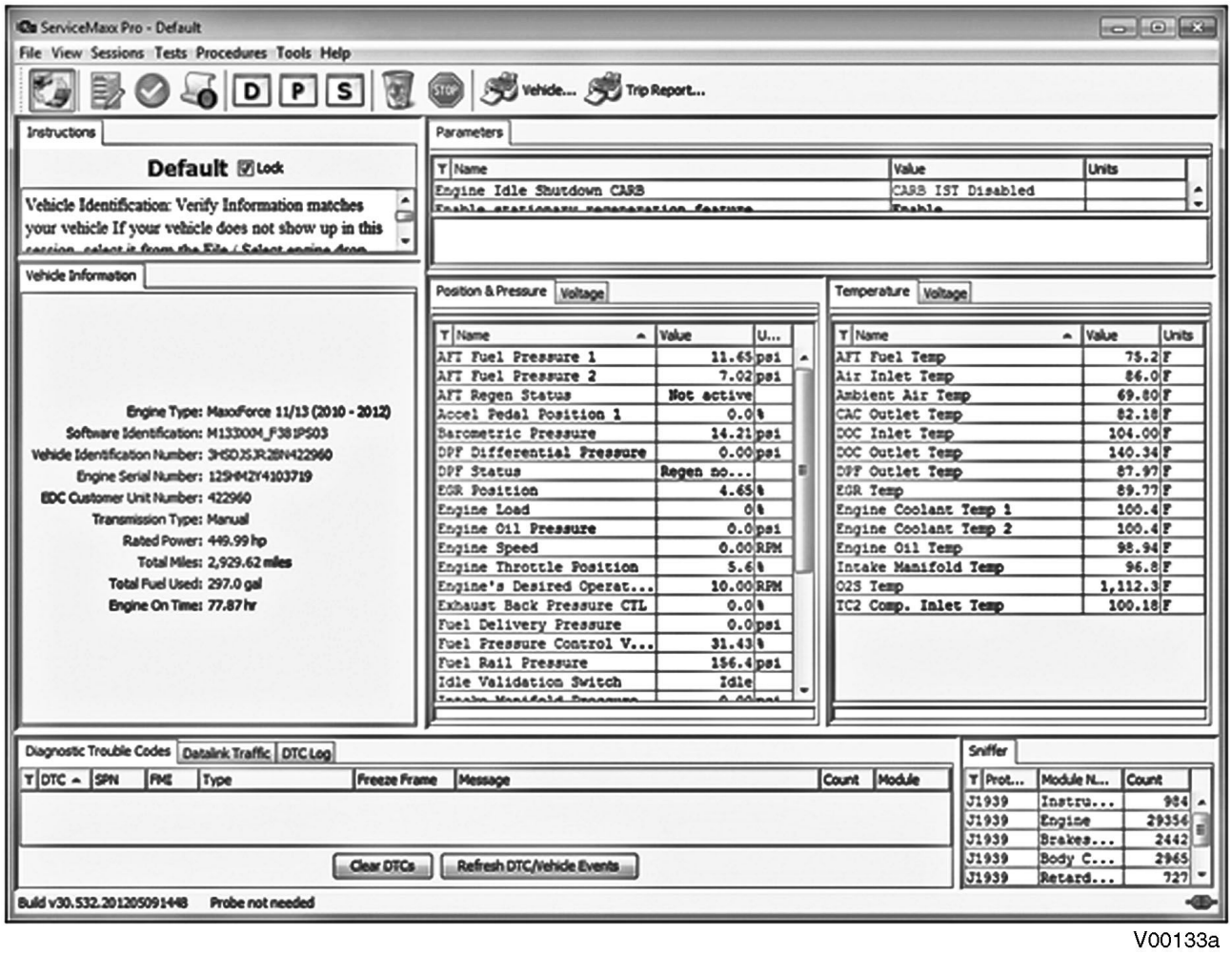
Check Engine Control Module (ECM) software, sensor signals and DTCs, and to record additional vehicle information on Diagnostics Form.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
   - If unable to communicate with the ECM, see the *ServiceMaxx™ Users Guide*.
   - If unable to communicate with the ECM and no problems are found using the *ServiceMaxx™ Users Guide*, go to J1939 Data Link (page 804) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”



V00133a

Figure 81 ServiceMaxx™ startup screen – vehicle connected

4. Verify the following vehicle information matches the displayed information in ServiceMaxx™ software and record on Diagnostics Form.
   - Software Identification
   - Vehicle Identification Number (VIN)
   - Engine Serial Number (ESN)
   - Transmission Type
   - Rated Power
   - Total Miles
   - Engine On Time

NOTE: The engine serial number is located on the front left side of the crankcase, below the cylinder head. It is also on the engine emission label on the valve cover.

5. Record the following Key ON, Engine OFF (KOEO) temperature sensor values on Diagnostics Form:

   NOTE: If possible, allow the engine to cold soak for at least 8 hours before recording results.

   - Inlet Air Temperature (IAT)
   - Engine Coolant Temperature 1 (ECT1)
   - Engine Coolant Temperature 2 (ECT2)
   - Engine Oil Temperature (EOT)

6. Record the following KOEO pressure sensor values on Diagnostics Form:

   - Fuel Rail Pressure (FRP)
   - Fuel Delivery Pressure (FDP)
   - TC1 Turbine Outlet Pressure (TC1TOP)
   - Intake Manifold Pressure (IMP)
   - Barometric Pressure (BARO)
   - DPF Differential Pressure (DPFDP)

7. Look for sensor values that are out of specification. A sensor out of specification could cause abnormal operating behavior, incorrect fueling, and injection timing problems.

   - If sensor is out of specification, go to the suspect sensor in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”

8. Use ServiceMaxx™ software to run Actuator Test.

9. Record EGR Valve Position and Engine Throttle Position values at 5% (open) and 95% (closed) on Diagnostics Form.

   - If either signal is not within specification, go to the suspect actuator in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”

10. Look for sensor values that are not within specification. A sensor out of specification could cause air management problems.

11. Use ServiceMaxx™ software to run Actuator Test.

12. Visually monitor movement of Exhaust Back Pressure Valve (EBPV). Record results on Diagnostics Form.

    NOTE: ServiceMaxx™ software does not have an EBPV feedback position signal.

    - If EBPV does not move, go to Exhaust Back Pressure Valve (page 163).

13. Use ServiceMaxx™ software to monitor DPF status. Record results on Diagnostics Form.

    - If DPF status is “Regen needed - critical level”, run an Onboard Filter Cleanliness Test.

4. Check for Diagnostic Trouble Codes (DTCs)

NOTE: 2010 model year vehicles no longer utilize DTC identification by number. DTCs are now identified using the SPN and FMI identifiers only. These two identifiers, known as the Suspect Parameter Number (SPN) and the Failure Mode Indicator (FMI), are displayed in the DTC Window.

- **Suspect Parameter Number (SPN) – The SPN identifies the individual component causing the DTC.**
- **Failure Mode Indicator (FMI) – The FMI identifies the fault or condition affecting the individual component.**
- **Pending DTCs are possible emission faults that were detected on first drive cycle.**
- **Active DTC are faults that are present now or emission faults that were detected on two consecutive drive cycles.**
- **Previously Active or Healing DTCs are historical faults. These faults may have been caused by an intermittent or operating condition which is not currently present.**

Purpose

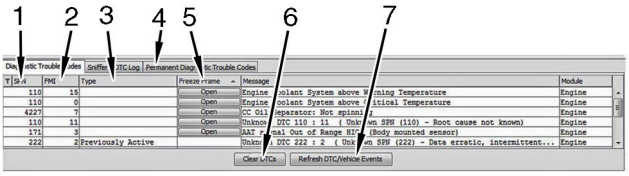
Identify DTCs.

Tools

- EST with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.



V00134a

Figure 82 DTC window

1. Suspect Parameter Number (SPN)
2. Failure Mode Indicator (FMI)
3. Fault Code Type
4. Permanent Diagnostic Trouble Codes tab
5. Freeze Frame
6. Clear DTCs button
7. Refresh DTC/Vehicle Events button

4. Record DTCs and Freeze Frame Data on Diagnostics Form.
   - Correct any active DTCs. See “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - Investigate any previously active, healing or pending DTCs for possible intermittent operating conditions in which the DTC was set.

NOTE: Freeze Frame Data is a snapshot of all influencing signals at the time the DTC was set. This can help diagnose hard to duplicate failures. Freeze Frame Data is cleared as soon as the DTC is cleared.

5. Engine Low Idle to High Idle

Purpose

Validate engine performance throughout rpm range.

Tools

- EST with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Performance session.
5. Monitor Accel Pedal Position 1 (APP1) signal and depress accelerator pedal to floor. Record results on Diagnostics Form.
   - If APP1 signal does not go from 0% to 99.6%, see APP Sensor (page 363) in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If APP1 signal does go from 0% to 99.6%, continue to next step.

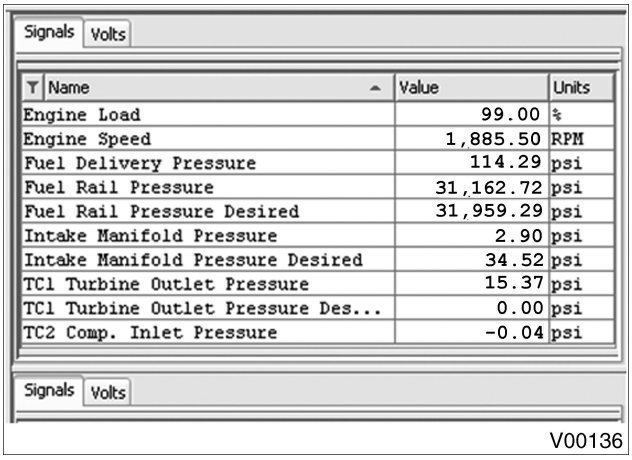


Figure 83 Performance session signals

6. Monitor the following signals:

   NOTE: ServiceMaxx™ software displays Fuel Delivery Pressure (FDP) signal 15 psi below actual gauge pressure. When monitoring FDP with ServiceMaxx™ software, the specification listed below is correct.

   - Fuel Delivery Pressure (FDP)
   - Fuel Rail Pressure (FRP)
   - Fuel Rail Pressure Desired (FRPD)
   - Engine Speed
   - Intake Manifold Pressure (IMP)
   - TC1 Turbine Outlet Pressure (TC1TOP)

7. Press the record button and start engine.
8. Allow engine to idle for 5 seconds. Depress accelerator pedal to floor and hold for 20 seconds, then return to low idle.
9. Review results with accelerator pedal at 99.6% and record on Diagnostics Form.
    - If FDP is below specification, go to Fuel Delivery Pressure Test (page 167) in the Low-pressure Fuel System section.
    - If FDP is above specification, go to High-pressure Pump Inlet Pressure Test (page 175).
    - If engine does not accelerate smoothly, or feels unbalanced, (not running on all cylinders), perform Cylinder Performance Test (page 181) and Fuel Pressure Control Valve (FPCV) Test (page 184).
    - If TC1TOP is above specification, verify Exhaust Back Pressure Valve (EBPV) is not the cause of the performance loss. See Exhaust Back Pressure Valve (EBPV) (page 163). If EBPV is operating correctly, inspect Pre-Diesel Oxidation Catalyst (PDOC) and Diesel Oxidation Catalyst (DOC) for face plugging.
    - If IMP is below specifications, visually inspect for:
        - Charge Air Cooler (CAC) and tubing leaks
        - Intake restriction
        - Turbocharger damage
    - Remove and inspect IMP sensor for soot build up. Clean sensor, reinstall, and continue.

6. KOER Air Management Test

NOTE: Truck air tank must be full before running this test.

Purpose

To verify air management valves are working correctly.

Tools

- EST with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Start engine.
5. Select KOER Air Management Test from the Tests drop-down menu. Begin recording snapshot and follow instructions in ServiceMaxx™ software. Record results on Diagnostics Form.

   NOTE: Record whether Intake Manifold Pressure (IMP) increases or decreases with actuator change.

   NOTE: Turbocharger 1 Wastegate Control (TC1WC) does not affect engine performance and is removed from later-built engines.

   - If IMP does not decrease during EGR Valve and TC2 Wastegate CTL movement, or IMP increases during Exhaust Back Pressure Valve movement, go to the appropriate actuator in Air Control Valve (ACV) Tests (page 163) to diagnose suspect actuator.

7. Road Test (Full load to highway speed)

Purpose

Check for unacceptable engine performance at full load and rated speeds by means of maximum boost, minimum fuel pressure, and minimum Fuel Rail Pressure (FRP).

Tools

- EST with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

⚠ WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

NOTE: If truck has progressive shift or gear down protection enabled, disable these features prior to performing the road test.

NOTE: Perform test while bobtailing (not pulling a trailer).

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Performance session.
5. Start engine.

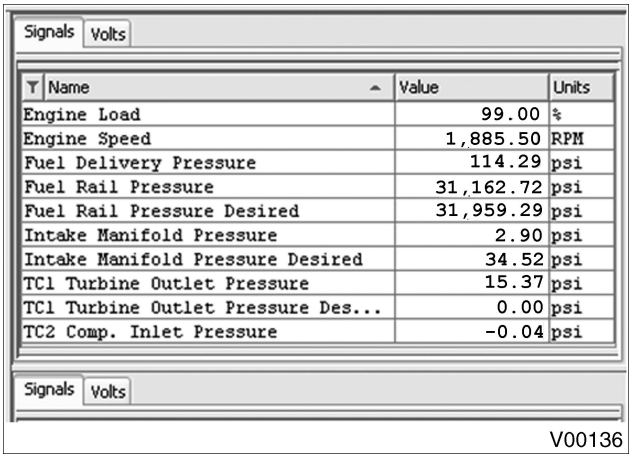


Figure 84 Performance session signals

6. Monitor the following signals:
   - Fuel Rail Pressure (FRP)
   - Fuel Delivery Pressure (FDP)
   - Fuel Rail Pressure Desired (FRPD)
   - Intake Manifold Pressure (IMP)
   - TC1 Turbine Outlet Pressure (TC1TOP)
7. Find an open stretch of road. Begin recording. When driving conditions are safe, select a suitable gear, press accelerator pedal fully to the floor, and accelerate to rated speed at 100% load.
8. When road test is complete, stop recording.
9. Review recorded results when engine was at 100% engine load and engine speed was at the rated speed specified in “APPENDIX A: PERFORMANCE SPECIFICATIONS." Record results on Diagnostics Form.
   - If FDP is below specification, go to Fuel Delivery Pressure Test (page 167) in the Low-pressure Fuel System section.
   - If FDP is above specification, go to High-pressure Pump Inlet Pressure Test (page 175).
   - If engine does not accelerate smoothly, or feels unbalanced, (not running on all cylinders), perform Cylinder Performance Test (page 181)and Fuel Pressure Control Valve (FPCV) Test (page 184).
   - If TC1TOP is above specification, verify Exhaust Back Pressure Valve (EBPV) is not the cause of the performance loss. See Exhaust Back Pressure Valve (EBPV) (page 163). If EBPV is operating correctly, inspect Pre-Diesel Oxidation Catalyst (PDOC) and Diesel Oxidation Catalyst (DOC) for face plugging.
   - If IMP is below specifications, check for Charge Air Cooler (CAC) and tubing leaks.

Special Test Procedures

Air Control Valve (ACV) Tests

NOTE: Truck air tank must be full before running these tests.

Purpose

Verify air management valves are working correctly.

Tools

- EST with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Exhaust Back Pressure Valve (EBPV)

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select 2010 BB Actuator session.
5. Select EBPV from Actuator drop-down menu and set to 95%.

NOTE: Test will command the actuator ON for 5 seconds, then will return it to the default closed position.

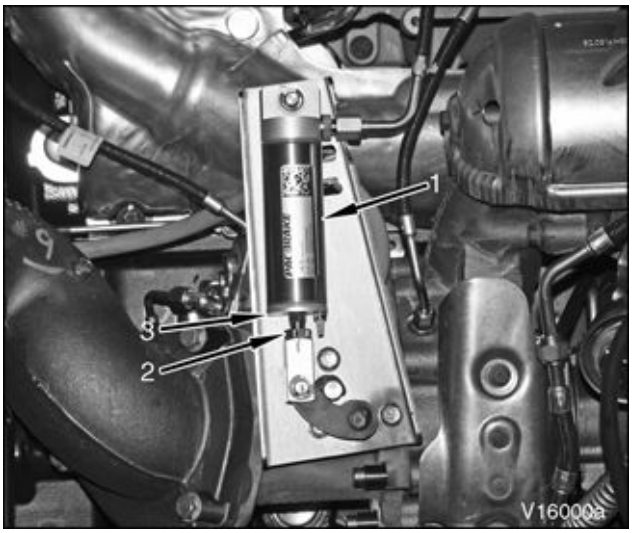


Figure 85 EBPV closed

1. EBPV
2. Jam nut
3. Bottom of housing

6. Press the Start button and measure actuator rod movement. Record results on Diagnostics Form.

   NOTE: Measurement is taken between the bottom of the housing and the jam nut.

   - If actuator rod moves full travel, no action is required.
   - If actuator rod does not move full travel, continue to next step.

7. Remove air supply line from actuator and repeat actuator test.
   - If air cannot be heard leaving the open air supply line when running the test, inspect supply line for blockage or damage. If supply line is not blocked or damaged, see EBPV (page 578), in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If air can be heard leaving the open air supply line, continue to next step.
8. Remove actuator rod from valve arm. Check if the valve arm moves freely.
   - If valve arm moves freely, replace air actuator.
   - If valve arm does not move freely, replace valve.

Turbocharger 2 Wastegate Control (TC2WC)

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select 2010 BB Actuator session.

NOTE: On a cold engine, the TC2 Wastegate Control defaults to open (100.00%) to prevent turbocharger damage.

5. Select TC2 Wastegate Control from Actuator drop-down menu and set to ON (95% Duty Cycle).

   NOTE: If TC2 Wastegate CTL displays a value of 100.00% before test is started, duty cycle must be set to Off (5% duty cycle) for actuator rod to move.

NOTE: Test will command actuator ON for 5 seconds, then actuator will return to default position.

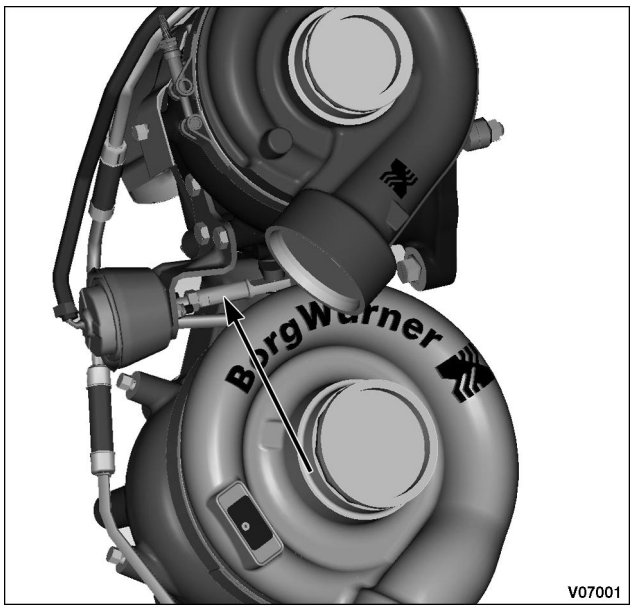


Figure 86 TC2 wastegate valve in closed position

6. Press the Start button and measure actuator rod movement. Record results on Diagnostics Form.
   - If actuator rod moves full travel, no action is required.
   - If actuator rod does not move full travel, continue to next step.
7. Remove air supply line from actuator and repeat actuator test.
   - If air cannot be heard leaving the open air supply line when running the test, see TC2WC (page 838), in “ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS.”
   - If air can be heard leaving the open air supply line, continue to next step.
8. Remove actuator rod from valve arm. Check if the valve arm moves freely.
   - If valve arm moves freely, replace air actuator.
   - If valve arm does not move freely, replace valve.

Fuel System

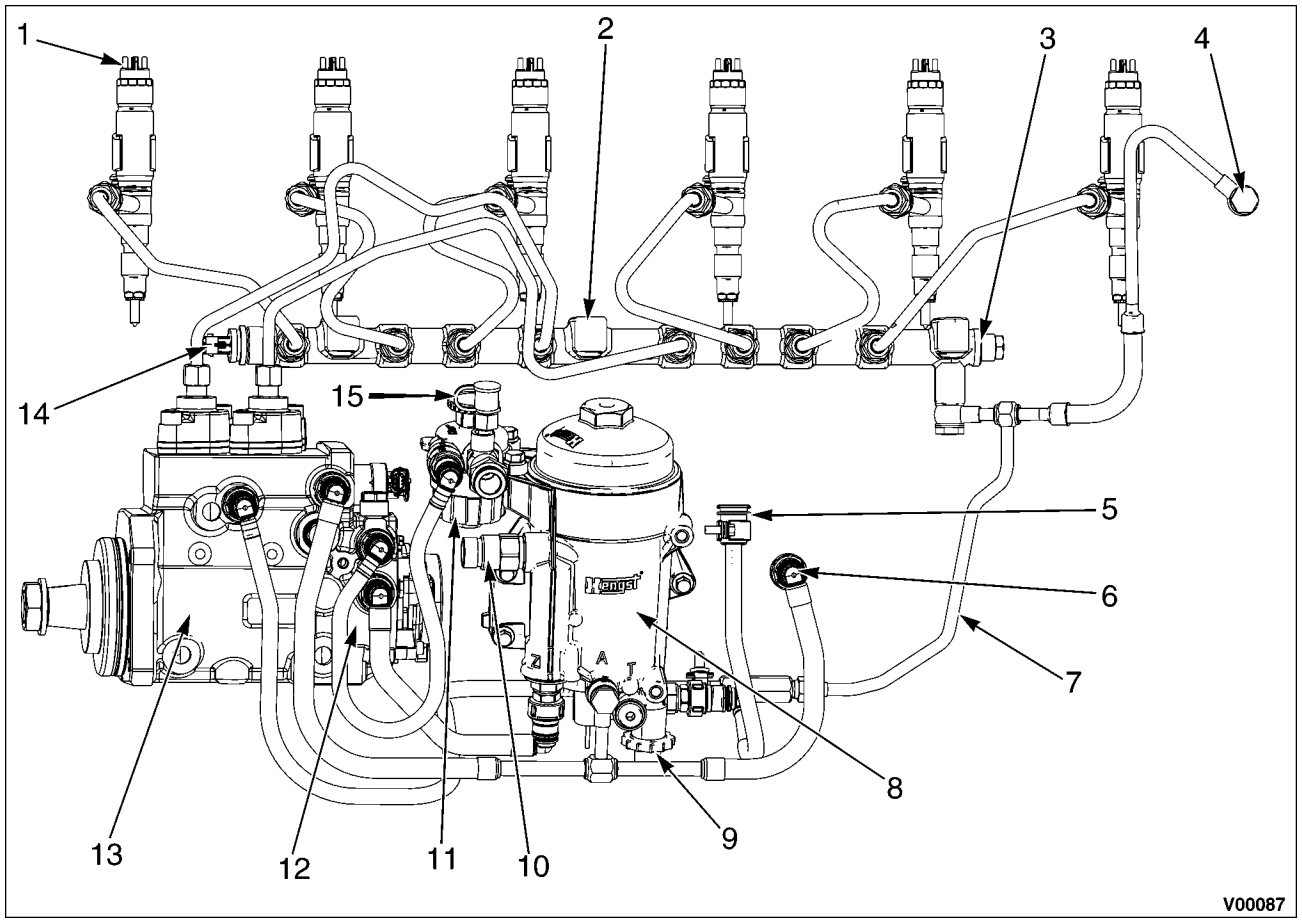


Figure 87 Fuel system

1. Injector (6)
2. Fuel Rail
3. Fuel rail pressure limiting valve
4. Fuel return from cylinder head
5. Engine fuel return connection (to chassis filter)
6. Fuel supply to DSI unit
7. Fuel return line
8. Secondary fuel filter assembly
9. Drain screw
10. Fuel Delivery Pressure (FDP) sensor
11. Fuel strainer
12. Low-pressure (LP) fuel pump
13. HP fuel pump
14. Fuel Rail Pressure (FRP) sensor
15. Fuel primer pump

Low-pressure Fuel System

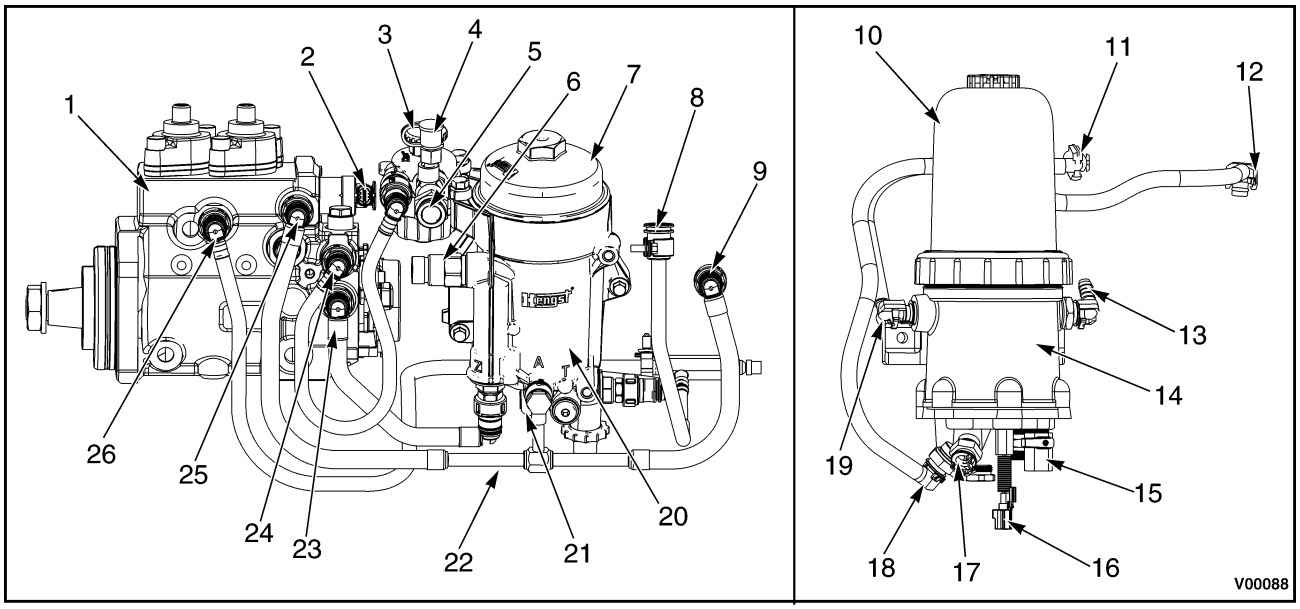


Figure 88 Low-pressure (LP) fuel system

1. HP fuel pump
2. Fuel Pressure Control Valve (FPCV)
3. Fuel primer pump assembly w/ fuel strainer element
4. Fuel pressure test port
5. Engine fuel supply connection
6. FDP sensor
7. Engine mounted secondary fuel filter access
8. Engine fuel return connection
9. Fuel supply to DSI unit
10. Chassis mounted primary fuel filter access
11. Fuel supply to engine
12. Fuel return from engine
13. Fuel supply from tank
14. Chassis mounted fuel filter/water separator
15. Fuel Heater
16. Water In Fuel (WIF) sensor
17. Fuel return to tank
18. Fuel return from engine
19. Fuel supply to engine
20. Engine mounted fuel module
21. Inlet air heater port
22. Fuel supply from primary fuel filter
23. LP fuel pump outlet
24. LP fuel pump inlet
25. HP fuel pump inlet
26. HP fuel pump return

GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.

WARNING: To prevent personal injury or death, provide proper ventilation when operating an engine in a closed area. Inhalation of exhaust gas can be fatal.

Fuel Delivery Pressure (FDP) Test

NOTE: Perform this test if led here from the Low Idle to High Idle Test or Road Test.

Purpose

Verify low-pressure fuel pump has the ability to build sufficient fuel pressure for proper engine performance.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- Diesel fuel container
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4891 – Air Cap, Fuel Cap, and Plug Kit

Procedure

CAUTION: To prevent damage to engine, use clean fuel system caps to plug component connections immediately after each fuel line is removed.

NOTE: Ensure fuel lines are clean from heavy debris before breaking fuel line connections.

1. With the engine OFF, disconnect fuel supply line at low-pressure fuel pump inlet and cap it off using Air Cap, Fuel Cap, and Plug Kit ZTSE4891.

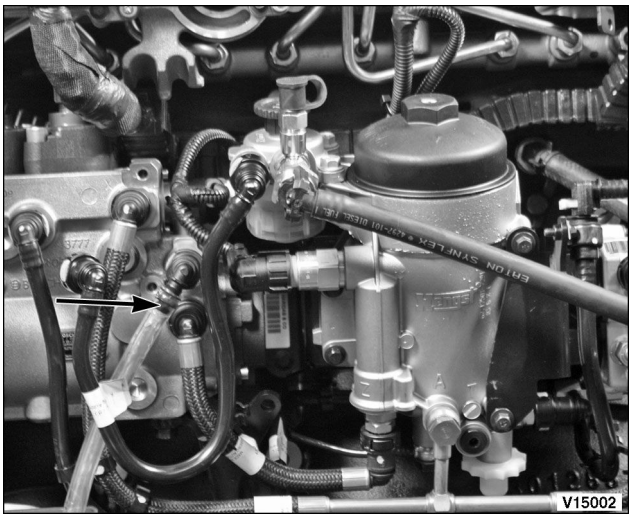


Figure 89 Clean Fuel Source Tool connected to low-pressure fuel pump inlet

2. Connect Clean Fuel Source Tool 15-637-01 to low-pressure fuel pump inlet.
3. Use Clean Fuel Source Tool 15-637-01 to prime fuel system.
    a. Close the ball valve on the Clean Fuel Source Tool 15-637-01 fuel supply line.
    b. Fully squeeze the primer bulb on the Clean Fuel Source Tool 15-637-01. Repeat until fuel system is primed (no air visible in clear lines of Clean Fuel Source Tool).

c. After fuel system is primed, open ball valve on Clean Fuel Source Tool 15-637-01 fuel supply line.

4. Turn ignition switch to ON, engine OFF.
5. Connect EST to vehicle's Diagnostic Connector.
6. Start ServiceMaxx™ software.
7. Select Performance session.

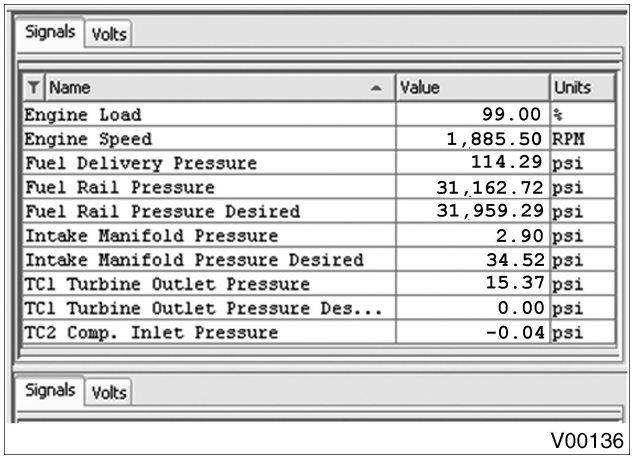


Figure 90 Performance session signals

8. Start engine while monitoring Fuel Delivery Pressure (FDP). Depress accelerator pedal to floor for 20 seconds and return to low idle. Record results on Diagnostics Form.

   NOTE: ServiceMaxx™ software displays Fuel Delivery Pressure (FDP) signal 15 psi below actual gauge pressure. When monitoring FDP with ServiceMaxx™ software, the specification listed on the Diagnostics Form is correct.

   - If FDP is below specification, go to Fuel Dead Head Test.
   - If FDP is within specification, go to Fuel Aeration and Restriction Tests (page 170).
   - If FDP builds above specification, go to High Pressure Pump Inlet Pressure Test (page 184).

Fuel Dead Head Test

Purpose

Isolate fuel pump to determine if it is able to build proper pressure.

Tools

- ZTSE4526 - Compucheck Fitting
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool

Procedure

1. Retain connection between Clean Fuel Source Tool 15-637-01 and low-pressure fuel pump inlet from previous test.
2. Disconnect fuel line from low-pressure fuel pump outlet.

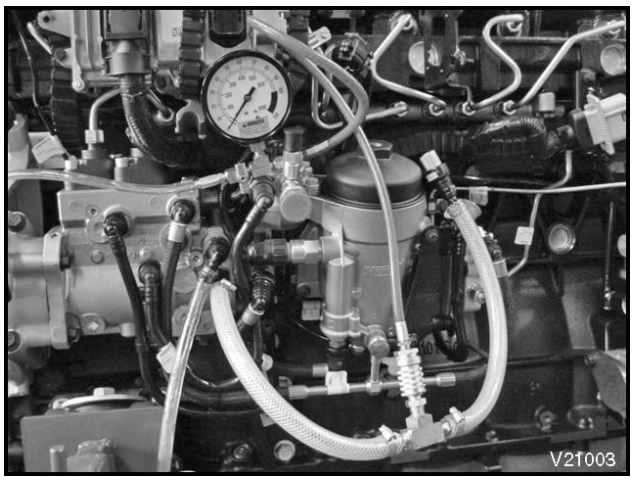


Figure 91 Fuel Inlet Restriction / Aeration Tool connected to low-pressure fuel pump outlet.

3. Connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 to low-pressure fuel pump outlet.
4. Use ZTSE4526 - Compucheck Fitting to connect Fuel Pressure Gauge ZTSE4681 to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
5. Connect Fuel Block Off Tool ZTSE4905 to Fuel Restriction/Aeration Tool ZTSE4886.
6. Crank engine to remove air from fuel lines.

7. Crank engine until fuel pressure stabilizes or up to a maximum of 20 seconds.
8. Record gauge pressure on Diagnostics Form.
    - If pressure is within specification, inspect secondary fuel filter, stand pipe, and housing for defects or damage. If no defect or damage is found, go to Fuel Rail Pressure Return Flow Test (page 176).
    - If pressure is below specification, replace fuel pump following procedures in the *Engine Service Manual*. To prevent damage to a newly installed fuel pump and to verify high back pressure did not cause fuel pump to fail, perform HP Pump Fuel Return Pressure Test (page 139) any time fuel pump is replaced.

NOTE: Before installing a new fuel pump, ensure new fuel pump is the correct replacement part.

Fuel Aeration and Restriction Tests

Aeration Test

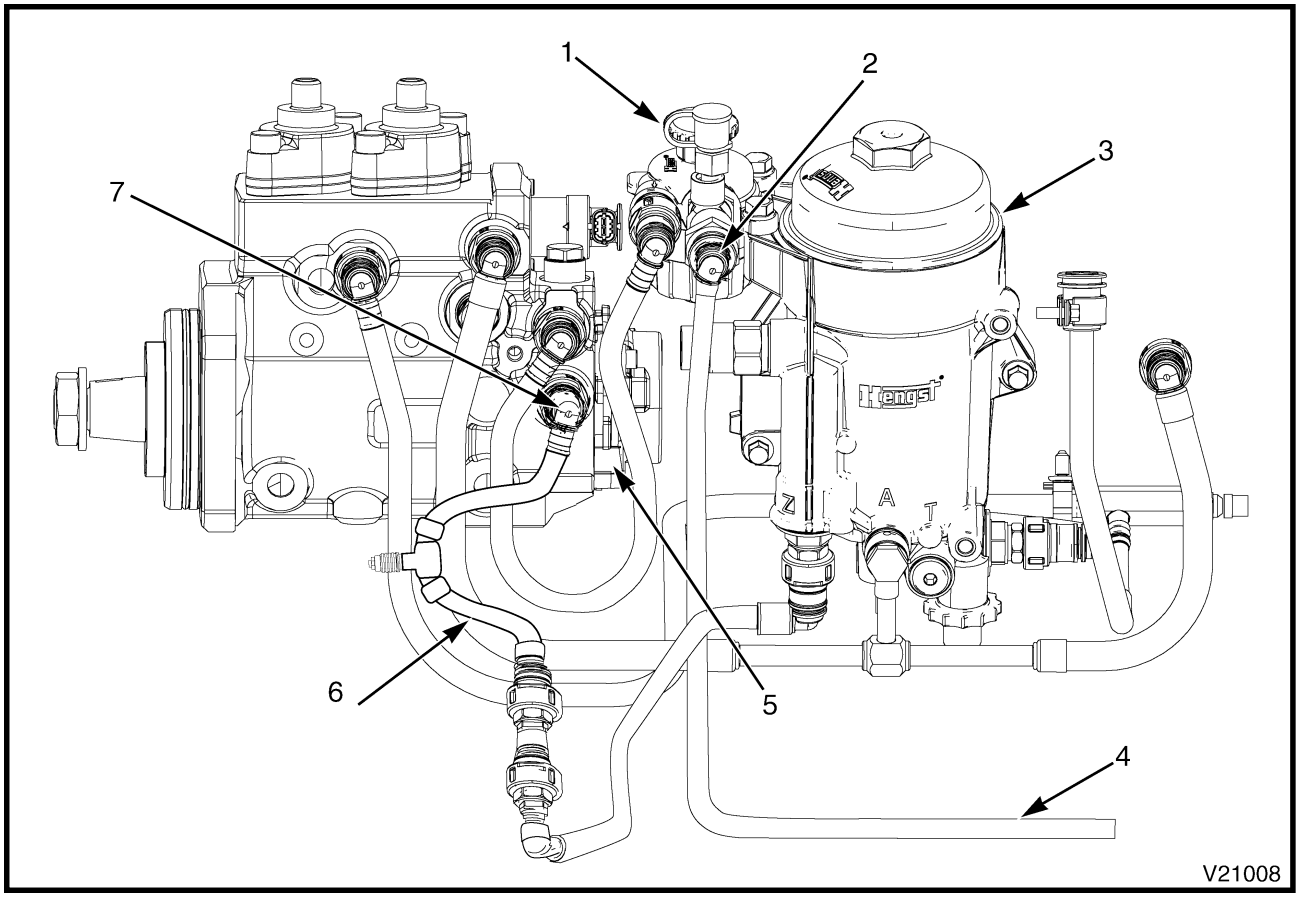


Figure 92 Fuel Aeration Test

1. Strainer / primer pump
2. Test point 2
3. Secondary fuel filter
4. Fuel supply from primary fuel filter
5. Low-pressure fuel pump
6. Fuel Inlet Restriction / Aeration Tool
7. Test point 1

Purpose

Check for fuel aeration.

Tools

- 15-637-01 – Clean Fuel Source Tool
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool
- ZTSE4906 – Fuel Line Coupler

Aeration Test Point 1

Procedure

1. Remove Clean Fuel Source Tool 15-637-01 from low-pressure fuel pump inlet and restore vehicle fuel supply line.
2. Use Fuel Line Coupler ZTSE4906 to connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 between fuel supply line to secondary fuel filter and low-pressure fuel pump outlet.
3. Prime fuel system by pumping primer pump.
4. Start engine while visually monitoring for fuel aeration (air bubbles passing through the clean line). Record results on Diagnostics Form.
   - If fuel is not aerated, go to Restriction Test.
   - If fuel is aerated, continue to step 5.

Aeration Test Point 2

5. Connect Clean Fuel Source Tool 15-637-01 to primer pump inlet.
6. Prime fuel system by pumping primer pump.
7. Start engine while visually monitoring for fuel aeration (air bubbles passing through the clean line). Record results on Diagnostics Form.
   - If fuel is not aerated, repair fuel supply line between fuel primer pump and fuel tank.
   - If fuel is aerated, repair low-pressure fuel pump supply line or fuel primer pump.

Restriction Test

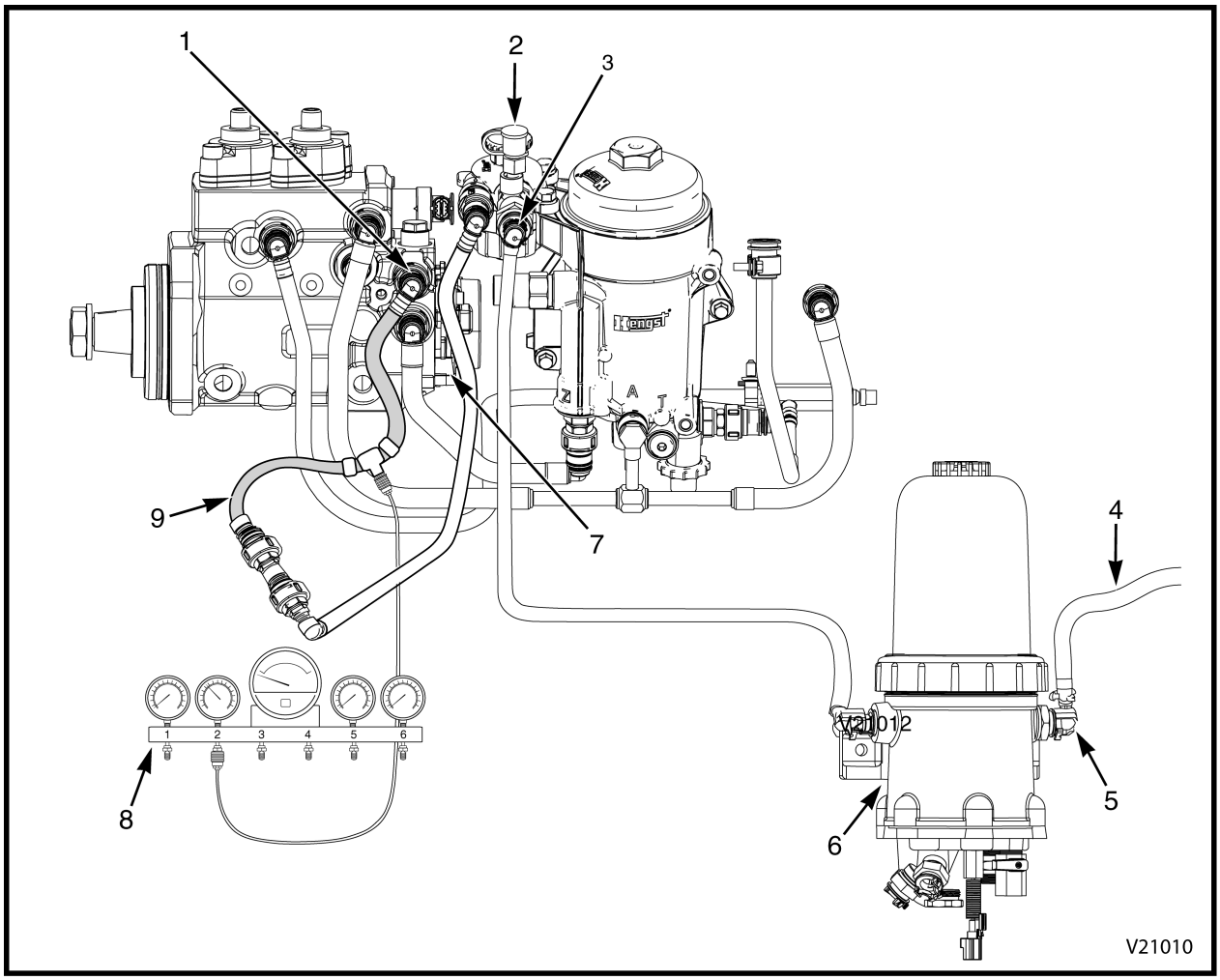


Figure 93 Fuel Restriction Test

1. Test point 1
2. Strainer / primer pump
3. Test point 2
4. Fuel supply from tank
5. Test point 3
6. Primary fuel filter
7. Low-pressure fuel pump
8. Pressure Test Kit (vacuum gauge)
9. Fuel Inlet Restriction / Aeration Tool

Purpose

Check for fuel supply restriction.

Tools

- ZTSE4526 - Compucheck Fitting
- 15-637-01 – Clean Fuel Source Tool
- ZTSE4409 – Pressure Test Kit
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4906 – Fuel Line Coupler

Procedure

Test Point 1

1. Use Fuel Line Coupler ZTSE4906 to connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 between low-pressure fuel pump supply line and low-pressure fuel pump inlet.
2. Connect Pressure Test Kit ZTSE4409 vacuum gauge to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
3. Prime fuel system by pumping primer pump.
4. Start engine while monitoring Pressure Test Kit vacuum gauge. Record results on Diagnostics Form.
    - If restriction is above specification, go to Restriction Test Point 2.

Test Point 2

1. Connect Clean Fuel Source Tool 15-637-01 to primer pump inlet.
2. Prime fuel system by pumping primer pump.
3. Start engine while monitoring Pressure Test Kit ZTSE4409 vacuum gauge. Record results on Diagnostics Form.
    - If restriction is within specification, go to Restriction Test Point 3.
    - If restriction is above specification, repair or replace fuel strainer and primer pump assembly, and check fuel lines.

Test Point 3

1. Connect Clean Fuel Source Tool 15-637-01 to primary filter inlet.
2. Prime fuel system by pumping primer pump.
3. Start engine while monitoring Pressure Test Kit ZTSE4409 vacuum gauge. Record results on Diagnostics Form.
    - If restriction is within specification, repair restriction between primary fuel filter and fuel tank.
    - If restriction is above specification, replace primary fuel filter, clean fuel strainer, and check fuel lines.

High-pressure Fuel System

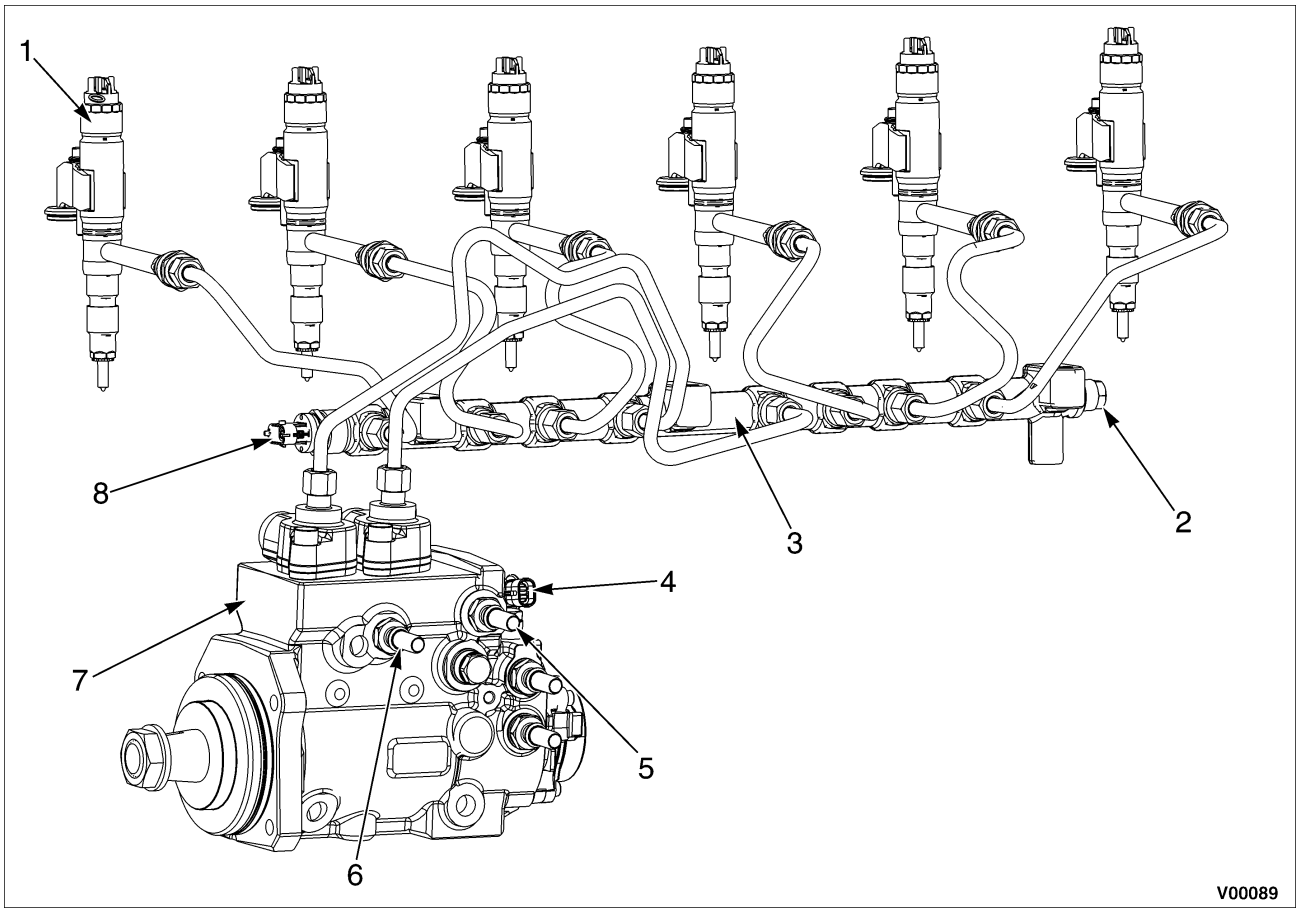


Figure 94 High-pressure (HP) fuel system

1. Injector (6)
2. Fuel rail pressure limiting valve
3. Fuel Rail
4. Fuel Pressure Control Valve (FPCV)
5. HP fuel pump inlet
6. HP fuel pump return
7. HP fuel pump
8. Fuel Rail Pressure (FRP) sensor

High-pressure Pump Inlet Pressure Test

Purpose

Verify high-pressure fuel pump is receiving fuel.

Tools

- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool
- ZTSE4906 – Fuel Line Coupler

Procedure

1. Disconnect fuel supply to Down Stream Injection (DSI) valve assembly.
2. Use Fuel Line Coupler ZTSE4906 to connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 to DSI fuel supply line.

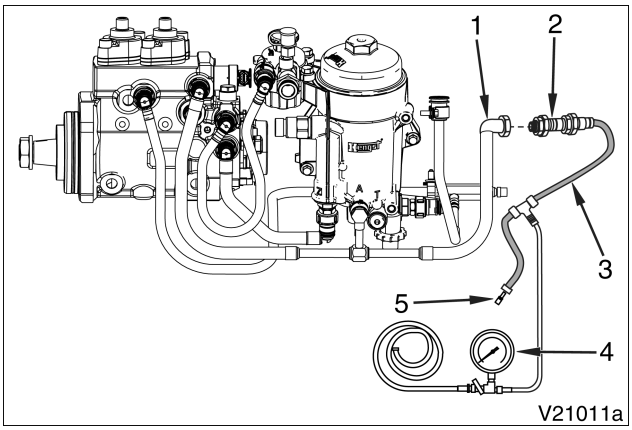


Figure 95 Pressure Test Kit connected to DSI fuel supply line

1. DSI Fuel Supply Line
2. Fuel Line Coupler
3. Fuel Inlet Restriction / Aeration Tool
4. Fuel Pressure Gauge
5. Fuel Block Off Tool

3. Connect Fuel Block Off Tool ZTSE4905 to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
4. Connect ZTSE4681 Fuel Pressure Gauge to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
5. Start engine and run at high idle for 20 seconds, while monitoring Fuel Pressure Gauge ZTSE4681. Record results on Diagnostics Form.
   - If gauge pressure is within specification, go to Fuel Rail Pressure (FRP) Return Flow Test (page 176).
   - If gauge pressure is below specification, replace secondary fuel filter.

Fuel Rail Pressure (FRP) Return Flow Test

Purpose

Verify return flow is within specifications.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- Diesel fuel container
- ZTSE4887 – High Pressure Return Line Tester

Fuel Rail Pressure (FRP) Return Flow Test Part 1

NOTE: Before running this test, ensure low-pressure fuel system is operating correctly.

1. Disconnect fuel drain tube assembly at rear of cylinder head.

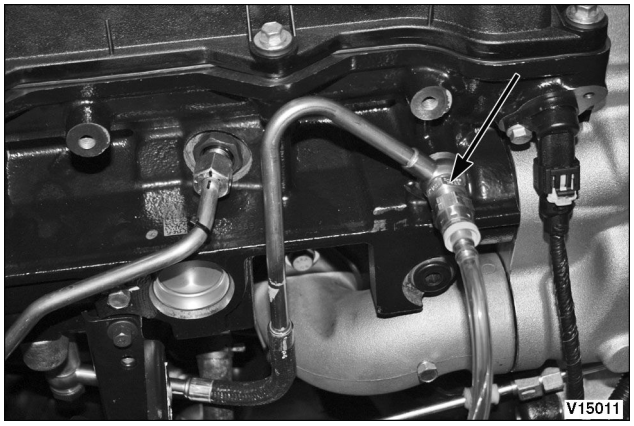


Figure 96 High Pressure Return Line Tester ZTSE4887 connected to cylinder head

2. Connect High Pressure Return Line Tester ZTSE4887-2 using 2 banjo ring seals to cylinder head fuel drain tube fitting. Thread ZTSE4887-3 to ZTSE4887-2 and route the end into a diesel fuel container.
3. Crank engine for 20 seconds while monitoring fuel return from High Pressure Return Line Tester ZTSE4887.
   - If fuel is returning, go to Fuel Rail Pressure (FRP) Leak Isolation.
   - If no fuel is returning, continue to next step.

Fuel Rail Pressure (FRP) Return Flow Test Part 2

NOTE: Before running this test, ensure low-pressure fuel system is operating correctly.

4. Reconnect fuel drain tube assembly disconnected in step 1.
5. Disconnect fuel rail return line at fuel rail.
6. Connect High Pressure Return Line Tester ZTSE4887-2 using 2 banjo ring seals to fuel rail return port. Thread ZTSE4887-3 to ZTSE4887-2 and route the end into a diesel fuel container.
7. Crank engine and monitor fuel return from High Pressure Return Line Tester ZTSE4887.
   - If fuel flows from High Pressure Return Line Tester ZTSE4887, replace fuel rail pressure relief valve.
   - If fuel does not flow from High Pressure Return Line Tester ZTSE4887, go to HP Pump Return Flow Test.

Fuel Rail Pressure (FRP) Leak Isolation

Normal fuel return flow with number of connected injectors

All 6 INJs	5 INJs	4 INJs	3 INJs	2 INJs
20 - 22 ml	16 - 18 ml	12 – 16 ml	8 - 12 ml	8 - 10 ml

NOTE: This table displays typical fuel return volume specifications for a good running engine. Results much higher than specification indicate an excessive leak.

Purpose

Isolate pressure loss in high-pressure fuel system.

Tools

- Diesel fuel container measuring in milliliters
- ZTSE4887 – High Pressure Rail Return Line Tester
- ZTSE6098 – High Pressure Rail Plugs

Procedure

WARNING: The high-pressure fuel system may have extremely high pressure. Verify pressure is below 500 psi before cracking a line. Every time the engine is shut down and the key is in the OFF position, the ECM commands a blank shot injection process that drains the high-pressure fuel rail.

NOTE: Only run this test if engine fails High Pressure Pump test.

1. Retain High Pressure Return Line Tester ZTSE4887 connection to cylinder head from previous test.

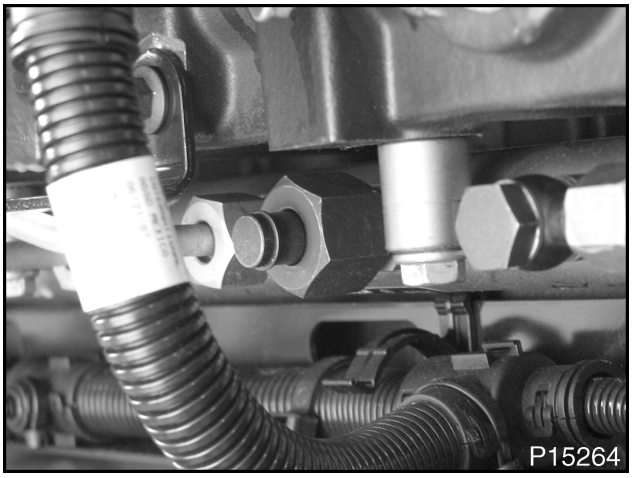


Figure 97 High Pressure Rail Plug installed on injector six

2. Disconnect number six injector fuel line and cap off rail with High Pressure Rail Plug ZTSE6098.
3. Start engine and run at low idle. When fuel flow is steady and fuel volume reaches a good starting measurement point, start timer, and begin measurement. Measure fuel return volume for 1 minute. Record results on Diagnostics Form.
   - If fuel volume is above specification, leave High Pressure Rail Plug ZTSE6098 installed and continue to next step.
   - If fuel volume is within specification, replace injector tube and high-pressure connector body following procedures in the *Engine Service Manual*. Retest volume of fuel being returned with all six injectors connected to verify repair.
4. Disconnect number five injector fuel line and cap off rail with High Pressure Rail Plug ZTSE6098.

5. Start engine and run at low idle. When fuel flow is steady and fuel volume reaches a good starting measurement point, start timer and begin measurement. Measure fuel return volume for 1 minute. Record results on Diagnostics Form.
    - If fuel volume is above specification, leave High Pressure Rail Plug ZTSE6098 connected and continue capping off one injector supply port at a time until excessive leak is isolated. Once the excessive leak is isolated, replace the removed injector tubes with new parts.

HP Pump Fuel Return Pressure Test

Purpose

Verify return flow is within specifications.

Tools

- ZTSE4526 - Compucheck Fitting
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4906 – Fuel Line Coupler

Procedure

NOTE: Prior to performing this test, ensure new fuel pump is the correct replacement part.

1. Restore fuel system to normal operating condition.
2. Disconnect high-pressure fuel pump return line.

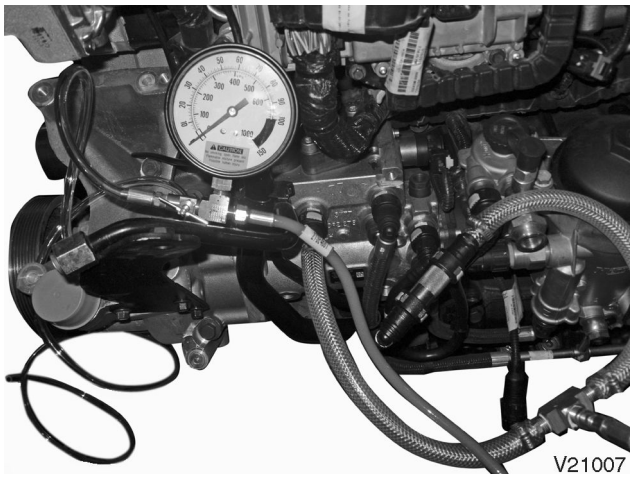


Figure 98 High-pressure fuel pump return line connected to Fuel Pressure Gauge

3. Use Fuel Line Coupler ZTSE4906 to connect high-pressure fuel pump return line to Fuel Inlet Restriction / Aeration Tool ZTSE4886.
4. Use ZTSE4526 - Compucheck Fitting to connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 to Fuel Pressure Gauge ZTSE4681.
5. Start engine and run high idle while monitoring Fuel Pressure Gauge.
    - If pressure is above specification, inspect fuel return line for restriction between high-pressure fuel pump and fuel tank.
    - If pressure is below specification, no further action is required.

Crankcase Oil Breather Separator Test

Purpose

Check if centrifuge breather is functioning properly.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- ZTSE4800 – Ultrasonic Ear

Procedure

⚠ WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

⚠ WARNING: To prevent personal injury or death, make sure the parking brake is set, the transmission is in neutral or park, and the wheels are blocked when running the engine in the service bay.

⚠ WARNING: To prevent personal injury or death, avoid rotating parts (belts and fan) and hot engine surfaces.

NOTE: Before performing this test, ensure engine operating temperature is 82 to 88˚ C (180 to 190˚ F) and oil level and pressure are within specification.

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Performance session.
5. Start engine. Ensure engine operating temperature is 82 to 88˚ C (180 - 190˚ F).

   NOTE: The Crankcase Oil Separator Speed (CCOSS) sensor does not have circuit fault codes. A Diagnostic Trouble Code (DTC) will only be set if the Engine Control Module (ECM) does not see an rpm signal with the engine running.

6. Monitor CC Oil Separator (CCOS) signal with engine at low and high idle. Record results on Diagnostics Form.
   - If CCOS is within specification, crankcase breather system is operating correctly.
   - If CCOS is reading 0 rpm with engine running, continue to next step.
7. With engine running, place Ultrasonic Ear ZTSE4800 near CCOSS sensor.
8. Turn engine OFF and quickly monitor for centrifugal noise.

   NOTE: The centrifuge will continue spinning for 15 seconds after engine is shut off.

   - If centrifuge noise is not heard, go to *Engine Service Manual* for removal and replacement procedures.
   - If centrifuge noise can be heard, go to Crankcase Oil Separator Speed (CCOSS) Sensor (page 376) in "ELECTRONIC CONTROL SYSTEMS DIAGNOSTICS."

Crankcase Pressure Test

Purpose

Verify if engine is in need for a possible overhaul or repair due to cylinder or valve wear or damage. Verify operation of air compressor or turbochargers for possible worn or damaged parts.

Tools

- Digital manometer
- ZTSE2217A – Water Manometer
- ZTSE4039 – Crankcase Pressure Test Tool
- ZTSE4891 – Air Cap, Fuel Cap and Plug Kit

Procedure

NOTE: Before performing this test, ensure engine is at normal operating temperature of 70˚ C (158˚ F) and oil level and pressure are within specification.

1. Verify crankcase oil breather separator is functioning properly before running this test. See Crankcase Oil Breather Separator Test.
2. Disconnect breather outlet tube from top of oil separator.

3. Connect Crankcase Pressure Test Tool ZTSE4039 to 90 degree breather elbow.



Figure 99 Digital manometer connected to Crankcase Pressure Tool

1. Crankcase Pressure Test Tool
2. Digital manometer

4. Connect manometer to Crankcase Pressure Test Tool ZTSE4039.

⚠ WARNING: To prevent personal injury or death, when routing test line, do not crimp line, run line too close to moving parts, or let line touch hot engine. Secure the gauge and test line to not obstruct vehicle operation.

⚠ WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

⚠ WARNING: To prevent personal injury or death, wear safety glasses with side shields.

5. Start engine and run at high idle. Allow manometer reading to stabilize before recording pressure reading.
6. Record crankcase pressure on Diagnostics Form.
   - If pressure is within specification, no repair is required.
   - If pressure is above specification, continue to next step.
7. Shut engine OFF. Drain vehicle air tanks until pressure is removed from air system.
8. Remove air line from remote-mounted centrifugal filter and cap using Air Cap, Fuel Cap, and Plug Kit ZTSE4891.
9. Start engine and run at high idle. Allow manometer reading to stabilize before recording pressure reading.
10. Record crankcase pressure on Diagnostics Form.
    - If pressure is within specification, repair or replace centrifugal filter assembly.
    - If pressure is above specification, continue to next step.

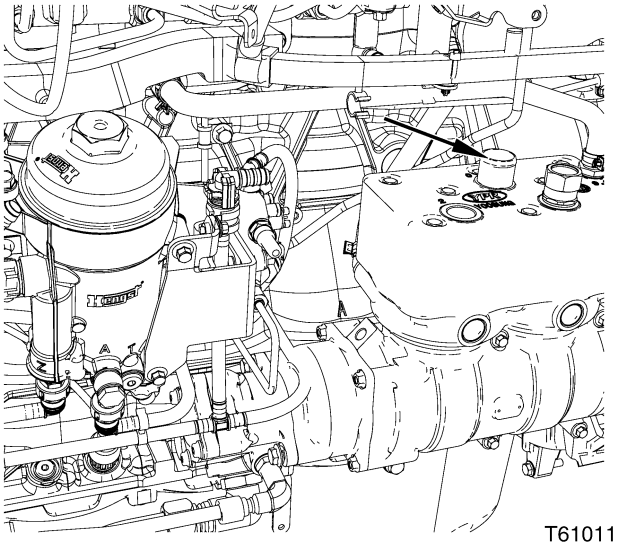


Figure 100 Air compressor discharge port

11. If engine has an air compressor, remove discharge line and test again. Allow manometer reading to stabilize before recording pressure reading.
12. Record crankcase pressure on Diagnostics Form.
    - If pressure is above specification, go to Relative Compression Test to pinpoint suspect cylinder.
    - If pressure is at or below specification, compressed air is leaking into crankcase. Repair or replace air compressor.

Cylinder Performance Test – Step 1

Relative Compression Test

Purpose

Verify all cylinders have good compression.

NOTE: The Relative Compression Test will validate cylinder balance. If an unbalanced cylinder is found, it is caused by a mechanical problem, not an injector fault.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

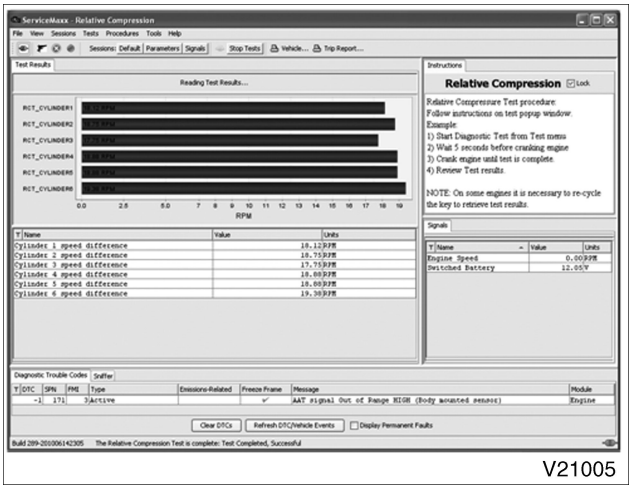
Procedure

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

NOTE: Use a battery charger when performing this test. It is important that cranking rpm remains consistent throughout test.

NOTE: Run Relative Compression Test a minimum of three times.

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Select Relative Compression test.
5. Follow on-screen instructions.
6. Record results on Diagnostics Form.
    - If the speed difference for one cylinder is significantly lower than the others, that cylinder is suspect for compression loss.



V21005

Figure 101 Relative Compression test

Possible Causes

- Valve train damage
- Valves out of adjustment
- Worn or broken piston rings
- Excessive cylinder wall wear
- Damaged piston

Cylinder Performance Test – Step 2

Cylinder Cutout Test

Purpose

Determine cause of rough engine idle.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Possible Causes

- Open or shorted injector wiring
- Scuffed or failed injector
- Power cylinder problem

Procedure

NOTE: Steps taken before running this test:

- **Run Relative Compression Test.**
- **Verify fuel system pressure is not below specification and fuel is not aerated.**

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. Start engine.
5. Select Cylinder Cutout Test.
6. Follow on-screen instructions.

NOTE: This test is only meant to isolate a low contributing cylinder due to an injector or injector circuit failure.

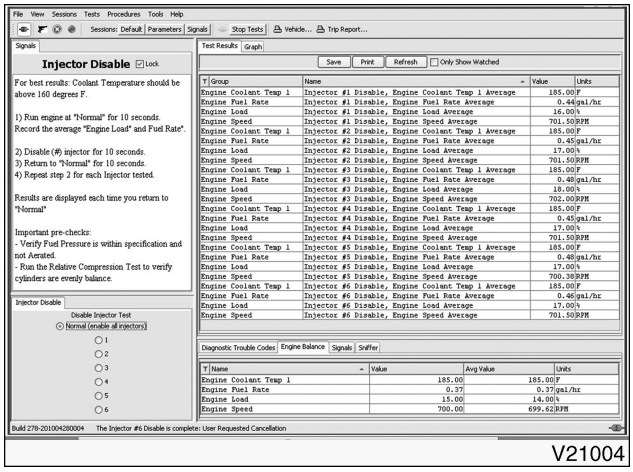


Figure 102 ServiceMaxx™ Cylinder Cutout Test

7. Record results on Diagnostics Form.

- If Cylinder Cutout Test does not identify a suspect cylinder, no action is required.
- If Cylinder Cutout Test identifies a suspect cylinder and Relative Compression Test does not, replace failed Injector. See Injector Replacement.

Injector Replacement

Purpose

Calibrate Engine Control Module (ECM) for newly installed injectors.

NOTE: Each injector is encrypted with an Injection Quantity Adjustment (IQA) code that must be programmed into the ECM anytime an injector has been replaced.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

IQA injects the correct amount of fuel for each individual injector throughout the operating range of the engine. Injector mechanical tolerances, high flow, and low flow can be evenly balanced with the ECM calibration.

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.

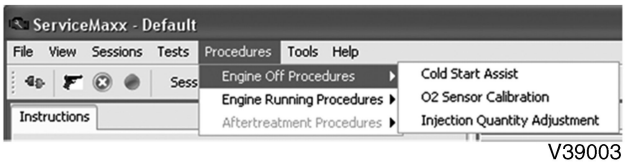


Figure 103 Injector Quantity Adjustment procedure

4. Select Injection Quantity Adjustment from Procedures drop-down menu.

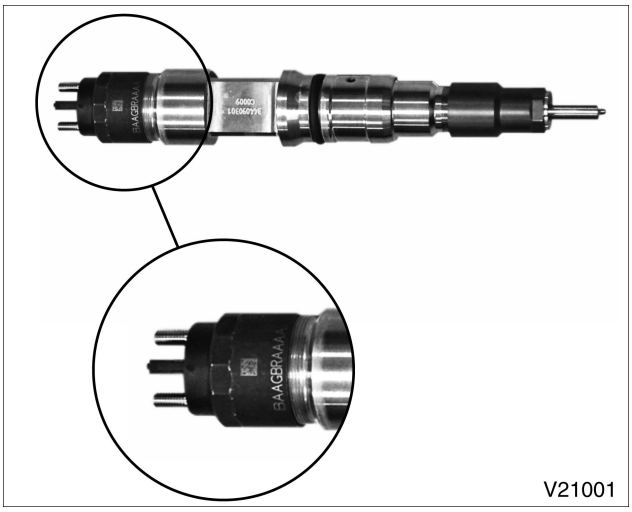


Figure 104 Picture of IQA code location

5. Type in new IQA code (stamped on top portion of injector) into proper cylinder location.

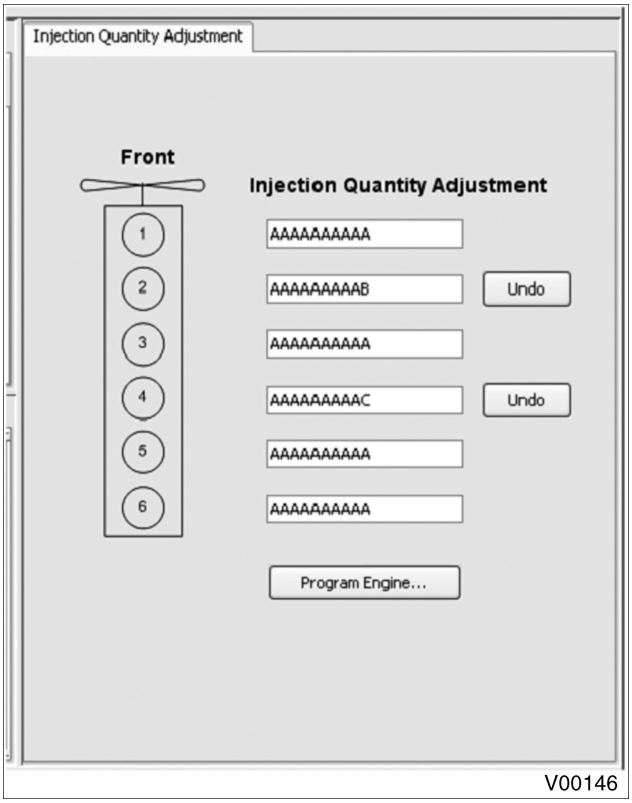


Figure 105 Injector Quantity Adjustment

NOTE: When the Undo button appears, the Program Engine button becomes active.

6. Press the Program Engine button.
7. Replace failed injector following procedures in the *Engine Service Manual*.

Fuel Pressure Control Valve (FPCV) Test

Purpose

Verify FPCV is not sticking.

Tools

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Procedure

1. Verify fuel system is operating within specifications and is not aerated.
2. Start engine and run until Engine Coolant Temperature is above 65 °C (150 °F)
3. Use ServiceMaxx™ software to run the Fuel Pressure Control Valve Test. Follow on-screen instructions.
4. Record results on Diagnostics Form.

NOTE: A minor ripple in the FRP signal graph display is acceptable. A shark-tooth fluctuation indicates FPCV is sticking.

- If FRP signal fluctuates in a shark-tooth pattern, replace FPCV following procedures in the *Engine Service Manual*.
- If FRP signal does not fluctuate in a shark-tooth pattern, no further action is required.

Charge Air Cooler (CAC) Pressure Test

Procedure

1. Attach Charge Air Cooler Test Kit ZTSE6042 to the CAC using three-inch couplers and clamps (obtain locally).
2. Attach pressure test gauge and gradually pressurize CAC to 30 psi (207 kPa). Turn off air supply when pressure reaches 30 psi (207 kPa).
3. If pressure drops, spray a soapy water solution on the CAC. Look for leaks from hose connections, CAC, and test components. Locate and mark leaks.
4. If a leak is detected on the CAC or the test gauge pressure drops, replace the CAC.

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27	0	EGR (page 621)	EGRP fault: over temperature
27	3	EGR (page 621)	EGRP signal Out of Range HIGH
27	4	EGR (page 621)	EGRP signal Out of Range LOW
27	7	EGR (page 621)	EGRP does not agree with commanded position
51	0	ETV (page 640)	ETP fault: over temperature
51	3	ETV (page 640)	ETP signal Out of Range HIGH
51	4	ETV (page 640)	ETP signal Out of Range LOW
51	7	ETV (page 640)	ETP does not agree with commanded position
84	2	VS (page 861)	Vehicle speed anti-tampering fault
91	2	APP (page 363)	APP1 and APP2 signal conflict
91	3	APP (page 363)	APP1 signal Out of Range HIGH
91	4	APP (page 363)	APP1 signal Out of Range LOW
94	0	FDP (page 674)	Fuel Delivery Pressure above maximum
94	3	FDP (page 674)	FDP signal Out of Range HIGH
94	4	FDP (page 674)	FDP signal Out of Range LOW
97	3	WIFL (page 891)	WIFL short to PWR
97	4	WIFL (page 891)	WIFL short to GND
97	5	WIFL (page 891)	WIFL open load/circuit
98	3	EOL (page 632)	EOL signal Out-of-Range HIGH
98	4	EOL (page 632)	EOL signal Out-of-Range LOW
100	1	EWPS (page 647)	Engine Oil System below Critical Pressure
100	3	EOP (page 635)	EOP signal Out of Range HIGH
100	4	EOP (page 635)	EOP signal Out of Range LOW
100	11	EWPS (page 647)	Engine oil pressure below dealer programmed engine RPM value
100	17	EWPS (page 647)	Low Oil Pressure vehicle event fault
100	18	EWPS (page 647)	Engine Oil System below Warning Pressure
102	2	IMP (page 715)	IMP signal does not agree with BARO
102	3	IMP (page 715)	IMP signal Out of Range HIGH
102	4	IMP (page 715)	IMP signal Out of Range LOW
102	10	IMP (page 715)	IMP Boost slow response
102	16	AMS (page 356)	Intake Manifold Pressure Overboost
102	18	AMS (page 356)	Intake Manifold Pressure Underboost

SPN	FMI	Sub-section	Condition Description
105	2	IMT (page 725)	IMT signal does not agree with other sensors
105	3	IMT (page 725)	IMT signal Out of Range HIGH
105	4	IMT (page 725)	IMT signal Out of Range LOW
105	18	IMT (page 725)	IMT signal not responding as expected
108	3	ECM Self (page 596)	BARO signal Out of Range HIGH
108	4	ECM Self (page 596)	BARO signal Out of Range LOW
110	0	EWPS (page 647)	Engine Coolant System above Critical Temperature
110	3	ECT1 (page 605)	ECT1 signal Out of Range HIGH
110	4	ECT1 (page 605)	ECT1 signal Out of Range LOW
110	11	EWPS (page 647)	Event logger, coolant temperature hot, extreme
110	15	EWPS (page 647)	Engine Coolant System above Warning temperature
110	16	EWPS (page 647)	Engine Coolant System above OBD maximum temperature
110	17	ECS (page 599)	Engine Coolant System below OBD monitoring temperature
110	18	ECS (page 599)	Engine coolant system below closed loop minimum temperature
111	1	EWPS (page 647)	Low Engine Coolant Level
		ECL (page 587)	
157	0	FRP (page 693)	FRP relief valve opening fault
157	3	FRP (page 683)	FRP signal Out of Range HIGH
157	4	FRP (page 683)	FRP signal Out of Range LOW
157	14	FRP (page 693)	FRP Relief Valve failure
157	20	FRP (page 683)	FRP signal Drifted HIGH
157	21	FRP (page 683)	FRP signal Drifted LOW
158	15	ECM PWR (page 589)	ECM Switched voltage too HIGH
158	17	ECM PWR (page 589)	ECM Switched voltage too LOW
171	2	AAT (page 207)	AAT signal does not agree with other sensors
171	3	AAT (page 207)	AAT signal Out of Range HIGH (Body mounted sensor)
171	4	AAT (page 207)	AAT signal Out of Range LOW (Body mounted sensor)
172	2	IAT (page 710)	IAT signal does not agree with other sensors
172	3	IAT (page 710)	IAT signal Out of Range HIGH
172	4	IAT (page 710)	IAT signal Out of Range LOW
175	0	EWPS (page 647)	Engine Oil System above Critical Temperature
175	3	EOT (page 638)	EOT signal Out of Range HIGH

SPN	FMI	Sub-section	Condition Description
175	4	EOT (page 638)	EOT signal Out of Range LOW
175	11	EWPS (page 647)	Oil Temperature Exceeds limit by large amount
175	15	EWPS (page 647)	Engine Oil System above warning temperature
188	0	EWPS (page 647)	Engine unable to achieve desired idle speed (too high)
188	1	EWPS (page 647)	Engine unable to achieve desired idle speed (too low)
190	0	EWPS (page 647)	Engine overspeed most severe level
190	11	EWPS (page 647)	Engine overspeed vehicle event fault
190	15	EWPS (page 647)	Engine overspeed detected
191	1	TOSS (page 861)	TOSS not detected with vehicle moving
191	2	TOSS (page 861)	TOSS signal erratic, intermittent or incorrect
191	3	TOSS (page 861)	TOSS signal Out of Range HIGH
191	4	TOSS (page 861)	TOSS signal Out of Range LOW
191	16	TOSS (page 861)	Hard wired vehicle speed reading higher than limit
251	19	SART (page 829)	ECM not detecting SART module J1939
354	3	HS (page 710)	Relative Humidity signal Out of Range HIGH
354	4	HS (page 710)	Relative Humidity signal Out of Range LOW
412	1	EGRT (page 618)	EGRT signal stuck low, not warming up
412	2	EGRT (page 618)	EGRT signal does not agree with other sensors
412	3	EGRT (page 618)	EGRT signal Out of Range HIGH
412	4	EGRT (page 618)	EGRT signal Out of Range LOW
560	19	J1939 (page 804)	Transmission Driveline Engaged not detected on J1939
626	3	IAHFS (page 421)	IAHFS short to PWR
626	4	IAHFS (page 421)	IAHFS short to GND
626	5	IAHFS (page 421)	IAHFS open load/circuit
626	18	IAHFS (page 421)	Inlet Air Heater fault: Lack of heat in the Intake Manifold
		IAHFI (page 411)	
628	12	ECM Self (page 596)	ECM Memory Error
629	2	ECM Self (page 596)	ECM Error – Level 2 Monitoring
629	8	ECM Self (page 596)	Engine Off timer fault
629	12	ECM Self (page 596)	ECM Internal chip Error
629	14	ECM Self (page 596)	ECM Internal component
633	3	FPCV (page 681)	FPCV short to PWR
633	4	FPCV (page 681)	FPCV short to GND
633	5	FPCV (page 681)	FPCV open load/circuit

SPN	FMI	Sub-section	Condition Description
636	2	CMP (page 393)	CMP and CKP Synchronization Error
636	8	CMP (page 393)	CMP signal noise
636	10	CMP (page 393)	CMP signal missing
637	8	CKP (page 382)	CKP signal noise
637	10	CKP (page 382)	CKP signal inactive
639	14	J1939 (page 804)	J1939 Data Link Error (ECM unable to transmit)
639	19	J1939 (page 804)	J1939 Data Link Error (ECM unable to transmit or receive)
647	3	EFC (page 615)	EFC short to PWR
647	4	EFC (page 615)	EFC short to GND
647	5	EFC (page 615)	EFC open load/circuit
651	4	INJ (page 728)	INJ short circuit
651	5	INJ (page 728)	INJ open circuit
651	13	CYL Balance (page 424)	Injector 1 programmable parameter error
651	16	CYL Balance (page 424)	Injector 1 Fuel quantity/timing high error
651	18	CYL Balance (page 424)	Injector 1 Fuel quantity/timing low error
652	4	INJ (page 728)	Injector 2 short circuit
652	5	INJ (page 728)	Injector 2 open circuit
652	13	CYL Balance (page 424)	Injector 2 programmable parameter error
652	16	CYL Balance (page 424)	Injector 2 Fuel quantity/timing high error
652	18	CYL Balance (page 424)	Injector 2 Fuel quantity/timing low error
653	4	INJ (page 728)	Injector 3 short circuit
653	5	INJ (page 728)	Injector 3 open circuit
653	13	CYL Balance (page 424)	Injector 3 programmable parameter error
653	16	CYL Balance (page 424)	Injector 3 Fuel quantity/timing high error
653	18	CYL Balance (page 424)	Injector 3 Fuel quantity/timing low error
654	4	INJ (page 728)	Injector 4 short circuit
654	5	INJ (page 728)	Injector 4 open circuit
654	13	CYL Balance (page 424)	Injector 4 programmable parameter error
654	16	CYL Balance (page 424)	Injector 4 Fuel quantity/timing high error
654	18	CYL Balance (page 424)	Injector 4 Fuel quantity/timing low error
655	4	INJ (page 728)	Injector 5 short circuit
655	5	INJ (page 728)	Injector 5 open circuit
655	13	CYL Balance (page 424)	Injector 5 programmable parameter error
655	16	CYL Balance (page 424)	Injector 5 Fuel quantity/timing high error

SPN	FMI	Sub-section	Condition Description
655	18	CYL Balance (page 424)	Injector 5 Fuel quantity/timing low error
656	4	INJ (page 728)	Injector 6 short circuit
656	5	INJ (page 728)	Injector 6 open circuit
656	13	CYL Balance (page 424)	Injector 6 programmable parameter error
656	16	CYL Balance (page 424)	Injector 6 Fuel quantity/timing high error
656	18	CYL Balance (page 424)	Injector 6 Fuel quantity/timing low error
724	2	O^2S (page 810)	O_2S Slow response detecting fueling to non-fueling
724	3	O^2S (page 810)	O_2S Circuit Fault: Open or short to PWR
724	4	O^2S (page 810)	O_2S Circuit Fault: Short to GND
724	5	O^2S (page 810)	O_2S Circuit Fault: Open circuit
724	20	O^2S (page 810)	O_2S adaptation above maximum limit
724	21	O^2S (page 810)	O_2S adaptation below minimum limit
837	14	SPEEDO	Speedometer Drive Output Error
			Refer to the *Chassis Electrical Circuit Diagram Manual*
974	3	RAPP (page 826)	Remote APP signal Out of Range HIGH
974	4	RAPP (page 826)	Remote APP signal Out of Range LOW
1072	3	ECB1 (page 581)	ECB1 Control short to PWR
1072	4	ECB1 (page 581)	ECB1 Control short to GND
1072	5	ECB1 (page 581)	ECB1 Control open load/circuit
1073	3	ECB2 (page 584)	ECB2 Control short to PWR
1073	4	ECB2 (page 584)	ECB2 Control short to GND
1073	5	ECB2 (page 584)	ECB2 Control open load/circuit
1081	3	WTSL (page 897)	WTSL short to PWR
1081	4	WTSL (page 897)	WTSL short to GND
1081	5	WTSL (page 897)	WTSL open load/circuit
1110	31	ECM Self (page 596)	ECM detects fueling without demand
1135	3	EOL (page 632)	EOT2 signal Out of Range HIGH
1135	4	EOL (page 632)	EOT2 signal Out of Range LOW
1173	2	TC2CIS (page 841)	TC2CIT signal does not agree with other sensors
1173	3	TC2CIS (page 841)	TC2CIT signal Out of Range HIGH
1173	4	TC2CIS (page 841)	TC2CIT signal Out of Range LOW
1173	16	AMS (page 356)	TC2CIT signal above desired (interstage CAC under cooling)
1177	2	TC2CIS (page 841)	TC2CIT signal erratic, intermittent, or incorrect
1177	3	TC2CIS (page 841)	TC2CIP signal Out of Range HIGH

SPN	FMI	Sub-section	Condition Description
1177	4	TC2CIS (page 841)	TC2CIP signal Out of Range LOW
1188	3	TC1WC (page 835)	TC1WC short to PWR
1188	4	TC1WC (page 835)	TC1WC short to GND
1189	3	TC2WC (page 838)	TC2WC short to PWR
1189	4	TC2WC (page 838)	TC2WC short to GND
1189	5	TC2WC (page 838)	TC2WC open load/circuit
1213	3	MIL (page 808)	MIL circuit short to PWR
1213	4	MIL (page 808)	MIL circuit short to GND
1213	5	MIL (page 808)	MIL open load/circuit
1322	31	CYL Balance (page 424)	Misfire - Multiple Cylinders
1323	31	CYL Balance (page 424)	Misfire - Cylinder 1
1324	31	CYL Balance (page 424)	Misfire - Cylinder 2
1325	31	CYL Balance (page 424)	Misfire - Cylinder 3
1326	31	CYL Balance (page 424)	Misfire - Cylinder 4
1327	31	CYL Balance (page 424)	Misfire - Cylinder 5
1328	31	CYL Balance (page 424)	Misfire - Cylinder 6
1378	31	Service (page 828)	Change Engine Oil Service Interval
1590	19	Adaptive Cruise Control (page 804)	Adaptive Cruise Control not detected on J1939
1659	20	ECS (page 599)	ECT1 below expected: Check Thermostat
1810	0	Hard Brake Monitor (page 709)	Hard Brake monitor, event log, extreme
1810	15	Hard Brake Monitor (page 709)	Hard Brake monitor, event log, non-extreme
2588	0	EWPS(page 647)	Vehicle overspeed 1, event log, extreme
2588	15	EWPS (page 647)	Vehicle overspeed 1, event log, non-extreme
2589	0	EWPS (page 647)	Vehicle overspeed 2, event log, extreme
2589	15	EWPS (page 647)	Vehicle overspeed 2, event log, non-extreme
2623	3	APP (page 363)	APP2 signal Out of Range HIGH
2623	4	APP (page 363)	APP2 signal Out of Range LOW
2630	2	CACOT (page 368)	CACOT signal does not agree with other sensors
2630	3	CACOT (page 368)	CACOT signal Out of Range HIGH
2630	4	CACOT (page 368)	CACOT signal Out of Range LOW
2630	16	CACOT (page 368)	CACOT undercooling
2659	20	AMS (page 356)	EGR High Flow Rate detected
2659	21	AMS (page 356)	EGR Low Flow Rate detected
2791	3	EGR (page 621)	EGRC short to PWR

SPN	FMI	Sub-section	Condition Description
2791	5	EGR (page 621)	EGRC open load/circuit
2791	8	EGR (page 621)	EGR valve not receiving ECM PWM signal
2797	11	INJ (page 728)	Injector Control Group 1 short circuit (INJ 1, 3, 5)
2798	11	INJ (page 728)	Injector Control Group 2 short circuit (INJ 2, 4, 6)
3055	0	FRPS (page 693)	FRP exceeded maximum
3055	1	FRPS (page 693)	No start due to low rail fuel pressure
3055	15	FRPS (page 693)	FRP below minimum with maximum command
3055	17	FRPS (page 693)	FRP above maximum with minimum command
3058	0	EGR System Monitor (page 625)	EGR did not go into Open loop EGR control when expected
3058	10	EGR System Monitor (page 625)	EGR did not go into Closed loop EGR control when expected
3223	0	O_2S (page 810)	O_2S heater temperature above maximum
3223	1	O_2S (page 810)	O_2S heater temperature below minimum
3223	3	O_2S (page 810)	O_2S heater short to PWR
3223	4	O_2S (page 810)	O_2S heater short to GND
3223	5	O_2S (page 810)	O_2S heater open load/circuit
3223	17	O_2S (page 810)	O_2S heater temperature below minimum at low battery PWR
3246	2	DPFOT (page 526)	DPFOT signal does not agree with other exhaust sensors
3246	3	DPFOT (page 526)	DPFOT signal Out of Range HIGH
3246	4	DPFOT (page 526)	DPFOT signal Out of Range LOW
3246	20	DPFOT (page 526)	DPFOT signal drifted HIGH
3246	21	DPFOT (page 526)	DPFOT signal drifted LOW
3251	0	AFT System (page 217)	DPFDP excessively HIGH (restricted filter)
3251	2	DPFDP (page 514)	DPFDP above or below desired level
3251	3	DPFDP (page 514)	DPFDP signal Out of Range HIGH
3251	4	DPFDP (page 514)	DPFDP signal Out of Range LOW
3251	14	AFT System (page 217)	DPFDP sensor pressure hoses reversed
3251	21	AFT System (page 217)	DPFDP excessively LOW (Sensor/circuit fault or missing DPF)
3464	3	ETV (page 640)	ETC short to PWR
3464	5	ETV (page 640)	ETC open load/circuit
3464	8	ETV (page 640)	ETC not receiving command from ECM
3471	1	AFT System (page 217)	Fuel Pressure 1 below desired (Low system pressure)
3471	7	AFT System (page 217)	Fuel Doser Valve not responding as expected

SPN	FMI	Sub-section	Condition Description
3479	3	AFTFD (page 330)	AFTFD Fuel Doser Valve short to PWR
3479	5	AFTFD (page 330)	AFT Fuel Doser Valve open/load circuit
3479	6	AFTFD (page 330)	AFT Fuel Doser Valve High Side Short circuit
3480	0	AFT System (page 217)	AFTFP1 too high while dosing
3480	1	AFT System (page 217)	AFTFP1 too low while dosing
3480	2	AFTFIS (page 333)	AFTFP1 sensor plausibility error
3480	3	AFTFIS (page 333)	AFTFP1 signal Out of Range HIGH
3480	4	AFTFIS (page 333)	AFTFP1 signal Out of Range LOW
3481	7	AFT System (page 217)	Incorrect dosing pressure, multiple events
3482	3	AFTFSV (page 349)	AFT Fuel Shutoff Valve short to PWR
3482	4	AFTFSV (page 349)	AFT Fuel Shutoff Valve short to GND
3509	14	VREF (page 881)	VREF1 voltage deviation ECM pins: C1-36
3510	14	VREF (page 881)	VREF2 voltage deviation ECM pins: E1-85 and E1-86
3511	14	VREF (page 881)	VREF3 voltage deviation ECM pins: E1-89
3512	14	VREF (page 881)	VREF4 voltage deviation ECM pins: C1-37, C1-49, C2-08 and E1-58
3513	14	VREF (page 881)	VREF5 voltage deviation ECM pins: C1-50, E1-81, and E1-82.
3514	14	VREF (page 881)	VREF6 voltage deviation ECM pin: E1-88
3556	0	AFT System (page 217)	AFT fuel pressure 2 excessively high
3556	1	AFT System (page 217)	AFT fuel pressure 2 below desired
3556	7	AFT System (page 217)	AFT fuel injector not responding as expected
3597	4	ECM PWR Output (page 591)	ECM Power Output 1 below normal ECM Pins: C1-31, C1-33, C1-54, C2-51, E1-01 and E1-51
3598	4	ECM PWR Output (page 591)	ECM Power Output 2 below normal ECM Pins: C1-42, C2-06, E1-05, E1-28, E1-29 and E1-54
3599	4	ECM PWR Output (page 591)	ECM Power Output 3 below normal ECM Pins: C1-30, C2-03, E1-24, E1-26 and E1-27
3719	0	DPF System (page 549)	DPF Soot Load - Highest (level 3/3)
3719	15	DPF System (page 549)	DPF Soot Load - Lowest (level 1/3)
3719	16	DPF System (page 549)	DPF Soot Load - Moderate (level 2/3)
3720	0	DPF System (page 549)	DPF Ash load at maximum limit (Remove DPF for cleaning)
3750	31	AFT System (page 217)	DPF Regen inhibited due to low exhaust temperatures
3936	10	DPF System (page 549)	DPF Thermal management mode failed to raise DOC-In Temp as expected
3936	20	DPF System (page 549)	High Regen Frequency

SPN	FMI	Sub-section	Condition Description
4076	0	EWPS (page 647)	ECT2 above Critical (EWPS programmable limit)
4076	2	ECT2 (page 607)	ECT2 signal erratic, intermittent, or incorrect
4076	3	ECT2 (page 607)	ECT2 signal Out of Range HIGH
4076	4	ECT2 (page 607)	ECT2 signal Out of Range LOW
4076	15	EWPS (page 647)	ECT2 above Warning (EWPS programmable limit)
4076	16	ECT2 (page 607)	ECT2 signal does not agree with other sensors (Cold soak)
4076	17	ECT2 (page 607)	ECT2 signal stuck low, not warming up
4077	0	AFT System (page 217)	AFTFP2 too high while dosing
4077	1	AFT System (page 217)	AFTFP2 too low while dosing
4077	3	AFTFP2 (page 346)	AFTFP2 signal out of Range HIGH
4077	4	AFTFP2 (page 346)	AFTFP2 signal out of Range LOW
4077	14	AFTFP2 (page 346)	AFTFP2 Sensor plausibility error
4192	3	WIF (page 888)	WIF signal Out of Range HIGH
4192	4	WIF (page 888)	WIF signal Out of Range LOW
4227	7	CCOSS (page 376)	CC Oil Separator Speed: Not spinning
4752	4	ECS (page 599)	EGR Cooler Efficiency: EGR outlet Temperature above expected
4765	2	DOCIT (page 487)	DOCIT signal does not agree with other exhaust sensors
4765	3	DOCIT (page 487)	DOCIT signal Out of Range HIGH
4765	4	DOCIT (page 487)	DOCIT signal Out of Range LOW
4765	20	DOCIT (page 487)	DOCIT signal drifted HIGH
4765	21	DOCIT (page 487)	DOCIT signal drifted LOW
4766	2	DOCOT (page 503)	DOCOT signal does not agree with other exhaust sensors
4766	3	DOCOT (page 503)	DOCOT signal Out of Range HIGH
4766	4	DOCOT (page 503)	DOCOT signal Out of Range LOW
4766	10	AFT System (page 217)	DPF Regeneration feedback fault
4766	20	AFT System (page 217)	DOC Outlet Temp above maximum desired
4766	21	AFT System (page 217)	DOC Outlet Temp below minimum desired
5298	2	AFT System (page 217)	Reduced DOC Efficiency – De-Rate
5319	31	AFT System (page 217)	DPF incomplete Regeneration
5395	0	EWPS (page 647)	Engine idle fuel quantity too high
5395	1	EWPS (page 647)	Engine idle fuel quantity too high
5456	3	AFTFIS (page 333)	AFTFT signal Out of Range HIGH

SPN	FMI	Sub-section	Condition Description
5456	4	AFTFIS (page 333)	AFTFT signal Out of Range LOW
5541	2	TC1TOP (page 831)	TC1TOP does not agree with BARO
5541	3	TC1TOP (page 831)	TC1TOP signal Out of Range HIGH
5541	4	TC1TOP (page 831)	TC1TOP signal Out of Range LOW
5542	15	EBPV (page 578)	TC1TOP above desired
5542	17	EBPV (page 578)	TC1TOP below desired
5543	3	EBPV (page 578)	EBPC short to PWR
5543	4	EBPV (page 578)	EBPC short to GND
5543	5	EBPV (page 578)	EBPC open load/circuit
5546	3	CMV (page 409)	CMV short to PWR
5546	4	CMV (page 409)	CMV short to GND
5546	5	CMV (page 409)	CMV open load/circuit
5547	3	CFV (page 380)	CFV short to PWR
5547	4	CFV (page 380)	CFV short to GND
5547	5	CFV (page 380)	CFV open load/circuit
5548	3	IAHFI (page 411)	IAHFI short to PWR
5548	4	IAHFI (page 411)	IAHFI short to GND
5548	5	IAHFI (page 411)	IAHFI open load/circuit
5548	7	IAHFI (page 411)	Inlet Air Heater Relay return (relay, or igniter, or circuit failure)

Diagnostics Form 0000002941 Usage

Diagnostics Form Example

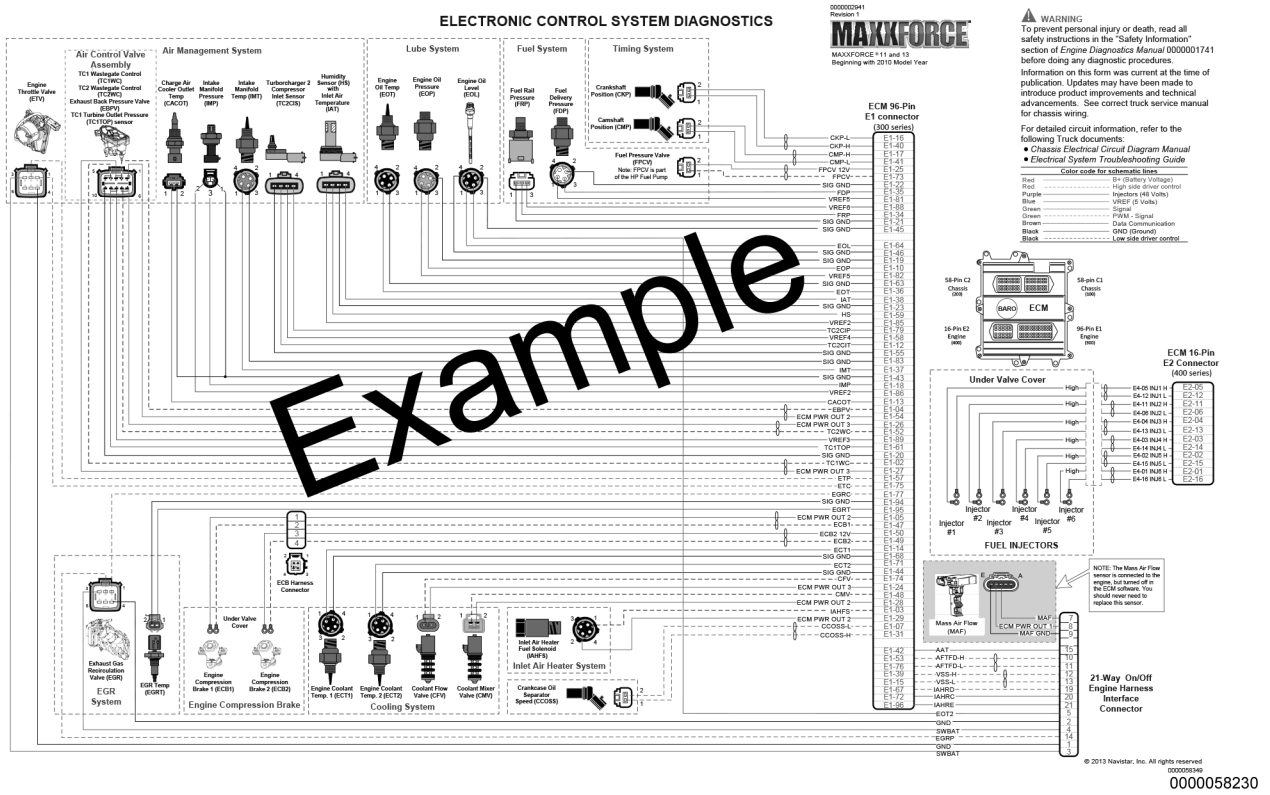


Figure 106 Diagnostics form (front side)

Engine diagnostics form 0000002941 assists technicians in troubleshooting MaxxForce® diesel engines. Diagnostic schematics and signal values help technicians find problems to avoid unnecessary repairs.

The Electronic Control System Diagnostics form consists of a circuit diagram for electrical components mounted on the engine and vehicle. For a detailed description of vehicle circuits, circuit numbers, or connector and fuse locations, see truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide*. The back side of the form consists of signal values.

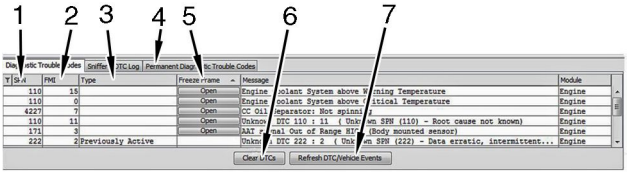
Diagnostics Form 0000002941 is available in 50 sheet pads. To order technical service literature, contact your International dealer.

HD-OBD System Description

Heavy Duty – Onboard Diagnostic System

HD-OBD System is comprised mainly of software designed into the engine's onboard computer to detect emission control system malfunctions as they occur by monitoring virtually every component and system that can cause an increase in emissions.

Diagnostic Trouble Codes (DTCs)



V00134a

Figure 107 Electronic Service Tool DTC Screen Shot

1. Suspect Parameter Number (SPN)
2. Failure Mode Indicator (FMI)
3. Fault Code Type
4. Permanent Diagnostic Trouble Codes tab
5. Freeze Frame
6. Clear DTCs button
7. Refresh DTC/Vehicle Events button

DTC Faults

NOTE: 2010 MaxxForce® engines are now complying with Society of Automotive Engineers (SAE) naming conventions. Many components will have different names than the 2008-2009 MaxxForce® 11 and 13 engines.

Suspect Parameter Number (SPN)

The SPN identifies the individual component causing the DTC.

Failure Mode Indicator (FMI)

The FMI identifies the type of failure of the individual component.

Pending DTC (MIL off)

Pending faults are possible faults that were detected on the first drive cycle and do not turn on the Malfunction Indicator Lamp (MIL). Only a Heavy Duty Onboard Diagnostic (HD-OBD) fault can be set as pending.

- If the same fault was not detected on the second drive cycle, that same fault is cleared on the third drive cycle.
- If the same fault is detected on the second drive cycle, the fault becomes Active and turns on the Malfunction Indicator Lamp (MIL).

Active DTC (MIL on)

Active faults or HD-OBD faults are faults that were detected on two consecutive drive cycles and are currently active right now.

Healing DTC (MIL on)

A Healing DTC is an Active fault that was detected on a previous drive cycle, but was not detected on the second drive cycle.

- If the same fault is not detected on the next three consecutive drive cycles, then the fault becomes Previously Active and the Malfunction Indicator Lamp (MIL) is turned off.
- If the same fault is detected within the next three consecutive drive cycles, then the fault returns to Active and the MIL stays on.

Previously Active DTC (MIL off)

Previously active faults, are historical faults that were detected in a previous drive cycle, but were not detected on then next 3 consecutive Healing drive cycles.

- If the same fault is not detected again on three consecutive drive cycles, the fault becomes Previously Active and Malfunction Indicator Lamp (MIL) is turned off.
- If the same fault is detected within three consecutive drive cycles, then the fault returns Active and the MIL turns on.

Freeze Frame

Freeze Frame data is a snapshot of the engine's operating condition at the time the fault was detected.

- Freeze Frame data is updated each drive cycle in which a fault is detected
- Freeze Frame data is cleared when the DTC is cleared.

Permanent Diagnostic Trouble Codes

Permanent DTCs are historic faults that should not be treated as a current problem with the control system. When an active HD-OBD DTC is set, a permanent DTC is also set. A permanent DTC is cleared when the monitor that set the active DTC passes on three consecutive drive cycles.

Clearing DTCs

DTCs can be cleared by pressing the Clear DTCs button with the ignition Key ON, Engine OFF (KOEO). DTCs cannot be cleared with the engine running. Cycle the ignition key to verify DTCs have been cleared from the ECM.

HD-OBD Fault Detection

The HD-OBD system monitors the control system much like a non-OBD system, but with much tighter tolerances. HD-OBD allows two occurrences of a fault before the MIL is turned on. This provides more confidence that the fault really exists. If a fault condition is detected, a pending fault is set with Freeze Frame data and will remain pending through the rest of the drive cycle. If the fault occurs again before the end of the next drive cycle, then it becomes an active fault, and the MIL is illuminated with updated Freeze Frame data. If the fault does not occur again before the end of the next drive cycle, then the pending fault is cleared along with the Freeze Frame data, and the MIL is not illuminated.

Not all faults require two occurrences to become active. Most sensor and actuator circuit faults will skip the pending status and make the fault active on the first occurrence.

After faults become active, the monitor will continue to check the fault condition. If the fault test continues to fail, it will be reported as active. If the fault test passes, it will start the process of clearing the fault. After three consecutive drive cycles, where the fault condition is tested and passed, the MIL will turn off, the code will go previous active for the next 40 warm-up cycles, and the MIL is not illuminated. After those warm-up cycles, the code is cleared without using the Electronic Service Tool (EST).

Readiness Monitors

Readiness indicates the status of the HD-OBD monitors, whether they can be run on this drive cycle and whether they have been run. It is not related to whether a fault is pending, active, or previously active.

Readiness is required to assist in HD-OBD inspections. If a vehicle is due for HD-OBD inspection and would fail because a fault code exists, it is possible for the driver to clear the code by using the Electronic Service Tool (EST) or by disconnecting the battery. However, either of these will reset the readiness status. The inspector will see that there are no codes, but also see that some of the HD-OBD monitors have not been run, so will refuse to allow the vehicle to pass inspection until all the monitors have a Run Status and no codes are present.

All monitors will run at some point during normal operation of the vehicle. However, to satisfy all the different trip monitors, the vehicle must be driven under a variety of conditions.

ServiceMaxx™ HD-OBD Monitor Session

HD-OBD monitors can be viewed using ServiceMaxx™ software with the HD-OBD Monitor session file.

Monitor Results

Monitor Results display the results of each monitors actual value with pass or fail thresholds. A technician can use this information to validate if a repair was successful.

- A monitor will pass if the value is within the minimum and maximum allowed value for a certain amount of time.
- A monitor will fail if the value is outside of the minimum and maximum allowed value for a certain amount of time. A failed monitor will set a DTC with Freeze Frame data.
- If a monitor has not run, the drive cycle conditions have not been met.

NOTE: Press the Refresh DTC/Vehicle Event button to view monitors. Press the Clear DTCs button to clear monitors.

Readiness Report Tab

This tab displays the results from the last execution of HD-OBD monitors. The results include the minimum and maximum allowed value (if applicable) and the actual test result value. If the test result is within the minimum and maximum allowed value, the monitor passed successfully and no failure was detected.

This information can be used by a technician to check the test results after repairs were performed.

Diagnostic Readiness Tab

This tab displays general information about the state of the HD-OBD system. This includes:

- The number of active and previous active fault codes.
- The HD-OBD Compliant level of the system.
- The status of groups of HD-OBD monitors: whether or not the monitors in each group are supported on this vehicle, whether or not the monitors in each group have finished, and whether or not a condition has occurred that would prevent the execution of the monitors in each group on the current drive cycle.

After faults have been cleared, the technician could use this information to find out if monitors have been run or not.

Not-To-Exceed Operation Status Tab

This tab displays information about whether the engine is operating in a geographical region to control NOx and particulate matter emissions that cannot exceed specified limits. For both NOx and particulate matter emissions, the information includes whether or not the engine is operating in the defined Not-To-Exceed area, whether or not the engine is operating in an area of limited Not-To-Exceed testing (the carve-out area), and whether or not the engine is operating in an area where a Not-To-Exceed deficiency has been received.

Calibration Identification Tab

This tab displays information about the calibration in the engine control module. This information includes the calibration identifier and a verification number that is computed for each calibration.

Diagnostic Procedure Process With Examples

Description

The test procedures in this section are based on the assumption there is a Diagnostic Trouble Code (DTC) or problem with the component being tested.

When a DTC is detected, select the appropriate SPN, FMI, and sub-section page number from DTC list to locate a specific component or circuit to be tested.

Do checks in sequence unless directed otherwise. If a test point is out of specification, the comment area will direct the technician to the possible cause or to another test point. It is not necessary to complete all the test points, unless additional assistance is needed to pinpoint the fault.

Pin-grip Inspection

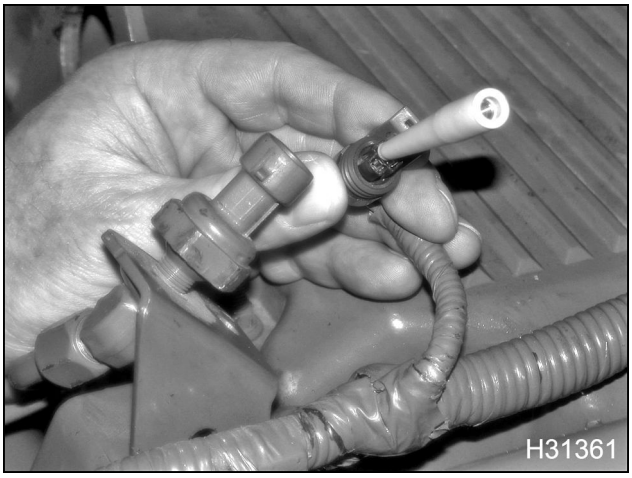


Figure 108 Pin grip check

1. Disconnect the harness connector from the sensor or actuator.
2. Inspect for corrosion, bent pins, spread pins, or conditions that could cause a loose or intermittent connection.
3. Check the pin grip in the female pin by inserting the correct tool from Terminal Test Kit.

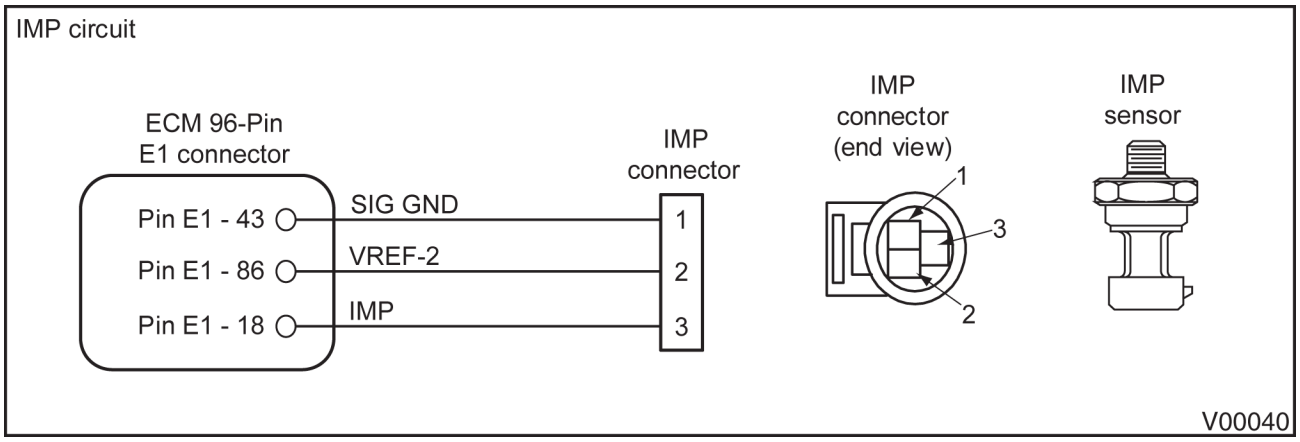


Figure 109 “Example” IMP sensor circuit diagram

Using Electronic Service Tool, monitor IMP voltage.

Using a Digital Multi-Meter, measure voltage between pin 2 and battery ground.

Using a Digital Multi-Meter, measure voltage between pin 1 and 2.

Sens Circuit Check With S viceMaxx™ Software

Conn ct breakout harness nd leave sensor disconnected. urn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor IMPv	5 V	If < 4.5 V, check IMP signal circuit for short to GND. Do Harness Resistance Check (page 185).
DMM – Measure volts 2 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF2 circuit for short to PWR. If < 4.5 V, check VREF2 circuit for OPEN or short to GND. Do Harness Resistance Check (page 185).
DMM – Measure voltage 1 to 2	5.0 V ± 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 185).
EST – Monitor IMPv Short across breakout harness pins 1 and 3	0 V	If > 0.5 V, check IMP signal circuit for OPEN or short to PWR. Do Harness Resistance Check (page 185).
If check are within specifications, connect sensor and clear DTCs. If active DTC remains, replace IMP sensor.		

Using Electronic Service Tool, monitor IMP voltage, while shorting pin 1 to pin 3.

V00164

Pin-point Diagnostics (without ServiceMaxx™ software)

1. Connect Breakout Harness to the engine harness. Leave sensor disconnected.
2. Turn ignition switch ON, engine OFF.
3. Use a DMM to measure voltage on each circuit to engine ground.

Example

Test Point	Specifications	Comment – < Less than, > Greater than
C to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Checks.

- If the circuit is not within specification, the comment area will list possible cause or direct the technician to the next test point. Do Harness Resistance Check if additional assistance is needed in diagnosing fault.
- If the circuit is within specification, continue to the next test point.

Actuator Operational Voltage Check – Output State Test

This test will allow the technician to take voltage measurements on actuators commanded high or low.

1. Disconnect actuator. Inspect connector for damaged pins. Repair as necessary.

2. Connect Breakout Harness between engine harness and actuator.

3. Connect the EST to the Diagnostic Connector.

4. Turn ignition switch ON, engine OFF.

5. Start ServiceMaxx™ software.

6. Open the Output State session. This session allows the technician to monitor the state of all engine actuators.

7. Run the Output State test (high or low) or Glow Plug / IAH test.

8. Use a DMM to measure voltage on each circuit to engine ground.

Example

Test Point	Test	Specifications	Comment – < Less than, > Greater than
A to GND	Key On-Engine Off (KOEO)	B+	If < B+, check for OPEN circuit.
B to GND	KOEO	B+	If < B+, check actuator coil for OPEN.
B to GND	Output State HIGH	B+	If < B+, check actuator control circuit for short to GND.
B to GND	Output State LOW	7.5 V	If > 7.5 V, check actuator control circuit for OPEN or short to PWR or failed across coil.

- If any circuit is not within specification, the comment area will list possible cause or direct the technician to the next test point.
- If all circuits are within specification, the actuator may not be operating mechanically.

Harness Resistance Check

Complete Sensor End Diagnostics or Pin-point Diagnostics tests before using this procedure.

Resistance cannot be measured on a circuit if voltage is present. Isolate circuit from voltage before continuing.

1. Turn ignition switch to OFF or disconnect batteries.

2. Connect 180-Pin Breakout Box and breakout harness to vehicle or engine harness. Leave ECM and sensor or actuator disconnected.

3. Use a DMM to measure resistance on each circuit from point to point, then to engine ground.

⚠ WARNING: To prevent personal injury or death, always disconnect main negative battery cable first. Always connect the main negative battery cable last.

Example

Test Point	Specifications	Comment – < Less than, > Greater than
E-66 to 2	< 5 Ω	If > 5 Ω, check EOT control circuit for OPEN.
E-66 to GND	> 1k Ω	If < 1k Ω, check EOT control circuit for short to GND.

- If the circuit is not within specification, the comment area will list possible circuit faults.
- If the circuit is within specification, continue to the next test point.

Operational Voltage Check

This test shows what a normal sensor or actuator should read at certain operating conditions. This test is helpful in diagnosing in-range faults or intermittent problems.

1. Connect 180-Pin Breakout Box or breakout harness between ECM and the component being tested.

2. Turn ignition switch to ON.

3. Open Continuous Monitor session or Output State test session (dependent upon what is being tested) using the ServiceMaxx™ software.

4. Run the Continuous Monitor test.

5. Verify actual sensor or actuator readings are within specification.

Example

Test Point	Condition	DMM	Signal Value
APP	Foot off pedal	0.64 V ± 0.5 V	0%
A to GND or C-48 to GND	Pedal to floor	3.85 V ± 0.5 V	102%
APP2	Foot off pedal	0 V	0 V
D to GND or C-33 to GND	Pedal to floor	B+	B+

Circuit Diagnostics

AAT Sensor (Ambient Air Temperature)

SPN	FMI	Condition	Possible Causes	Actions
171	2	AAT signal does not agree with other sensors	• Failed AAT sensor • High resistance in AAT circuit • High resistance in SIG GND circuit	Step-Based Diagnostics (page 209)
171	3	AAT signal Out of Range HIGH (Body mounted sensor)	• High resistance or open in SIG GND circuit • High resistance or open in AAT circuit • Short to PWR in AAT circuit • Failed AAT sensor	Step-Based Diagnostics (page 212)
171	4	AAT signal Out of Range LOW (Body mounted sensor)	• Short to GND in AAT circuit • SIG GND circuit shorted to AAT circuit • Failed AAT sensor	Step-Based Diagnostics (page 215)

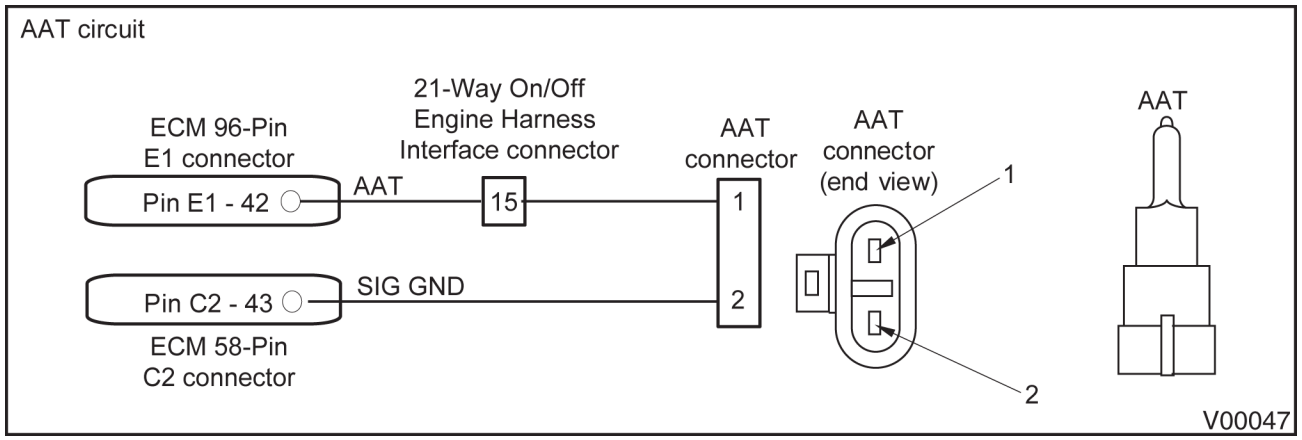


Figure 111 AAT circuit diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Ambient Air Temperature (AAT) measures the outside air temperature where the engine is operating. AAT represents the air temperature for engine cooling performance.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- Breakout Harness 00-01467-00
- Breakout Harness 00-01468-00
- 3-Banana Plug Harness ZTSE4498
- Breakout Harness ZTSE4871 (AAT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

SPN 171 FMI 2 - AAT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Ambient Air Temperature (AAT) does not agree with other sensors.	AAT sensor temperature differs from Inlet Air Temperature (IAT), Engine Coolant Temperature 1 (ECT1), and Engine Coolant Temperature 2 (ECT2) > 27°F (15°C).	Key ON Engine is cold soaked Engine speed > 1000 RPM Vehicle speed > 24.85 mph Engine speed and vehicle speed conditions met for > 30 seconds	1 event

Fault Overview

Fault code sets when Ambient Air Temperature (AAT) sensor temperature differs from Inlet Air Temperature (IAT), Engine Coolant Temperature 1 (ECT1), and Engine Coolant Temperature 2 (ECT2) by greater than 27°F (15°C) after a cold soak.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 171 FMI 3 and 4 (AAT)

Fault Facts

Diagnostic runs at initial Key ON after a minimum of an 8 hour cold soak.

Drive Cycle to Determine Fault Status

Drive Cycle 10 then 5 in 2013 HD-OBD Diagnostic Reference Manual.

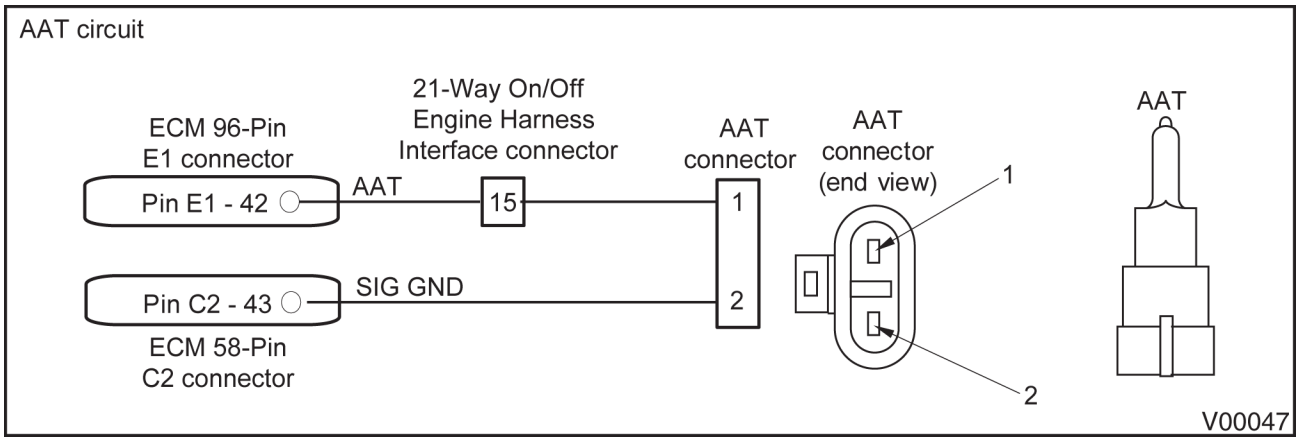


Figure 112 AAT circuit diagram

Possible Causes

- Failed AAT sensor
- High resistance in AAT circuit
- High resistance in SIG GND circuit

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 171 FMI 3 and 4 (AAT). Is EST DTC list free of SPN 171 FMI 3 and 4?	Yes: Go to step 2. No: Repair SPN 171 FMI 3 and 4. After repairs are complete, retest for SPN 171 FMI 2.

Step	Action	Decision
2	Inspect connections at Ambient Air Temperature (AAT) sensor. Key OFF, disconnect AAT sensor connector. Check AAT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AAT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 171 FMI 2.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 171 FMI 2.

Step	Action	Decision
4	Check AAT circuit for high resistance. Connect Breakout Harness ZTSE4871 to AAT harness and leave AAT disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01468-00 to ECM E1 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness pin-1 and Breakout Box pin E1-42. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair high resistance between AAT connector pin-1 and ECM connector pin E1-42. After repairs are complete, retest for SPN 171 FMI 2.

Step	Action	Decision
5	Check SIG GND circuit for high resistance. Connect Breakout Harness ZTSE4871 to AAT harness and leave AAT disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01467-00 to Chassis C2 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness pin-2 and Breakout Box pin C2-43. Is resistance less than 5 ohms?	Yes: Replace AAT sensor. After repairs are complete, retest for SPN 171 FMI 2. No: Repair high resistance between AAT connector pin-2 and ECM connector pin C2-43. After repairs are complete, retest for SPN 171 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 171 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 171 FMI 3- AAT Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Ambient Air Temperature (AAT) value greater than expected.	AAT sensor voltage > 4.5 volts.	Key ON	2 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that the Ambient Air Temperature (AAT) voltage is greater than 4.5 volts for 2 seconds.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

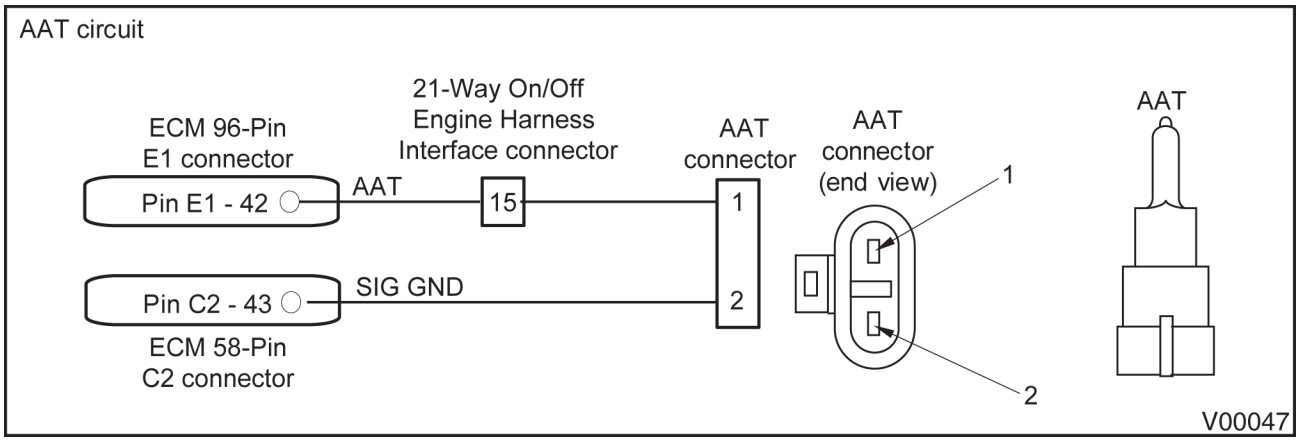


Figure 113 AAT circuit diagram

Possible Causes

- High resistance or open in SIG GND circuit
- High resistance or open in AAT circuit
- Short to PWR in AAT circuit
- Failed AAT sensor

Step	Action	Decision
1	Inspect connections at Ambient Air Temperature (AAT) sensor. Key OFF, disconnect AAT sensor connector. Check AAT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AAT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 171 FMI 3.

Step	Action	Decision
2	Check AAT circuit for short to PWR. Connect Breakout Harness ZTSE4871 to vehicle harness and leave AAT sensor disconnected. Key-On Engine-Off (KOEO) measure voltage between Breakout Harness pin-1 and a known good ground. Is voltage within 0.5 volts of 5 volts?	Yes: Go to step 3. No: Repair short to power in AAT circuit. After repairs are complete, retest for SPN 171 FMI 3.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 171 FMI 3.

Step	Action	Decision
4	Check AAT circuit for high resistance or Open. Connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. With Breakout Harness ZTSE4871 connected to vehicle harness and with AAT sensor disconnected. Use a DMM to measure resistance from Breakout Box pin E1-42 and Breakout Harness pin-1. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance in AAT circuit between ECM pin E1-42 and AAT sensor pin-1. After repairs are complete, retest for SPN 171 FMI 3.

Step	Action	Decision
5	Check SIG GND circuit for high resistance or Open. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness, and leave ECM disconnected. With Breakout Harness ZTSE4871 connected to vehicle harness and with AAT sensor disconnected. Use a DMM to measure resistance from Breakout Box pin C2-43 and Breakout Harness pin-2. Is resistance less than 5 ohms?	Yes: Replace AAT sensor. After repairs are complete, retest for SPN 171 FMI 3. No: Repair Open or high resistance in SIG GND circuit between ECM pin C2-43 and AAT sensor pin-2. After repairs are complete, retest for SPN 171 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 171 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 171 FMI 4- AAT Signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Ambient Air Temperature (AAT) sensor reading less than expected.	AAT sensor voltage > 0.25 volts.	Key ON	2 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that the Ambient Air Temperature (AAT) signal voltage is less than expends.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

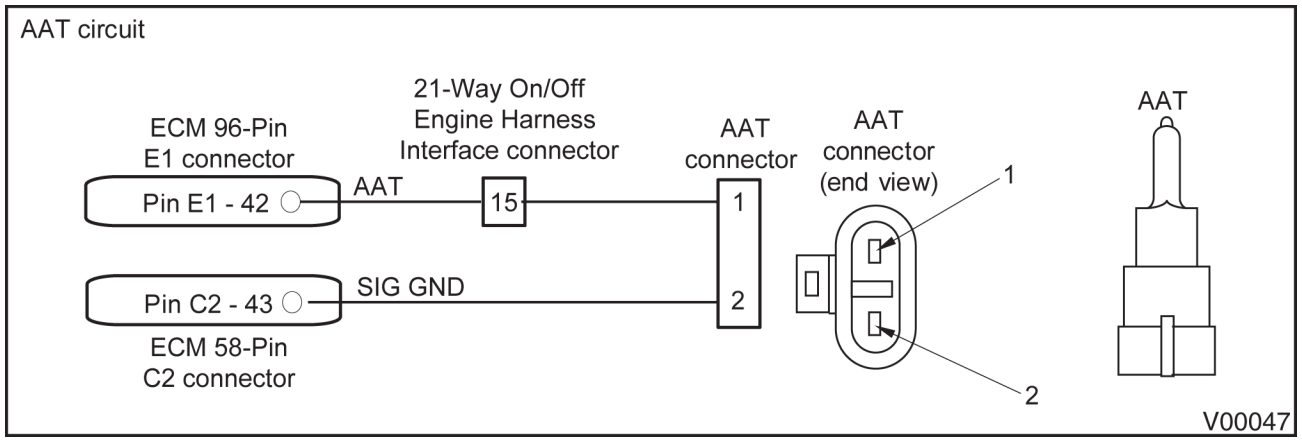


Figure 114 AAT circuit diagram

Possible Causes

- Short to GND in AAT circuit
- SIG GND circuit shorted to AAT circuit
- Failed AAT sensor

Step	Action	Decision
1	Inspect connections at Ambient Air Temperature (AAT) sensor. Key OFF, disconnect AAT sensor connector. Check AAT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AAT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 171 FMI 4.

Step	Action	Decision
2	Check AAT circuit for short to GND. Connect Breakout Harness ZTSE4871 to vehicle harness and leave AAT sensor disconnected. Key-On Engine-Off (KOEO) measure voltage between Breakout Harness pin-1 and a known good ground. Is voltage within 0.5 volts of 5 volts?	Yes: Go to step 3. No: Repair short to GND in AAT circuit. After repairs are complete, retest for SPN 171 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 171 FMI 4.

Step	Action	Decision
4	Check for short between AAT and SIG GND circuits. Connect Breakout Harness ZTSE4871 and leave AAT sensor disconnected. Key OFF, disconnect ECM and measure resistance between Breakout Harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Replace AAT sensor. After repairs are complete, retest for SPN 171 FMI 4. No: Repair short between AAT and SIG GND circuits. After repairs are complete, retest for SPN 171 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 171 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

AFT (Aftertreatment) System

SPN	FMI	Condition	Possible Causes	Actions
3251	0	DPFDP excessively HIGH (Restricted filter)	• Restricted Diesel Particulate Filter (DPF) • Low Fuel Delivery Pressure • Restricted Aftertreatment Fuel Injector (AFI) unit • Parked Regen Inhibited • Exhaust leak(s) • Biased Diesel Particulate Filter Differential Pressure (DPFDP) sensor • Biased IMP sensor • Low boost pressure	Step-Based Diagnostics (page 225)
3251	14	DPFDP sensor pressure hoses reversed	• DPFDP sensor pressure hoses reversed • DPFDP sensor hose (before filter) restricted	Pin-Point Diagnostics (page 231)

3251	21	DPFDP excessively LOW (Sensor/circuit fault or missing DPF)	• Biased DPFDP sensor or circuit • Cracked DPF • DPFDP sensor pressure hoses reversed • DPFDP sensor hose (before filter) leaking or disconnected	Step-Based Diagnostics (page 232)
3471	1	Fuel Pressure 1 below desired (Low system pressure)	• Aftertreatment Fuel Doser (AFTFD) failure. Blocked, stuck open, or closed • Leak in AFTFD fuel supply line • Failed Aftertreatment Fuel Pressure 1 (AFTFP1) sensor • Aftertreatment Fuel Shutoff Valve (AFTFSV) stuck closed, or blocked	Step-Based Diagnostics (page 235)
3471	7	Fuel Doser Valve not responding as expected	• AFTFD failure. Blocked, stuck open, or closed. • Stuck AFI or AFTFSV • Biased AFT Fuel Pressure 2 signal	Step-Based Diagnostics (page 240)

3480	0	AFTFP1 too high while dosing	• Fuel Delivery Pressure (FDP) above maximum • Restricted fuel return line between filter housing and fuel tank	Step-Based Diagnostics (page 246)
3480	1	AFTFP1 too low while dosing	• FDP below minimum • Dirty fuel filter • Stuck closed AFT Shutoff valve • Fuel Leak in Down Stream Injection (DSI) System	Pin-Point Diagnostics (page 250)
3481	7	Incorrect dosing pressure, multiple events	• FDP above maximum • Restricted fuel return line between filter housing and fuel tank	Step-Based Diagnostics (page 254)
3556	0	AFT fuel pressure 2 excessively high (Restricted injection)	• Aftertreatment Fuel Injector (AFI) is restricted or sticking	Step-Based Diagnostics (page 258)
3556	1	AFT fuel pressure 2 below desired	• Leak in DSI system • AFT Fuel Doser sticking Open • AFI stuck Open	Step-Based Diagnostics (page 262)

3556	7	AFT Fuel Injector not responding as expected	• DSI failed system validation cycle • Biased AFTFIS or circuit • Biased Aftertreatment Fuel Pressure 2 (AFTFP2) sensor or circuit • Failed AFTFD or circuit • Failed AFTFSV or circuit • Aftertreatment Fuel Injector (AFI) failure (restricted)	Step-Based Diagnostics (page 266)
3750	31	DPF Regen inhibited due to low exhaust temperatures	• Degraded Diesel Oxidation Catalyst (DOC) • Exhaust leak • Damaged or missing Diesel Particulate Filter (DPF) • Failed DOC / DPF temperature sensors	Step-Based Diagnostics (page 271)
4077	0	AFTFP2 too high while dosing	• AFTFD stuck closed • AFI restricted	Step-Based Diagnostics (page 273)
4077	1	AFTFP2 too low while dosing	• Fuel leak between AFTFD and AFI • AFTFSV stuck closed	Step-Based Diagnostics (page 277)

4766	10	DPF Regeneration feedback fault	• Diesel Oxidation Catalyst Outlet Temperature (DOCOT) not heating up during exhaust injection • Diesel Oxidation Catalyst (DOC) failure (face plugged)	Step-Based Diagnostics (page 281)
4766	20	DOC Outlet Temp above maximum desired	• Aftertreatment Fuel Injector (AFI) restricted or sticking • Engine over-fueling • DSI leaking into exhaust • AFTFD stuck open • Fuel leak(s) to exhaust • DOCOT sensor or circuit failure	Step-Based Diagnostics (page 288)
4766	21	DOC Outlet Temp below minimum desired	• DOC failure • DSI fault, not injecting when commanded • DSI system fuel leak • DOCOT sensor or circuit failure	Step-Based Diagnostics (page 294)

5298	2	Reduced DOC Efficiency — De-Rate	• Biased DOCOT sensor or circuit • Restricted AFI or AFI housing • DSI failure • DSI system leak • DOC failure • Restricted air filter • Exhaust leaks • Coolant leak to exhaust	Step-Based Diagnostics (page 300)
5319	31	DPF incomplete Regeneration	• Low engine performance • Failed fuel injector • Engine mechanical • Oil leak to exhaust • Failed Diesel Particulate Filter Differential Pressure (DPFDP) • Restricted DPFDP sensor hose(s) • Damaged or failed Diesel Oxidation Catalyst (DOC) • Restricted DOC (soot accumulation) • Failed DSI	Step-Based Diagnostics (page 307)

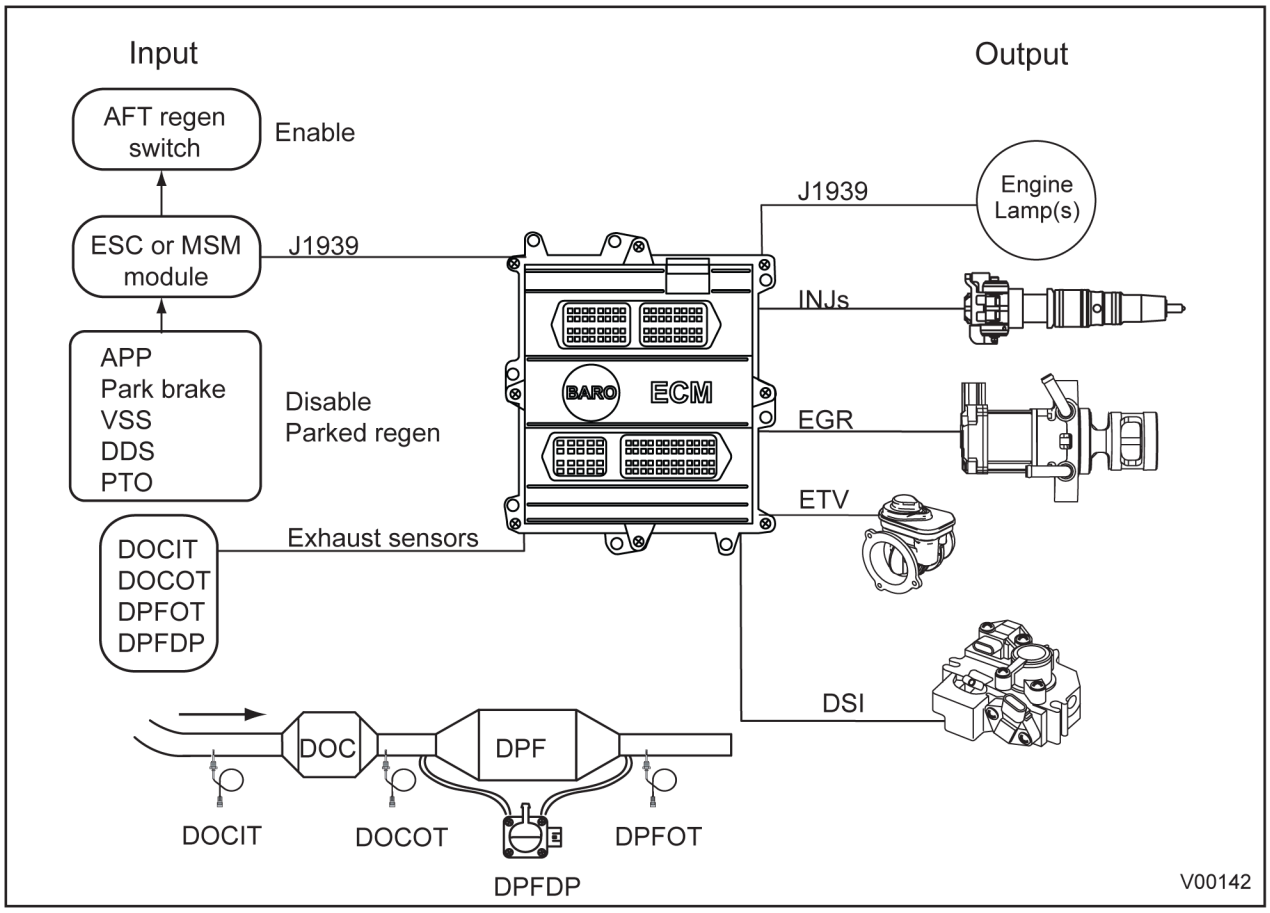


Figure 115 Function diagram for AFT System

Overview

The purpose of the Aftertreatment (AFT) System is to catalyze carbon monoxide (CO), Oxides of Nitrogen (NOx), and Hydrocarbons (HC). The Diesel Particulate Filter (DPF) will capture soot and other particulates exiting the exhaust pipe. Typically a good running engine will have 99% soot to 1% ash.

The soot is captured by the Diesel Particulate Filter (DPF). Although the Diesel Oxidation Catalyst (DOC) should not require regular maintenance, the DPF does require off-board cleaning to remove ash from the DPF.

Soot is converted to carbon dioxide by a process of regeneration (Regen). The temperature at the face of the DPF is raised to approximately 1000°F (538°C), for a period of time, depending on the amount of soot that accumulated within the DPF. Regen time is calculated by the Engine Gas Differential Pressure (DPFDP) feedback.

The Regen may take place as the vehicle is in operation under a steady state heavy engine loading condition, or by forcing a Stationary Regen process.

During a Stationary Regen, the engine speed is increased, while the Engine Control Module (ECM) controls the engine systems; Post-Injection, Exhaust Gas Recirculation (EGR), and Engine Throttle Valve (ETV) to increase the heat going into the exhaust system. The Inlet Air Heater (IAH) will also cycle on and off, not just to increase the Inlet Air Temperature (IAT), but to add extra load on the engine.

The health of the system and the Regen processes are monitored by the DOC Inlet Temperature (DOCIT), DOC Outlet Temperature (DOCOT), DPF Outlet Temperature (DPFOT) and the Diesel Particulate Filter Differential Pressure (DPFDP) sensor. The DPFDP measures the pressure difference across the DPF. The temperature sensors measure the temperature differences across the DOC and DPF.

The DPF and or the DOC may fail or plug prematurely for a number of reasons. It is important to pinpoint the root cause and repair the failure before replacing the DOC or DPF. Failure to do so could result in destroying a newly replaced component.

NOTE: Any time the DPF is replaced or removed for cleaning, record DPF serial number and use ServiceMaxx™ software to run the Diesel Particulate Filter Servicing procedure. Follow on-screen instructions. See DPF Servicing (page 66) in "DIAGNOSTIC SOFTWARE OPERATION" for additional information.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- ZTSE4526 - Compucheck Fitting
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4906 – Fuel Line Coupler

SPN 3251 FMI 0 - DPFDP excessively HIGH (Restricted filter)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The Diesel Particulate Filter Differential Pressure (DPFDP) is excessively high.	DPFDP reading does not equal modeled value DPFDP > 350 hPa	Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts DPF surface temp > 392°F (200°C) and < 752°F (400°C) Exhaust gas volume flow > 1500 cubic meters/hour and <6553 cubic meters/hour	0.5 seconds

Fault Overview

The Diesel Particulate Filter Differential Pressure (DPFDP) sensor is a variable-capacitance sensor that measures pressure at two locations. The first location is between the Diesel Oxidation Catalyst (DOC) and the Diesel Particulate Filter (DPF). The second location is immediately after the DPF. DPFDP provides a feedback signal to the ECM indicating pressure difference between the inlet and outlet of the DPF.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN's 27,102, 1189, 2791, 3480, 4077, 5456, and 5541.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

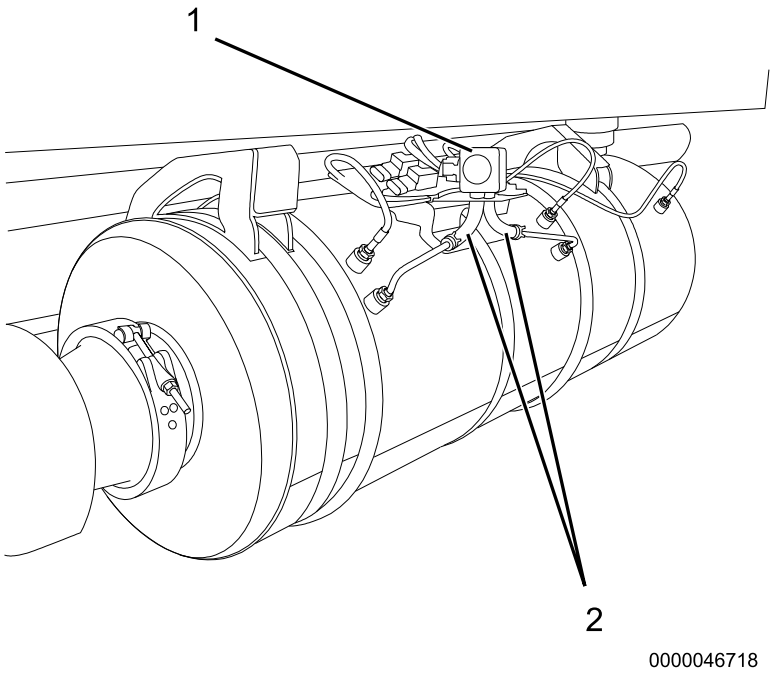


Figure 116 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

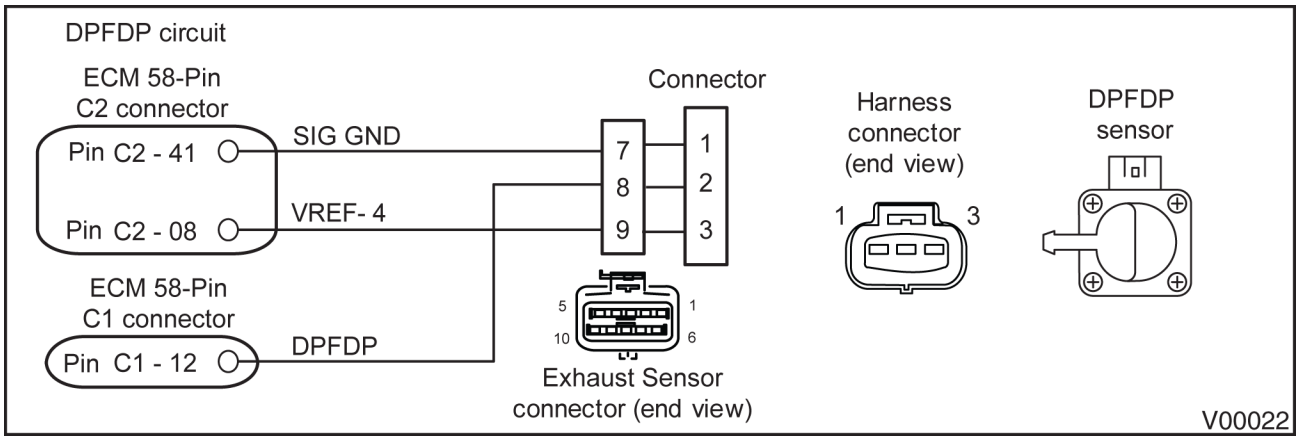


Figure 117 DPFDP sensor circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3251 FMI 0 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, monitor Diesel Particulate Filter Differential Pressure (DPFDP) signal with Key-On Engine-Off (KOEO). See "Appendix A (page 953)" for DPFDP specifications. Is DPFDP within specifications?	Yes: Go to step 5. No: Go to step 3.

Step	Action	Decision
3	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Key OFF, disconnect DPFDP sensor connector. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
4	Check for biased DPFDP sensor. Do DPFDP sensor biased check (page 514). Are DPFDP sensor and circuits within specifications?	Yes: Go to step 5. No: Repair DPFDP sensor or circuits. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
5	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to step 6. No: Repair DPFDP hoses. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
6	Using EST with ServiceMaxx software, start an Onboard Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort message in ServiceMaxx?	Yes: Go to Step 7. No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="9">7</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specification: Go to step 8.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="2">If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 3251 FMI 0.</td></tr>
<tr><td>Engine Coolant Temp (ECT)</td><td>Above 122°F (50°C) per ServiceMaxx</td><td></td></tr>
<tr><td>DOCIT</td><td>After 5 - 10 minutes above 500°F (260°C)</td><td></td><td rowspan="2">If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3251 FMI 0.</td></tr>
<tr><td>DOCOT</td><td>After 5 – 10 minutes above 986°F (530°C)</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td><td rowspan="3">If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 3251 FMI 0.</td></tr>
<tr><td>Aftertreatment Fuel Pressure 1 (AFTFP1)</td><td>> 110 psi during test</td><td></td></tr>
<tr><td>Aftertreatment Fuel Pressure 2 (AFTFP2)</td><td>Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.</td><td></td></tr>
</table>

Step	Action	Decision
8	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Go to step 9.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
9	Determine if Intake Manifold Pressure (IMP) sensor or circuit is out of specifications. Using EST with ServiceMaxx software, do IMP Biased Sensor Check (page 717). Is IMP sensor within specifications?	Yes: Go to step 10.
		No: Repair IMP sensor or circuit. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
10	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC) and Exhaust Gas Recirculation (EGR) valve are commanded On. Key-On Engine-Running (KOER). Run Air Management Test while monitoring IMP sensor signal. Does IMP sensor signal change: • When TC2WC is commanded On? • When EGR valve is commanded On?	IMP signal changes only when TC2WC is commanded On: Do EGR Pinpoint Diagnostics (page 622) and check for EGR issue. After repairs are complete, retest for SPN 3251 FMI 0.
		IMP signal changes only with EGR valve commanded On: Do TC2WC voltage and circuit checks (page 839). After repairs are complete, retest for SPN 3251 FMI 0.
		Neither change IMP signal when commanded On: Go to step 11.
		Both change IMP signal when commanded On: Go to step 12.

Step	Action	Decision
11	Verify IMP sensor and bore are not restricted due to carbon buildup. Remove and inspect IMP sensor and bore for carbon buildup. Is IMP sensor and bore free of carbon buildup?	Yes: Go to step 12.
		No: Clean IMP sensor bore of carbon deposits. After repairs are complete, retest for SPN 3251 FMI 0.

Step	Action	Decision
12	Do Road Test (Full load to highway speed) (page 161), 100% engine load (when safe to do so). Record a snapshot of the following signals: • Diesel Particulate Filter Differential Pressure (DPFDP) = 0.5 to 0.8 psi • Turbocharger 1 Turbine Outlet Pressure (TC1TOP) = 2 to 3 psi • Soot load < 40% Are DPFDP and TC1TOP signals within specifications? **NOTE: DPFDP and TC1TOP specifications only apply with soot load < 40%.**	**Both** TC1TOP and DPFDP signals are above specification: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		Only TC1TOP signal above specification: Remove Pre Diesel Oxidation Catalyst (PREDOC) and Diesel Oxidation Catalyst (DOC) for inspection and clean or replace as necessary. After repairs are complete, retest for SPN 3251 FMI 0.
		Neither signal above specification: Retest for SPN 3251 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 0 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFDP sensor pressure hoses reversed

Pinpoint AFT System Fault

1. Key On, Engine Off, check for biased DPFDP sensor. See Key-On Engine-Off in “APPENDIX A: PERFORMANCE SPECIFICATIONS.”
   - If sensor is not within specification, go to DPFDP Sensor Circuit Check (page 514).
2. Check DPFDP sensor hoses for correct routing and possible restriction.
   - If sensor hoses are reversed or restricted, repair condition.
3. Check for restriction. Remove and inspect filter for face plugging.

SPN 3251 FMI 21 - DPFDP excessively LOW (Sensor/circuit fault or missing DPF)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Missing / Cracked DPF	Function of exhaust gas flow and specific soot mass corrected for transfer lag DPFDP > 12 hPa	Simulated soot mass < 201 g and > 0 g DPF surface temp < 752°F (400°C) and > 392°F (200°C)	40 seconds

Fault Overview

The Diesel Particulate Filter Differential Pressure (DPFDP) sensor is a variable-capacitance sensor that measures pressure at two locations. The first location is between the Diesel Oxidation Catalyst (DOC) and the Diesel Particulate Filter (DPF). The second location is immediately after the DPF. The DPFDP provides a feedback signal to the ECM indicating pressure difference between the inlet and outlet of the DPF.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN's 3512.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

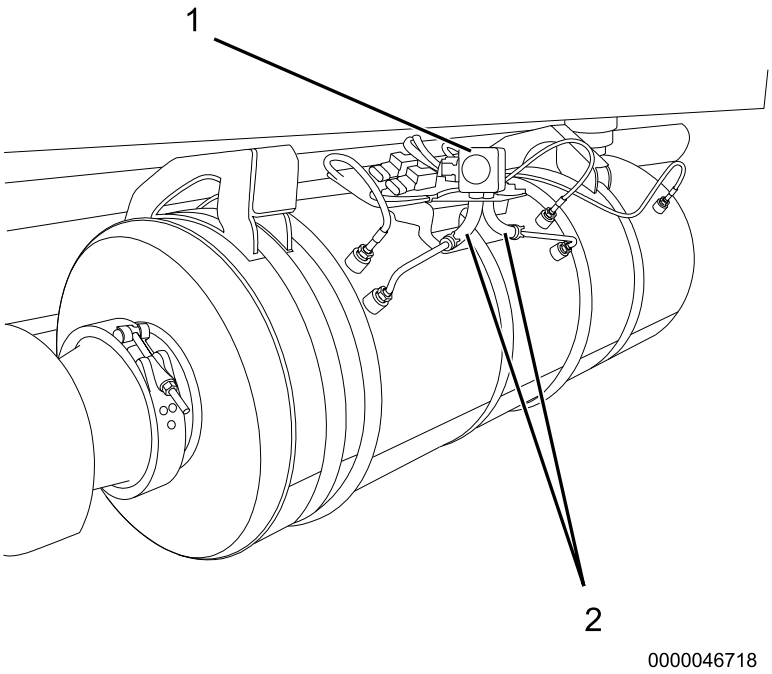


Figure 118 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

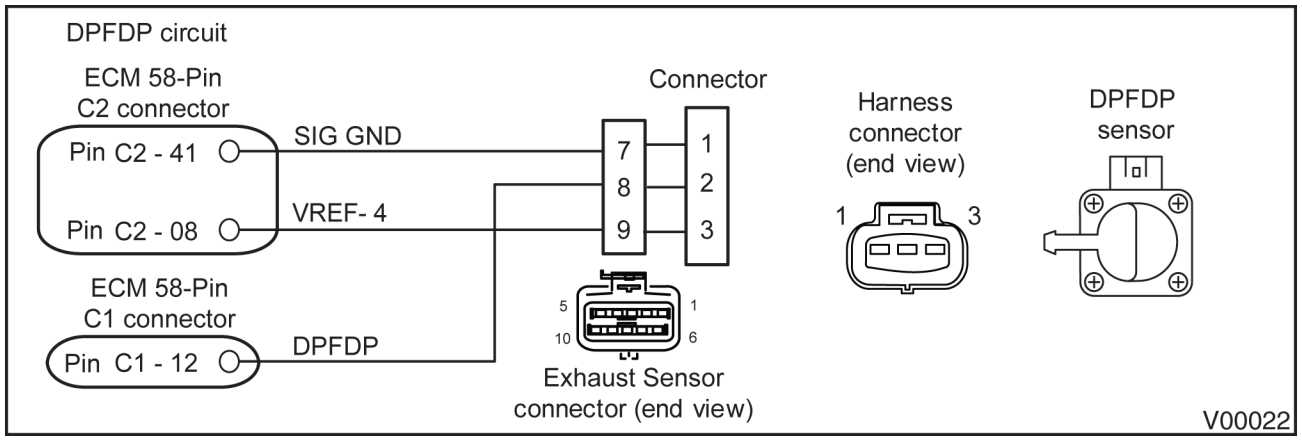


Figure 119 DPFDP sensor circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3251 FMI 21 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
2	Inspect exhaust system for missing Diesel Particulate Filter (DPF), leaks, or physical damage. Is DPF in place, and exhaust system free of leaks and physical damage?	Yes: Go to step 3.
		No: Replace DPF, repair exhaust leaks, or repair physical damage. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
3	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Key OFF, disconnect DPFDP sensor connector. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
4	Check for biased DPFDP sensor. Do DPFDP sensor biased check (page 514). Are DPFDP sensor and circuits within specification?	Yes: Go to step 5.
		No: Repair DPFDP sensor or circuits. After repairs are complete, retest for SPN 3251 FMI 21.

Step	Action	Decision
5	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Remove DPF and inspect the outlet of the DPF filter for damage and soot leakage (see DPF Outlet Leaking Soot (page 327). After repairs are complete, retest for SPN 3251 FMI 21.
		No: Repair DPFDP hoses. After repairs are complete, retest for SPN 3251 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 3251 FMI 21 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3471 FMI 1 - Fuel Pressure 1 Below Desired

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Pressure 1 (AFTFP1) signal is reading pressure below desired.	Aftertreatment Fuel System test failure (Table D002)	System test has run (Occurs before dosing) Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	3 event

Fault Overview

The Aftertreatment Fuel Inlet Sensor (AFTFIS) is both a variable-capacitance pressure sensor and a thermistor sensor used to measure fuel pressure and fuel temperature at the inlet of the Down Stream Injection (DSI) unit. The ECM measures signals given by this sensor to supply the Aftertreatment Fuel Injector (AFI) with the proper amount of fuel.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 2659, 3479, 3480, 3482, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

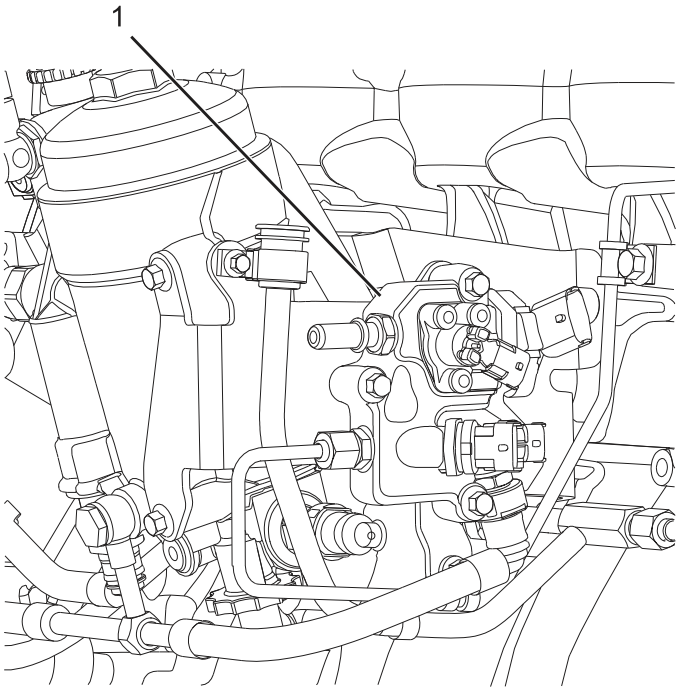


Figure 120 Downstream Injection (DSI) Unit Location

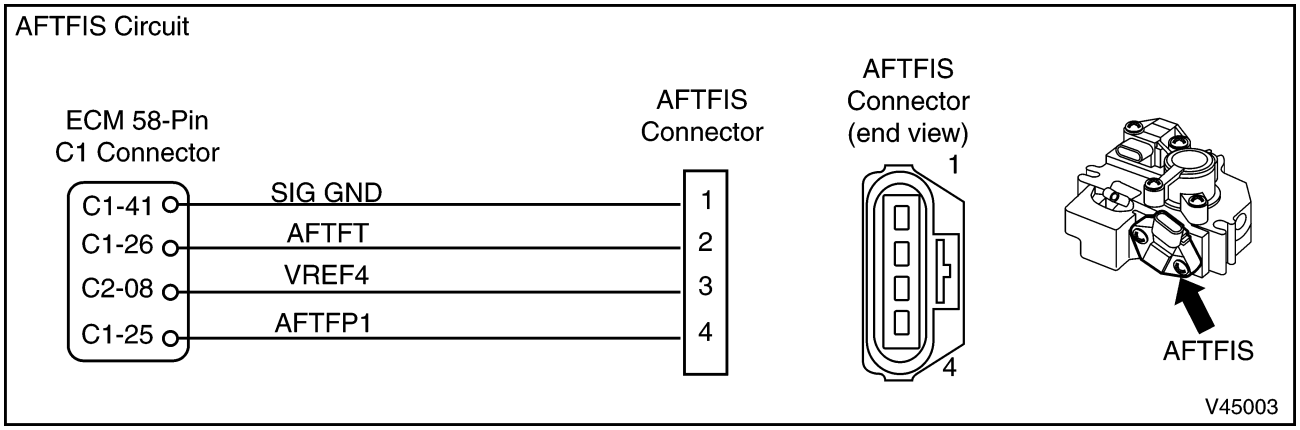


Figure 121 AFTFIS circuit diagram

Step	Action	Decision
1	Inspect connections at Aftertreatment Fuel Inlet Sensor (AFTFIS). Key OFF, disconnect AFTFIS. Check AFTFIS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Are the AFTFIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3471 FMI 1.

Step	Action	Decision
2	Check for biased AFTFP1 signal. Using EST with ServiceMaxx™ software, with AFTFIS connected, run Continuous Monitor session and monitor Aftertreatment Fuel Pressure 1 (AFTFP1) signal. Is AFTFP1 between 0.66 and 0.86 volts? (Wiggle test may be necessary if code is inactive or pending.) **NOTE: AFTFIS is a 4 wire sensor containing Aftertreatment Fuel Temperature (AFTFT) signal for fuel temperature, and AFTFP1 signal for fuel pressure.**	Yes: Go to step 3. No: Do AFTFIS Circuit Checks (page 344). After repairs are complete, retest for SPN 3471 FMI 1.

Step	Action	Decision
3	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 4. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 3471 FMI 1.

Step	Action	Decision
4	Prime Aftertreatment Fuel Injector (AFI) by actuating Aftertreatment Fuel Doser (AFTFD) valve and Aftertreatment Fuel Shutoff Valve (AFTFSV) with DSI De-Aeration test. Using EST with ServiceMaxx™ software, go to Procedures > KOER Aftertreatment Procedures > DSI De-Aeration procedure. Start engine, actuate AFTFSV while monitoring AFTFP1 signal during actuation. Does AFTFP1 rise to 100 psi or more and hold steady for at least 5 seconds?	Yes: Go to step 6. No: Go to step 5.

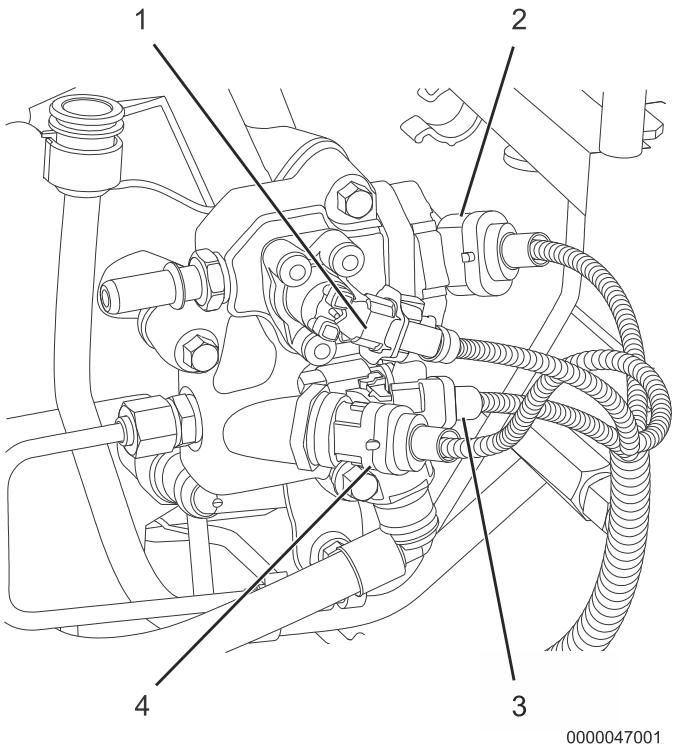


Figure 122 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
5	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location. (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Replace DSI unit. After repairs are complete, retest for SPN 3471 FMI 1. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 3471 FMI 1.

Step	Action	Decision
6	Using EST with ServiceMaxx software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 7. No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="10">7</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specification: Go to step 8.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="2">If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 3471 FMI 1.</td></tr>
<tr><td>Engine Coolant Temp (ECT)</td><td>Above 122°F (50°C) per ServiceMaxx</td><td></td></tr>
<tr><td>DOCIT</td><td>482°F (250°C) to 572°F (300°C)</td><td></td><td rowspan="2">If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3471 FMI 1.</td></tr>
<tr><td>DOCOT</td><td>After 5 – 10 minutes above 986°F (530°C)</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td><td rowspan="3">If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 3471 FMI 1.</td></tr>
<tr><td>Aftertreatment Fuel Pressure 1 (AFTFP1)</td><td>> 110 psi during test</td><td></td></tr>
<tr><td>Aftertreatment Fuel Pressure 2 (AFTFP2)</td><td>Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.</td><td></td></tr>
</table>

Step	Action	Decision
8	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3471 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 3471 FMI 1 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3471 FMI 7 - Fuel Doser Valve not responding as expected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Doser Vale (AFTFDV) is not responding as expected.	Aftertreatment Fuel System test failure (Table D002)	System test has run (occurs before dosing) Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	3 event

Fault Overview

The Aftertreatment Fuel Doser Valve (AFTFDV) is used to provide high-pressure fuel flow to the Aftertreatment Fuel Injector (AFI). The AFTFD is sent a pulse Width Modulated (PWM) signal from the Engine Control Module (ECM), after inputs from the Downstream Injection (DSI) unit components are processed.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 2659, 3479, 3480, 3482, 4077, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

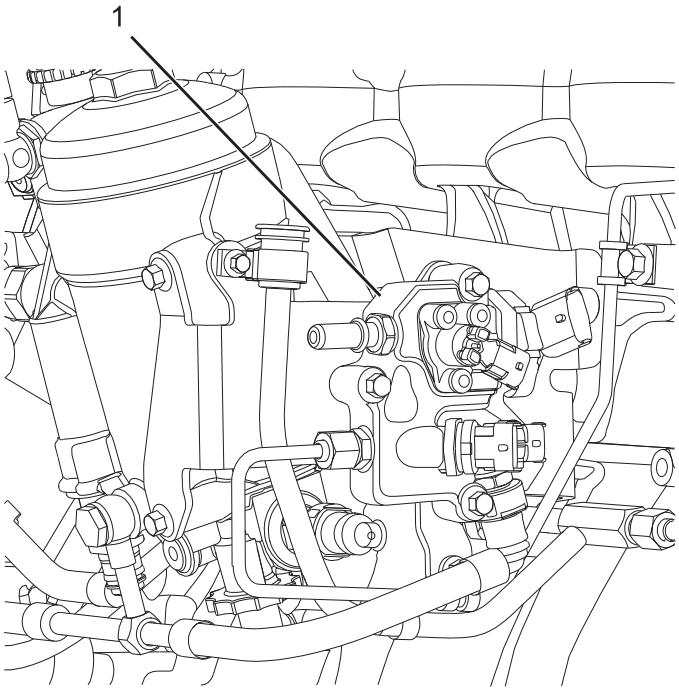


Figure 123 Downstream Injection (DSI) Unit Location

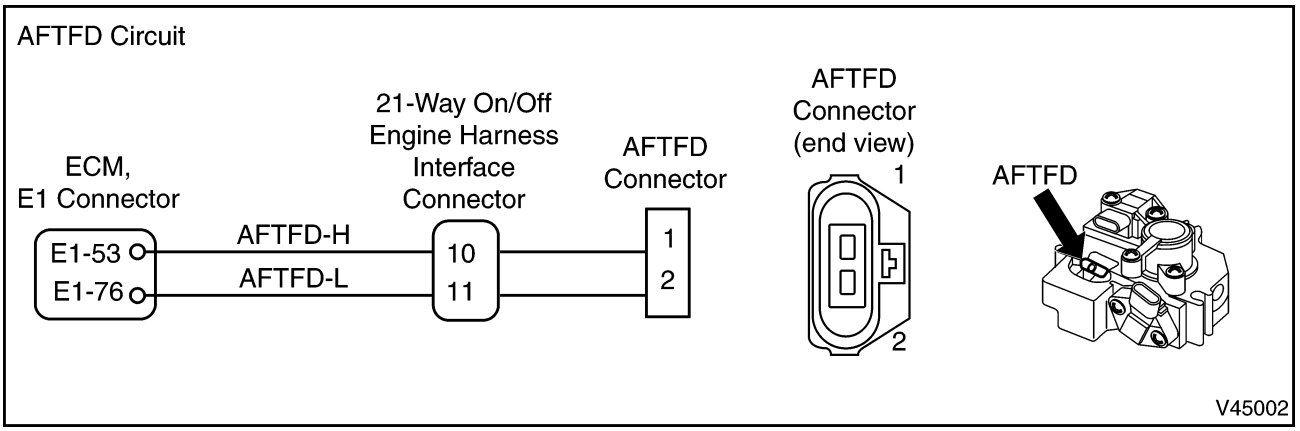


Figure 124 AFTFD circuit diagram

Step	Action	Decision
1	Inspect connections at Aftertreatment Fuel Pressure 2 (AFTFP2) sensor. Key OFF, disconnect AFTFP2 sensor. Check AFTFP2 sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Are the AFTFP2 sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3471 FMI 7.

NOTE: Using EST with ServiceMaxx™ software, open doser actuator to release pressure in DSI before checking for biased AFTFP2 sensor.

Step	Action	Decision
2	Check for biased AFTFP2 sensor. Using EST with ServiceMaxx™ software, with AFTFP2 sensor connected, run Continuous Monitor session and monitor Aftertreatment Fuel Pressure 2 (AFTFP2) signal. Is AFTFP2 signal value between 0.30 and 0.50 volts? (Wiggle test may be necessary if code is inactive or pending.)	Yes: Go to step 3. No: Do AFTFP2 Circuit Checks (page 348). After repairs are complete, retest for SPN 3471 FMI 7.

Step	Action	Decision
3	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 4. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 3471 FMI 7.

Step	Action	Decision
4	Prime Aftertreatment Fuel Injector (AFI) by actuating Aftertreatment Fuel Doser (AFTFD) valve and Aftertreatment Fuel Shutoff Valve (AFTFSV) with DSI De-Aeration test. Using EST with ServiceMaxx™ software, go to Procedures > KOER Aftertreatment Procedures > DSI De-Aeration procedure. Start engine, actuate AFTFSV while monitoring AFTFP1 signal during actuation. Does AFTFP1 rise to 100 psi or more and hold steady for at least 5 seconds?	Yes: Go to step 6. No: Go to step 5.

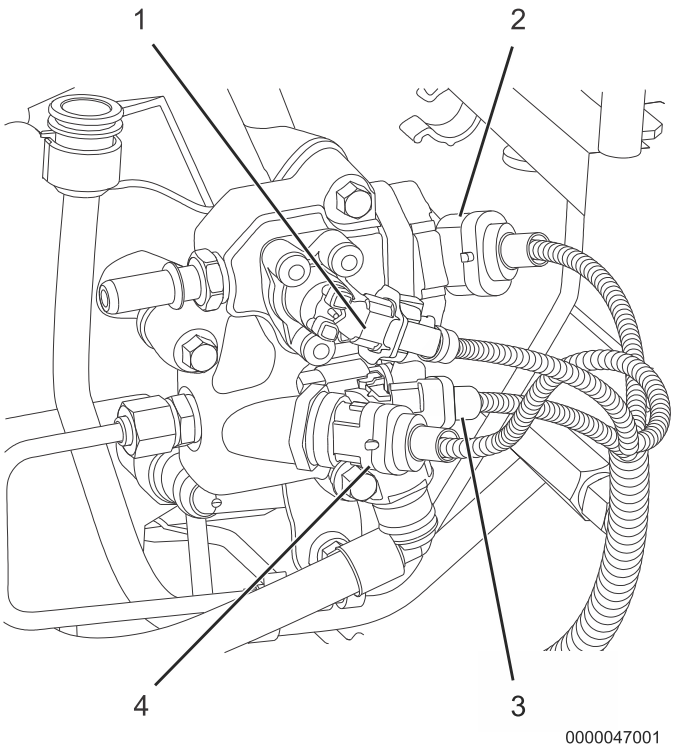


Figure 125 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
5	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location. (AFTFSV and AFTFD harness connectors can be swapped.)	Yes: Replace DSI unit. After repairs are complete, retest for SPN 3471 FMI 7.
	Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 3471 FMI 7.

Step	Action	Decision
6	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 3471 FMI 7.
		AFTFP2 signal value does not rise then drop when AFI opens: Go to step 7.
		AFTFP1 signal value drops and AFTFP2 rises, then drops when AFI is opened (correct operation): Retest for SPN 3471 FMI 7 status.

Step	Action	Decision
7	Visually inspect AFI supply line for leaks or damage. Is the line leaking or damaged?	Yes: Replace AFI supply line. After repairs are complete, retest for SPN 3471 FMI 7.
		No: Go to step 8.

Step	Action	Decision
8	Using EST with ServiceMaxx software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 9.
		No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

Step	Action			Decision
9	While running OBFCT, inspect for exhaust leaks and monitor following signals during test: Are Parked Regen Checks within specification during OBFCT?			If Parked Regen Checks are within specification: Go to step 10.
	Parked Regen Checks	**Specifications**	**Pass / Fail**	
	Engine condition	Smooth, not stumbling		If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 3471 FMI 7.
	Engine Coolant Temp (ECT)	Above 122°F (50°C) per ServiceMaxx		
	DOCIT	482°F (250°C) to 572°F (300°C)		If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3471 FMI 7.
	DOCOT	After 5 – 10 minutes above 986°F (530°C)		
	DPFOT	Below 1292°F (700°C)		If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 3471 FMI 7.
	Aftertreatment Fuel Pressure 1 (AFTFP1)	> 110 psi during test		
	Aftertreatment Fuel Pressure 2 (AFTFP2)	Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.		

Step	Action	Decision
10	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3471 FMI 7.

NOTE: After doing all diagnostic steps, if SPN 3471 FMI 7 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3480 FMI 0 - AFTFP1 too high while dosing

Fault Overview

The Aftertreatment Fuel Inlet Sensor (AFTFIS) is both a variable-capacitance pressure sensor and a thermistor sensor used to measure fuel pressure and fuel temperature at the inlet of the Down Stream Injection (DSI) unit. The ECM measures signals given by this sensor to supply the Aftertreatment Fuel Injector (AFI) with the proper amount of fuel.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 94 and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

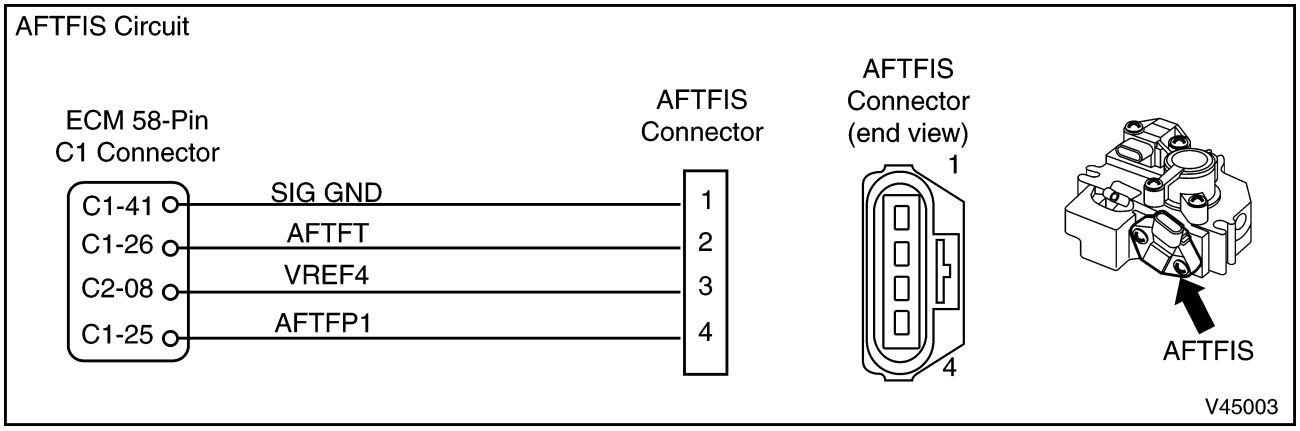


Figure 126 AFTFIS circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3480 FMI 0 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3480 FMI 0.

Step	Action	Decision
2	Inspect connections at Aftertreatment Fuel Inlet Sensor (AFTFIS). Key OFF, disconnect AFTFIS. Check AFTFIS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Are the AFTFIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3480 FMI 0.

Step	Action	Decision
3	Check for biased AFTFP1 signal. Using EST with ServiceMaxx™ software, with AFTFIS connected, run Continuous Monitor session and monitor Aftertreatment Fuel Pressure 1 (AFTFP1) signal. Is AFTFP1 between 0.66 and 0.86 volts? (Wiggle test may be necessary if code is inactive or pending.) **NOTE: AFTFIS is a 4 wire sensor containing Aftertreatment Fuel Temperature (AFTFT) signal for fuel temperature, and AFTFP1 signal for fuel pressure.**	Yes: Go to step 4. No: Do AFTFIS Circuit Checks (page 344). After repairs are complete, retest for SPN 3480 FMI 0.

Step	Action	Decision
4	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 5. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 3480 FMI 0.

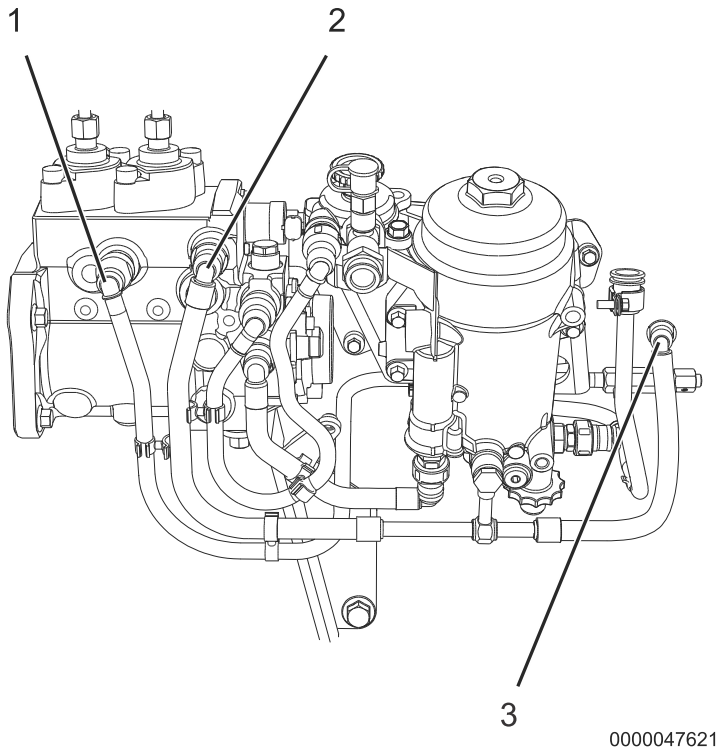


Figure 127 Fuel Pressure Test Locations

1. HP fuel pump return
2. HP fuel pump inlet
3. Fuel supply to DSI unit

Step	Action	Decision
5	Measure fuel return pressure from high-pressure fuel pump. Connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 and fuel pressure gauge between high-pressure fuel pump and fuel return line. Measure fuel pressure at high idle, no load, and stabilized engine operating temperature. Is fuel return pressure greater than 15 psi?	Yes: Go to step 6. No: Replace DSI unit. After repairs are complete, retest for SPN 3480 FMI 0.

Step	Action	Decision
6	Inspect fuel return line for fuel cooler. Is a fuel cooler present?	Yes: Remove fuel cooler and install a fuel line in its place. After repairs are complete, retest for SPN 3480 FMI 0.
		No: Repair restriction in fuel return line. After repairs are complete, retest for SPN 3480 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 3480 FMI 0 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3480 FMI 1- AFTFP1 too low while dosing

Fault Overview

The Aftertreatment Fuel Inlet Sensor (AFTFIS) is both a variable-capacitance pressure sensor and a thermistor sensor used to measure fuel pressure and fuel temperature at the inlet of the Down Stream Injection (DSI) unit. The ECM measures signals given by this sensor to supply the Aftertreatment Fuel Injector (AFI) with the proper amount of fuel.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 94, 3479, 3482, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

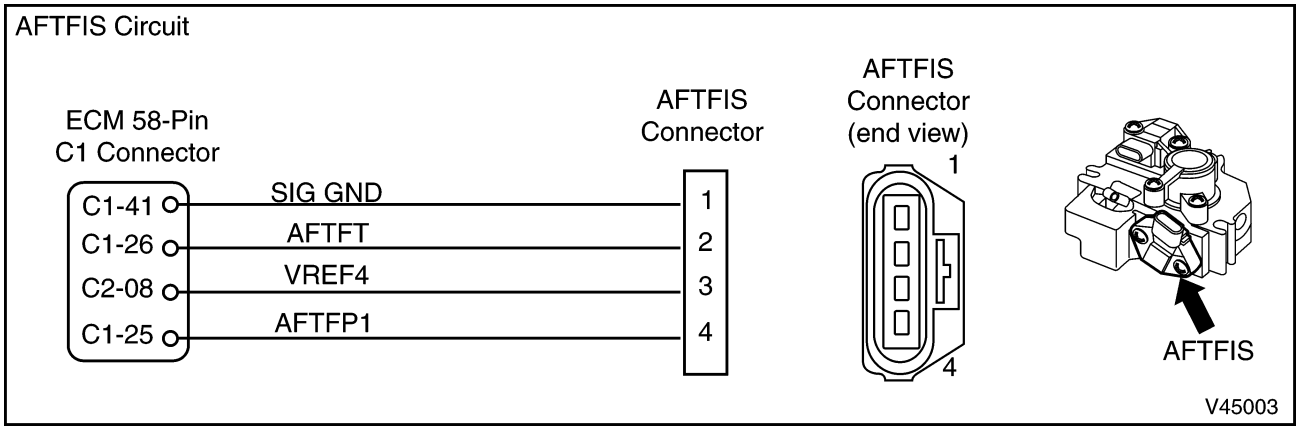


Figure 128 AFTFIS circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3480 FMI 1 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3480 FMI 1.

Step	Action	Decision
2	Visually inspect Down Stream Injection (DSI) unit supply line for leaks or damage. Is the line free of leaks and damage?	Yes: Go to step 3. No: Replace DSI supply line. After repairs are complete, retest for SPN 3480 FMI 1.

Step	Action	Decision
3	Inspect fuel filter(s). Check if fuel filter(s) is dirty, restricted, or clogged? Is fuel filter(s) clean, unrestricted, and unclogged?	Yes: Go to step 4. No: Replace fuel filter(s). After repairs are complete, retest for SPN 3480 FMI 1.

Step	Action	Decision
4	Inspect connections at Aftertreatment Fuel Inlet Sensor (AFTFIS). Key OFF, disconnect AFTFIS. Check AFTFIS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Are the AFTFIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3480 FMI 1.

Step	Action	Decision
5	Check for biased AFTFP1 signal. Using EST with ServiceMaxx™ software, with AFTFIS connected, run Continuous Monitor session and monitor Aftertreatment Fuel Pressure 1 (AFTFP1) signal. Is AFTFP1 between 0.66 and 0.86 volts? (Wiggle test may be necessary if code is inactive or pending.) **NOTE: AFTFIS is a 4 wire sensor containing Aftertreatment Fuel Temperature (AFTFT) signal for fuel temperature, and AFTFP1 signal for fuel pressure.**	Yes: Go to step 6. No: Do AFTFIS Circuit Checks (page 344). After repairs are complete, retest for SPN 3480 FMI 1.

Step	Action	Decision
6	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 7. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 3480 FMI 1.

Step	Action	Decision
7	Prime Aftertreatment Fuel Injector (AFI) by actuating Aftertreatment Fuel Doser (AFTFD) valve and Aftertreatment Fuel Shutoff Valve (AFTFSV) with DSI De-Aeration test. Using EST with ServiceMaxx™ software, go to Procedures > KOER Aftertreatment Procedures > DSI De-Aeration procedure. Start engine, actuate AFTFSV while monitoring AFTFP1 signal during actuation. Does AFTFP1 rise to 100 psi or more and hold steady for at least 5 seconds?	Yes: Retest for SPN 3480 FMI 1. No: Go to step 8.

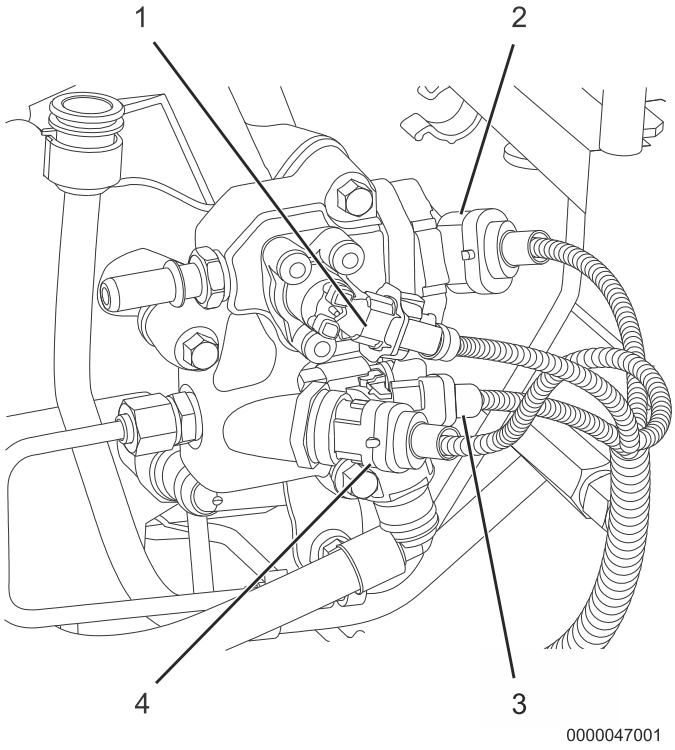


Figure 129 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
8	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location. (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Replace DSI unit. After repairs are complete, retest for SPN 3480 FMI 1. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 3480 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 3480 FMI 1 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3481 FMI 7 - Incorrect dosing pressure, multiple events

Fault Overview

The Aftertreatment Fuel Inlet Sensor (AFTFIS) is both a variable-capacitance pressure sensor and a thermistor sensor used to measure fuel pressure and fuel temperature at the inlet of the Down Stream Injection (DSI) unit. The ECM measures signals given by this sensor to supply the Aftertreatment Fuel Injector (AFI) with the proper amount of fuel.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 94, 2659, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

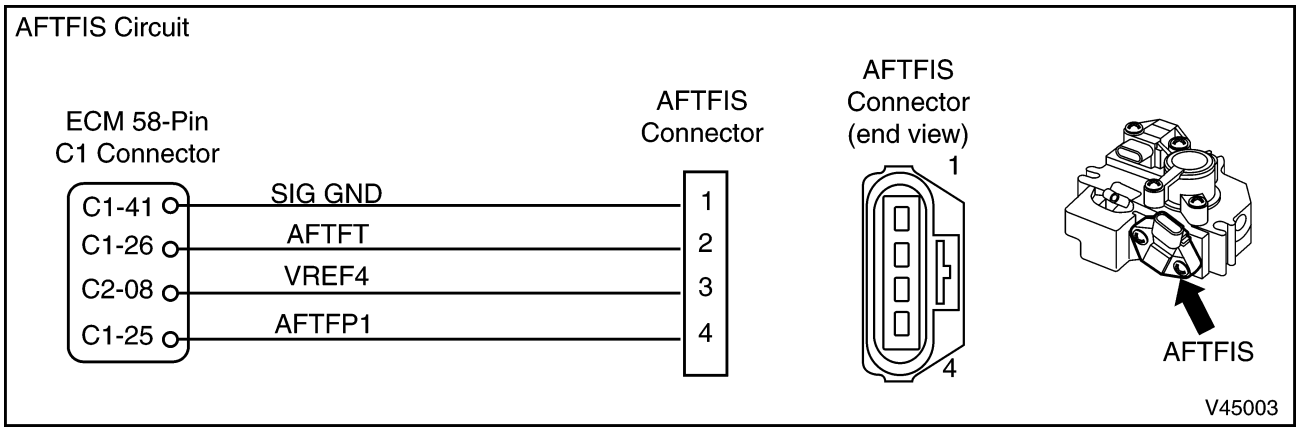


Figure 130 AFTFIS circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3481 FMI 7 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3481 FMI 7.

Step	Action	Decision
2	Inspect connections at Aftertreatment Fuel Inlet Sensor (AFTFIS). Key OFF, disconnect AFTFIS. Check AFTFIS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Are the AFTFIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3481 FMI 7.

Step	Action	Decision
3	Check for biased AFTFP1 signal. Using EST with ServiceMaxx™ software, with AFTFIS connected, Key-On Engine-Off (KOEO), run Continuous Monitor session and monitor Aftertreatment Fuel Pressure 1 (AFTFP1) signal. Is AFTFP1 between 0.66 and 0.86 volts? (Wiggle test may be necessary if code is inactive or pending.) **NOTE: AFTFIS is a 4 wire sensor containing Aftertreatment Fuel Temperature (AFTFT) signal for fuel temperature, and AFTFP1 signal for fuel pressure.**	Yes: Go to step 4. No: Do AFTFIS Circuit Checks (page 344). After repairs are complete, retest for SPN 3481 FMI 7.

Step	Action	Decision
4	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 5. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 3481 FMI 7.

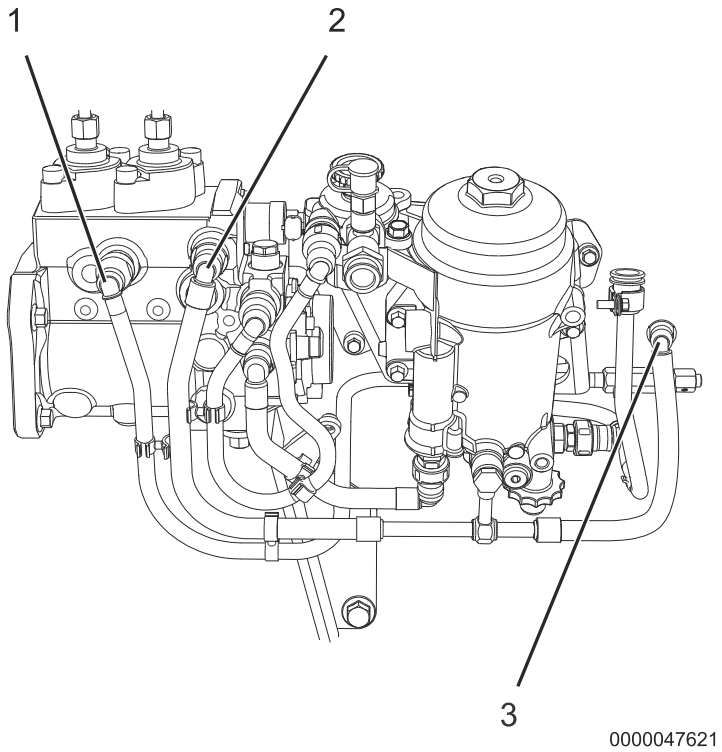


Figure 131 Fuel Pressure Test Locations

1. HP fuel pump return
2. HP fuel pump inlet
3. Fuel supply to DSI unit

Step	Action	Decision
5	Measure fuel return pressure from high-pressure fuel pump. Connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 and fuel pressure gauge between high-pressure fuel pump and fuel return line. Measure fuel pressure at high idle, no load, and stabilized engine operating temperature. Is fuel return pressure greater than 15 psi?	Yes: Go to step 6. No: Replace DSI unit. After repairs are complete, retest for SPN 3481 FMI 7.

Step	Action	Decision
6	Inspect fuel return line for fuel cooler. Is a fuel cooler present?	Yes: Remove fuel cooler and install a fuel line in its place. After repairs are complete, retest for SPN 3481 FMI 7.
		No: Repair restriction in fuel return line. After repairs are complete, retest for SPN 3481 FMI 7.

NOTE: After doing all diagnostic steps, if SPN 3481 FMI 7 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3556 FMI 0 - AFT Fuel Pressure 2 excessively high

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Pressure 2 (AFTFP2) signal is reading pressure excessively high.	Aftertreatment Fuel System test failure (Table D002)	System test has run (Occurs before dosing) Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	3 event

Fault Overview

The Aftertreatment Fuel Pressure 2 (AFTFP2) sensor is a variable capacitance sensor that monitors fuel pressure after the Aftertreatment Fuel Doser (AFTFD) valve. The Engine Control Module (ECM) uses the AFTFP2 sensor to monitor fuel delivery pressure to the Aftertreatment Fuel Injector (AFI).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 27, 94, 102, 1189, 2659, 2791, and 4077.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3556 FMI 0 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3556 FMI 0.

Step	Action	Decision
2	Visually inspect Down Stream Injection (DSI) unit supply line for leaks or damage. Is the line free of leaks and damage?	Yes: Go to step 3. No: Replace DSI supply line. After repairs are complete, retest for SPN 3556 FMI 0.

Step	Action	Decision
3	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Is air intake system, exhaust system, and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 4. No: Repair restrictions, air leaks, or physical damage. After repairs are complete, retest for SPN 3556 FMI 0.

Step	Action	Decision
4	Determine if Intake Manifold Pressure (IMP) sensor or circuit is out of specifications. Using EST with ServiceMaxx software, do IMP Biased Sensor Check (page 717). Is IMP sensor within specifications?	Yes: Go to step 5. No: Repair IMP sensor or circuit. After repairs are complete, retest for SPN 3556 FMI 0.

Step	Action	Decision
5	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC) and Exhaust Gas Recirculation (EGR) valve are commanded On. Key-On Engine-Running (KOER). Run Air Management Test while monitoring IMP sensor signal. Does IMP sensor signal change: • When TC2WC is commanded On? • When EGR valve is commanded On?	IMP signal change only when TC2WC is commanded On: Do EGR Pinpoint Diagnostics (page 622) and check for EGR issue. After repairs are complete, retest for SPN 3556 FMI 0. IMP signal change only with EGR valve commanded On: Do TC2WC voltage and circuit checks (page 839). After repairs are complete, retest for SPN 3556 FMI 0. Neither change IMP signal when commanded On: Go to step 6. Both change IMP signal when commanded On: Go to step 7.

Step	Action	Decision
6	Verify IMP sensor and bore are not restricted due to carbon buildup. Remove and inspect IMP sensor and bore for carbon buildup. Is IMP sensor and bore free of carbon buildup?	Yes: Go to step 7. No: Clean IMP sensor bore of carbon deposits. After repairs are complete, retest for SPN 3556 FMI 0.

Step	Action	Decision
7	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 8. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 3556 FMI 0.

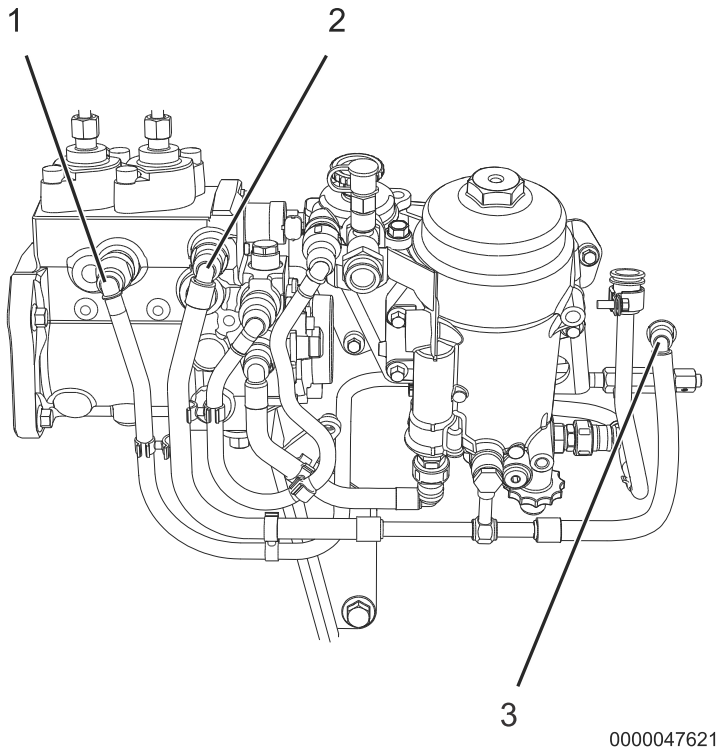


Figure 132 Fuel Pressure Test Locations

1. HP fuel pump return
2. HP fuel pump inlet
3. Fuel supply to DSI unit

Step	Action	Decision
8	Measure fuel return pressure from high-pressure fuel pump. Connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 and fuel pressure gauge between high-pressure fuel pump and fuel return line. Measure fuel pressure at high idle, no load, and stabilized engine operating temperature. Is fuel return pressure greater than 15 psi?	Yes: Go to step 10. No: Go to step 9.

Step	Action	Decision
9	Visually inspect Aftertreatment Fuel Injector (AFI) supply line for leaks or damage. Is the line leaking or damaged?	Yes: Replace AFI supply line. After repairs are complete, retest for fault SPN 3556 FMI 0. No: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3556 FMI 0.

Step	Action	Decision
10	Inspect fuel return line for fuel cooler. Is a fuel cooler present?	Yes: Remove fuel cooler and install a fuel line in its place. After repairs are complete, retest for SPN 3556 FMI 0.
		No: Repair restriction in fuel return line. After repairs are complete, retest for SPN 3556 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 3556 FMI 0 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3556 FMI 1- AFT Fuel Pressure 2 below desired

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Pressure 2 (AFTFP2) signal is reading pressure below desired.	Aftertreatment Fuel System test failure (Table D002)	System test has run (Occurs before dosing) Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	3 event

Fault Overview

The Aftertreatment Fuel Pressure 2 (AFTFP2) sensor is a variable capacitance sensor that monitors fuel pressure after the Aftertreatment Fuel Doser (AFTFD) valve. The Engine Control Module (ECM) uses the AFTFP2 sensor to monitor fuel delivery pressure to the Aftertreatment Fuel Injector (AFI).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 94, 2659, 3479, 3480, 3482, 4077, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

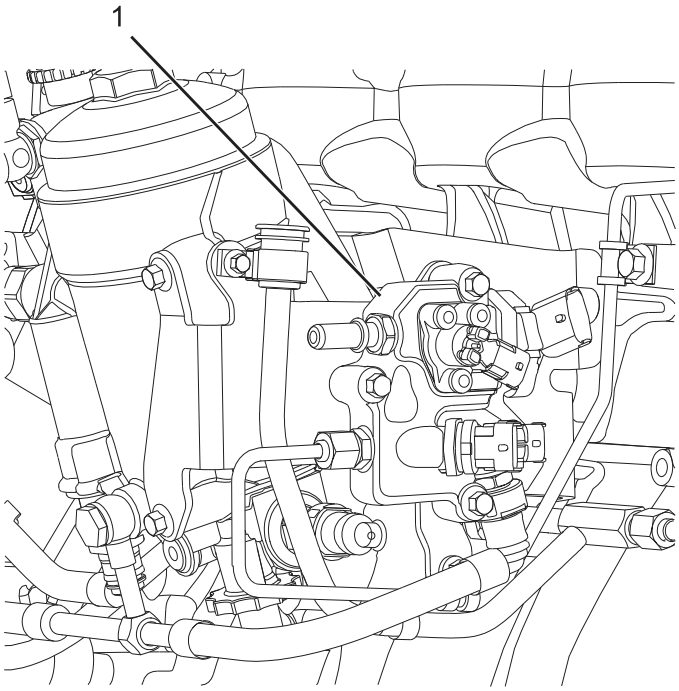


Figure 133 Downstream Injection (DSI) Unit Location

Step	Action	Decision
1	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 2. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 3556 FMI 1.

Step	Action	Decision
2	Determine if Aftertreatment Fuel Doser (AFTFD) is stuck open. Prime Aftertreatment Fuel Injector (AFI) by actuating AFTFD and Aftertreatment Fuel Shutoff Valve (AFTFSV) with DSI De-Aeration test. Using EST with ServiceMaxx™ software, go to Procedures > KOER Aftertreatment Procedures > DSI De-Aeration procedure. Start engine, actuate AFTFSV while monitoring AFTFP1 signal during actuation. Does AFTFP1 rise to 100 psi or more and hold steady for at least 5 seconds?	Yes: Go to step 4. No: Go to step 3.

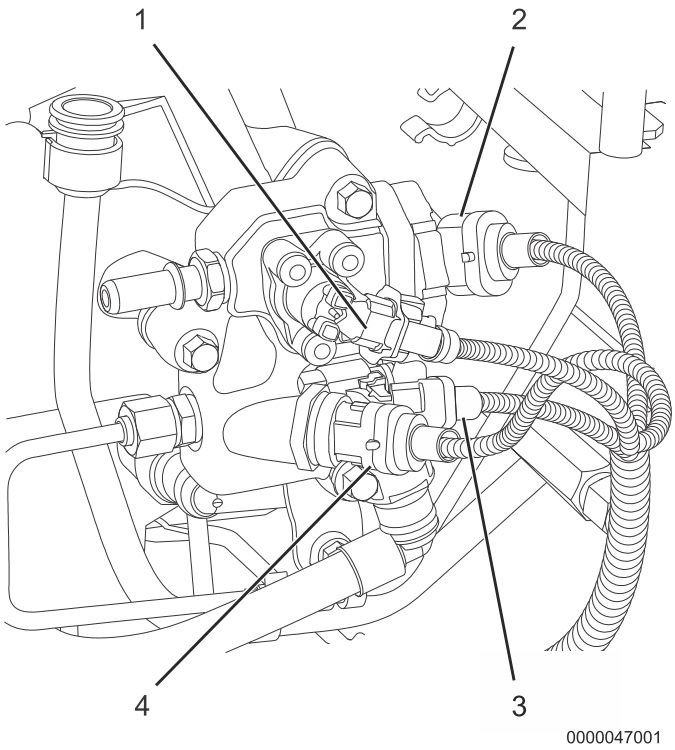


Figure 134 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
3	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location. (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Replace DSI unit. After repairs are complete, retest for SPN 3556 FMI 1. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 3556 FMI 1.

Step	Action	Decision
4	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 3556 FMI 1.
		AFTFP2 signal value does not rise then drop when AFI opens: Go to step 5.
		AFTFP1 signal value drops and AFTFP2 rises, then drops when AFI is opened (correct operation): Retest for SPN 3556 FMI 1 status.

Step	Action	Decision
5	Visually inspect AFI supply line for leaks or damage. Is the line leaking or damaged?	Yes: Replace AFI supply line. After repairs are complete, retest for SPN 3556 FMI 1.
		No: Clean AFI, AFI housing, and bore. After repairs are complete, retest for SPN 3556 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 3556 FMI 1 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3556 FMI 7 - AFT Fuel Injector not responding as expected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Injector (AFI) is not responding as expected.	Aftertreatment Fuel System test failure (Table D002)	System test has run (Occurs before dosing) Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	1 event

Fault Overview

The Aftertreatment Fuel Injector (AFI) receives pressurized fuel injection pulses from the Down Stream Injection (DSI) unit. The AFI is a mechanical poppet type injector, and will only inject fuel when fuel line pressure is increased above a specific pressure.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 2659, 3479, 3480, 3482, 4077, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

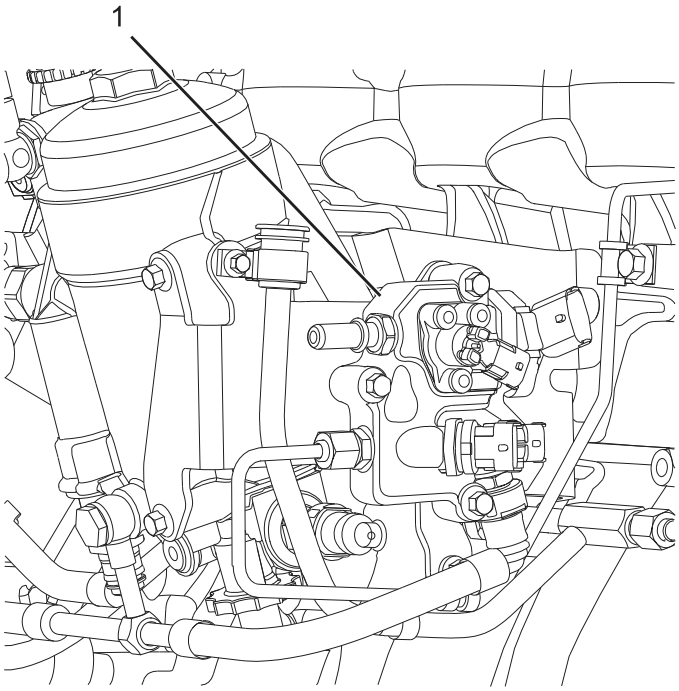


Figure 135 Downstream Injection (DSI) Unit Location

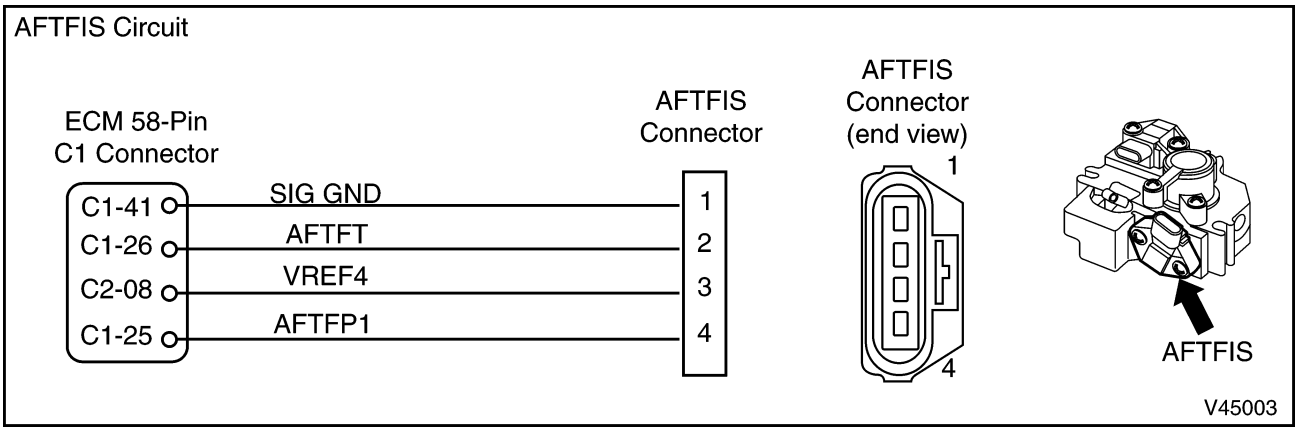


Figure 136 AFTFIS circuit diagram

Step	Action	Decision
1	Inspect connections at Aftertreatment Fuel Inlet Sensor (AFTFIS). Key OFF, disconnect AFTFIS. Check AFTFIS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Are the AFTFIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3556 FMI 7.

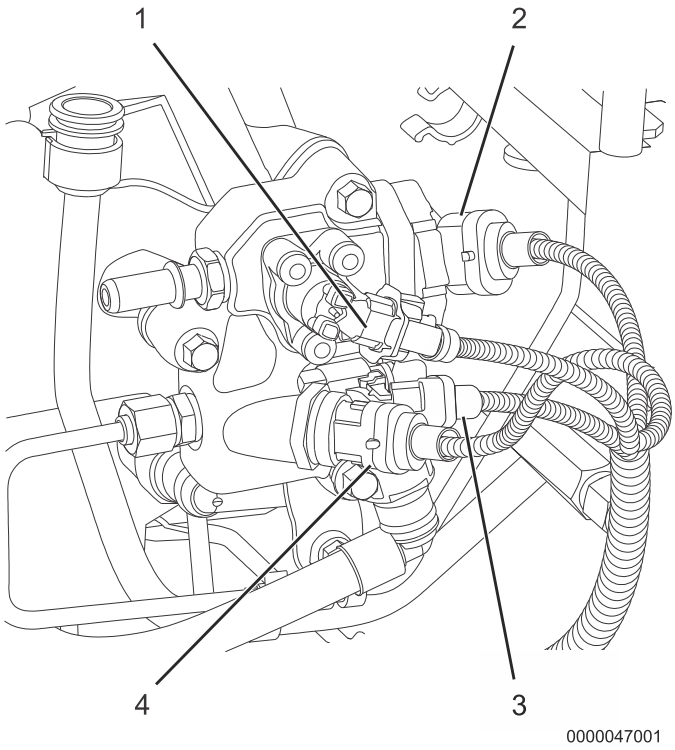


Figure 137 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
2	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location. (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Go to step 3. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 3556 FMI 7.

Step	Action	Decision
3	Check for biased AFTFP1 signal. Using EST with ServiceMaxx™ software, with AFTFIS connected, Key-On Engine-Off (KOEO), run Continuous Monitor session and monitor Aftertreatment Fuel Pressure 1 (AFTFP1) signal. Is AFTFP1 between 0.66 and 0.86 volts? (Wiggle test may be necessary if code is inactive or pending.) **NOTE: AFTFIS is a 4 wire sensor containing Aftertreatment Fuel Temperature (AFTFT) signal for fuel temperature, and AFTFP1 signal for fuel pressure.**	Yes: Go to step 4. No: Do AFTFIS Circuit Checks (page 344). After repairs are complete, retest for SPN 3556 FMI 7.

Step	Action	Decision
4	Inspect connections at Aftertreatment Fuel Pressure 2 (AFTFP2) sensor. Key OFF, disconnect AFTFP2 sensor. Check AFTFP2 sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Are the AFTFP2 sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3556 FMI 7.

Step	Action	Decision
5	Check for biased AFTFP2 sensor. Using EST with ServiceMaxx™ software, with AFTFP2 sensor connected, KOEO, run Continuous Monitor session and monitor Aftertreatment Fuel Pressure 2 (AFTFP2) signal. Is AFTFP2 signal value between 0.30 and 0.50 volts? (Wiggle test may be necessary if code is inactive or pending.)	Yes: Go to step 6. No: Do AFTFP2 Circuit Checks (page 348). After repairs are complete, retest for SPN 3556 FMI 7.

Step	Action	Decision
6	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 7. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 3556 FMI 7.

Step	Action	Decision
7	Determine if Aftertreatment Fuel Doser (AFTFD) is stuck open. Prime Aftertreatment Fuel Injector (AFI) by actuating AFTFD and Aftertreatment Fuel Shutoff Valve (AFTFSV) with DSI De-Aeration test. Using EST with ServiceMaxx™ software, go to Procedures > KOER Aftertreatment Procedures > DSI De-Aeration procedure. Start engine, actuate AFTFSV while monitoring AFTFP1 signal during actuation. Does AFTFP1 rise to 100 psi or more and hold steady for at least 5 seconds?	Yes: Go to step 8. No: Replace DSI unit. After repairs are complete, retest for SPN 3556 FMI 7.

Step	Action	Decision
8	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV, then actuate AFTFD. Monitor AFTFP1 signal value during actuation. Does AFTFP1 signal value drop when AFTFD is actuated?	Yes: Go to step 9. No: Replace DSI unit. After repairs are complete, retest for SPN 3556 FMI 7.

Step	Action	Decision
9	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV, then actuate AFTFD. Monitor AFTFP2 signal value during actuation. Does AFTFP2 signal value rise, then drop when AFI opens?	Yes: Retest for SPN 3556 FMI 7. No: Go to step 10.

Step	Action	Decision
10	Visually inspect AFI supply line for leaks or damage. Is the line leaking or damaged?	Yes: Replace AFI supply line. After repairs are complete, retest for SPN 3556 FMI 7. No: Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. After repairs are complete, retest for SPN 3556 FMI 7.

SPN 3750 FMI 31 - DPF Regen inhibited due to low exhaust temperatures

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Unable to begin closed loop control of active regeneration of Diesel Particulate Filter (DPF) due to low DOC temperature.	Diesel Oxidation Catalyst Outlet Temperature (DOCOT) < 500°F (260°C)	Engine speed > 800 RPM for 200 seconds Barometric Pressure (BARO) ≥ 10.9 psi (75 kPa) Ambient Air Temperature (AAT) ≥ -4°F (-20°C) Active regeneration of DPF has been requested more than 200 seconds. Inactive: SPN 3242 FMI 3 and 4; SPN 4765 FMI 3 and 4	90 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) is unable to achieve closed loop control of active regeneration of the aftertreatment system due to low Diesel Oxidation Catalyst (DOC) temperature.

Malfunction Indicator Lamp (MIL) Reaction

This fault does not illuminate the MIL when active.

Associated Faults

SPN 27 (EGR); SPN 51 (ETV); SPN 2659 (AMS); SPN 2791 (EGR); SPN 3058 FMI 10 (EGR System Monitor); SPN 3246 (DPFOT); SPN 3251 FMI 2, 3, and 4 (DPFDP); and SPN 4766 (DOCOT)

Drive Cycle to Determine Fault Status

Drive Cycle 13 then 3 in 2013 HD-OBD Diagnostic Reference Manual.

Fault Facts

This fault code may indicate exhaust temperature is not high enough to actively regenerate the aftertreatment system. Driving the vehicle with long-term increased load may increase exhaust temperatures and decrease aftertreatment regeneration frequency.

Possible Causes

- Degraded Diesel Oxidation Catalyst (DOC)
- Exhaust leak
- Damaged or missing Diesel Particulate Filter (DPF)
- Failed DOC / DPF temperature sensors

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 27 (EGR); SPN 51 (ETV); SPN 2659 (AMS); SPN 2791 (EGR); SPN 3058 FMI 10 (EGR System Monitor); SPN 3246 (DPFOT); SPN 3251 FMI 2, 3, and 4 (DPFDP); and SPN 4766 (DOCOT). Is EST DTC list free of SPN 27; SPN 51; SPN 2659; SPN 2791; SPN 3058 FMI 10; SPN 3246; SPN 3251 FMI 2, 3, and 4; and SPN 4766?	Yes: Go to step 2. No: Repair SPN 27; SPN 51; SPN 2659; SPN 2791; SPN 3058 FMI 10; SPN 3246; SPN 3251 FMI 2, 3, and 4; and SPN 4766. After repairs are complete, retest for SPN 3750 FMI 31.

Step	Action	Decision
2	Inspect exhaust system for leaks and physical damage. Is exhaust system free of leaks and physical damage?	Yes: Go to step 3. No: Repair or replace leaking or damaged exhaust components. After repairs are complete, retest for SPN 3750 FMI 31.

Step	Action	Decision
3	Compare Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Oxidation Catalyst Outlet Temperature (DOCOT), and DPF Outlet Temperature (DPFOT) temperatures. Perform Hot Run Sensor Comparison Test (page 72). Are the DOCIT, DOCOT, and DPFOT temperatures within 77°F (25°C) of each other?	Yes: Go to step 3. No: Replace sensors that are not reading as expected. After repairs are complete, retest for SPN 3750 FMI 31.

Step	Action	Decision
4	Check the exhaust system for an installed and undamaged Diesel Particulate Filter (DPF). Is a DPF installed in the exhaust system and free damage?	Yes: Inspect DOC for damage and replace if damaged. After repairs are complete, retest for SPN 3750 FMI 31. No: Install correct DPF. After repairs are complete, retest for SPN 3750 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 3750 FMI 31 remains, verify each step was completed correctly, and the proper decision was made. Notify supervisor for further action.

SPN 4077 FMI 0 - AFTFP2 too high while dosing

Fault Overview

The Aftertreatment Fuel Pressure 2 (AFTFP2) sensor is a variable capacitance sensor that monitors fuel pressure after the Aftertreatment Fuel Doser (AFTFD) valve. The Engine Control Module (ECM) uses the AFTFP2 sensor to monitor fuel delivery pressure to the Aftertreatment Fuel Injector (AFI).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN's 27, 94, 102, 1189, 2791, and 4077.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4077 FMI 0 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 4077 FMI 0.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Is air intake system, exhaust system, and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, or physical damage. After repairs are complete, retest for SPN 4077 FMI 0.

Step	Action	Decision
3	Visually inspect Down Stream Injection (DSI) unit supply line for leaks or damage. Is the line free of leaks and damage?	Yes: Go to step 4. No: Replace DSI supply line. After repairs are complete, retest for SPN 4077 FMI 0.

Step	Action	Decision
4	Determine if Intake Manifold Pressure (IMP) sensor or circuit is out of specifications. Using EST with ServiceMaxx software, do IMP Biased Sensor Check (page 717). Is IMP sensor within specifications?	Yes: Go to step 5. No: Repair IMP sensor or circuit. After repairs are complete, retest for SPN 4077 FMI 0.

Step	Action	Decision
5	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC) and Exhaust Gas Recirculation (EGR) valve are commanded On. Key-On Engine-Running (KOER). Run Air Management Test while monitoring IMP sensor signal. Does IMP sensor signal change: • When TC2WC is commanded On? • When EGR valve is commanded On?	IMP signal change only when TC2WC is commanded On: Do EGR Pinpoint Diagnostics (page 622) and check for EGR issue. After repairs are complete, retest for SPN 4077 FMI 0.
		IMP signal change only with EGR valve commanded On: Do TC2WC voltage and circuit checks (page 839). After repairs are complete, retest for SPN 4077 FMI 0.
		Neither change IMP signal when commanded On: Go to step 6.
		Both change IMP signal when commanded On: Go to step 7.

Step	Action	Decision
6	Verify IMP sensor and bore are not restricted due to carbon buildup. Remove and inspect IMP sensor and bore for carbon buildup. Is IMP sensor and bore free of carbon buildup?	Yes: Go to step 7.
		No: Clean IMP sensor bore of carbon deposits. After repairs are complete, retest for SPN 4077 FMI 0.

Step	Action	Decision
7	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 8. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 4077 FMI 0.

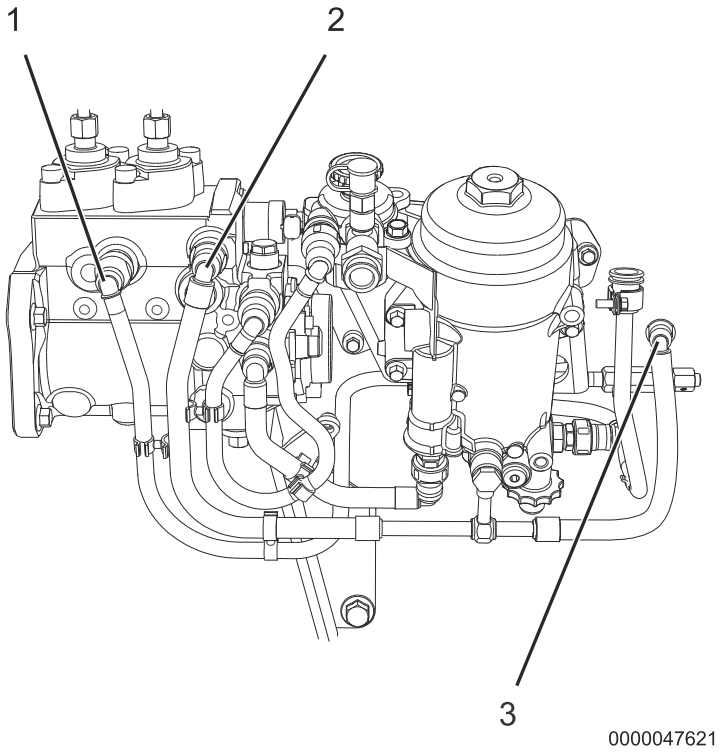


Figure 138 Fuel Pressure Test Locations

1. HP fuel pump return
2. HP fuel pump inlet
3. Fuel supply to DSI unit

Step	Action	Decision
8	Measure fuel return pressure from high-pressure fuel pump. Connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 and fuel pressure gauge between high-pressure fuel pump and fuel return line. Measure fuel pressure at high idle, no load, and stabilized engine operating temperature. Is fuel return pressure greater than 15 psi?	Yes: Go to step 10. No: Go to step 9.

Step	Action	Decision
9	Visually inspect Aftertreatment Fuel Injector (AFI) supply line for leaks or damage. Is the line leaking or damaged?	Yes: Replace AFI supply line. After repairs are complete, retest for SPN 4077 FMI 0.
		No: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 4077 FMI 0.

Step	Action	Decision
10	Inspect fuel return line for fuel cooler. Is a fuel cooler present?	Yes: Remove fuel cooler and install a fuel line in its place. After repairs are complete, retest for SPN 4077 FMI 0.
		No: Repair restriction in fuel return line. After repairs are complete, retest for SPN 4077 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 4077 FMI 0 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4077 FMI 1 - AFTFP2 too low while dosing

Fault Overview

The Aftertreatment Fuel Pressure 2 (AFTFP2) sensor is a variable capacitance sensor that monitors fuel pressure after the Aftertreatment Fuel Doser (AFTFD) valve. The Engine Control Module (ECM) uses the AFTFP2 sensor to monitor fuel delivery pressure to the Aftertreatment Fuel Injector (AFI).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

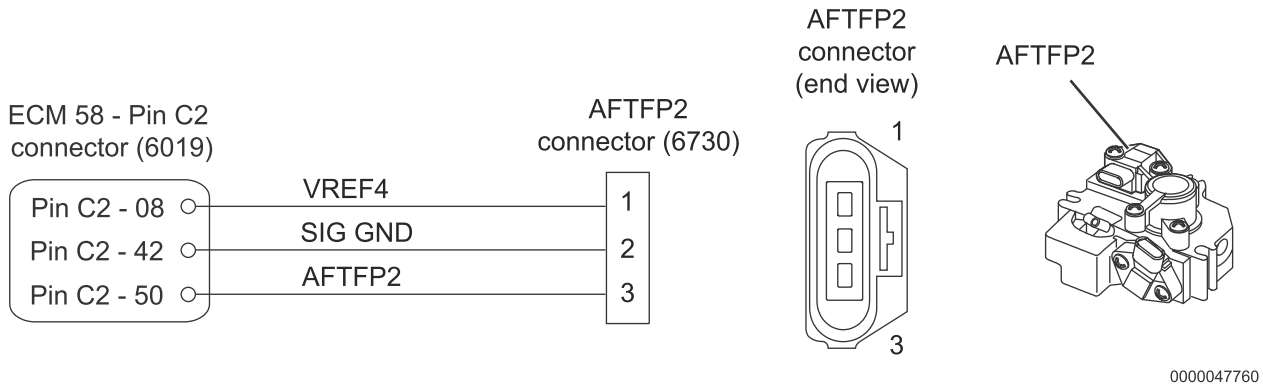
Associated Faults

SPN's 94, 3479, and 3482.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

AFTFP2 circuit



Step	Action	Decision
1	Visually inspect Down Stream Injection (DSI) unit supply line for leaks or damage. Is the line free of leaks and damage?	Yes: Go to step 2. No: Replace DSI supply line. After repairs are complete, retest for SPN 4077 FMI 1.

Step	Action	Decision
2	Inspect connections at Aftertreatment Fuel Pressure 2 (AFTFP2) sensor. Key OFF, disconnect AFTFP2 sensor. Check AFTFP2 sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Are the AFTFP2 sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4077 FMI 1.

Step	Action	Decision
3	Check for biased AFTFP2 sensor. Using EST with ServiceMaxx™ software, with AFTFP2 sensor connected, run Continuous Monitor session and monitor Aftertreatment Fuel Pressure 2 (AFTFP2) signal. Is AFTFP2 signal value between 0.30 and 0.50 volts? (Wiggle test may be necessary if code is inactive or pending.)	Yes: Go to step 4. No: Do AFTFP2 Circuit Checks (page 348). After repairs are complete, retest for SPN 4077 FMI 1.

Step	Action	Decision
4	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 5. No: See Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 4077 FMI 1.

Step	Action	Decision
5	Prime Aftertreatment Fuel Injector (AFI) by actuating Aftertreatment Fuel Doser (AFTFD) valve and Aftertreatment Fuel Shutoff Valve (AFTFSV) with DSI De-Aeration test. Using EST with ServiceMaxx™ software, go to Procedures > KOER Aftertreatment Procedures > DSI De-Aeration procedure. Start engine, actuate AFTFSV while monitoring AFTFP1 signal during actuation. Does AFTFP1 rise to 100 psi or more and hold steady for at least 5 seconds?	Yes: Go to step 7. No: Go to step 6.

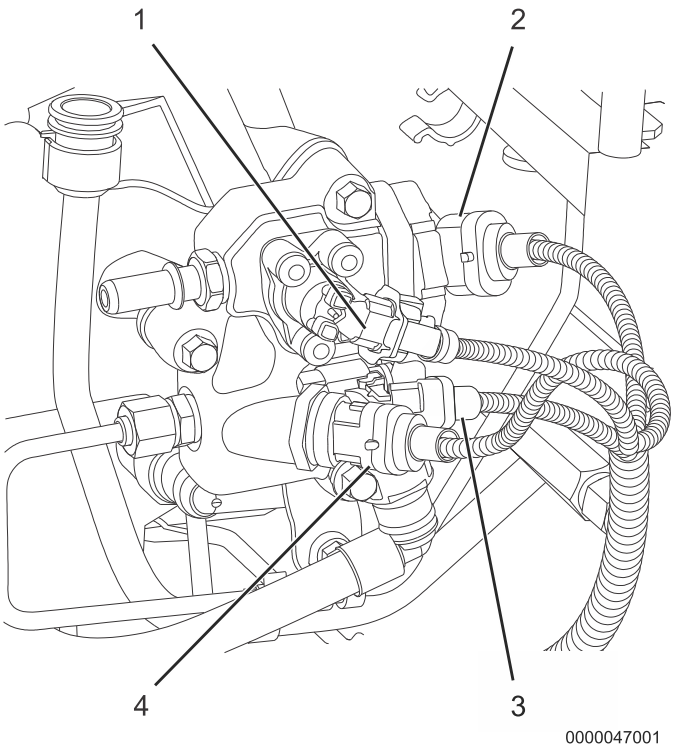


Figure 140 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
6	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location. (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Replace DSI unit. After repairs are complete, retest for SPN 4077 FMI 1. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 4077 FMI 1.

Step	Action	Decision
7	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 4077 FMI 1.
		AFTFP2 signal value does not rise then drop when AFI opens: Go to step 8.
		AFTFP1 signal value drops and AFTFP2 rises, then drops when AFI is opened (correct operation): Retest for SPN 4077 FMI 1.

Step	Action	Decision
8	Visually inspect AFI supply line for leaks or damage. Is the line leaking or damaged?	Yes: Replace AFI supply line. After repairs are complete, retest for SPN 4077 FMI 1.
		No: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 4077 FMI 1.

SPN 4766 FMI 10 - DPF Regeneration feedback fault

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Outlet Temperature (DOCOT) did not reach the desired operating temperature within the desired time.	Function of time to reach desired DOCOT and regeneration desired temperature (Tables A028, A021, A040, and C005)	Regeneration active Injection quantity < 1 mg / stroke and Engine operating status = Running for 30 seconds Open loop dosing active Engine Coolant temperature 1 (ECT1) > 122°F (50°C) Diesel Oxidation Catalyst Inlet Temperature (DOCIT) > 392°F (200°C) Exhaust gas mass flow > 200 kg / hr Engine operating in monitoring region: 900-2100 rpm and > 50% load Regeneration interruptions (disable) > 20 events less than 30 seconds in duration Regeneration interruptions (disable) > 1 event more than 30 seconds in duration	1 event

Fault Overview

Fault code sets when the Diesel Oxidation Catalyst Outlet Temperature (DOCOT) does not reach desired temperature within a predetermined time frame during exhaust injection.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN's 94, 2659, 3251, 3480, 4077, 4765, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

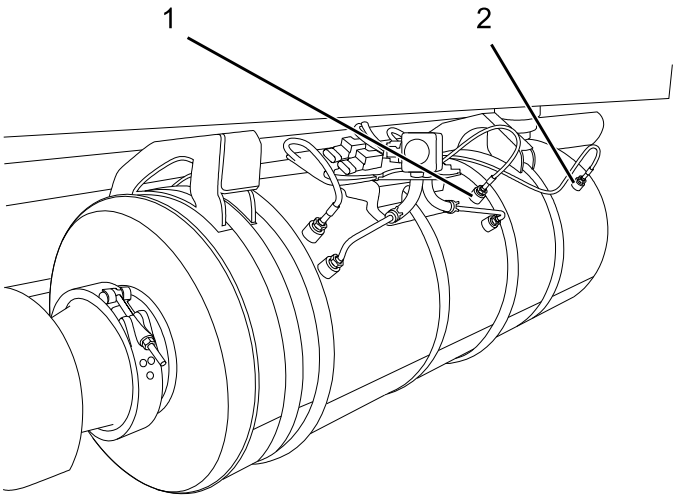


Figure 141 DOCOT and DOCIT Sensor Locations (Typical)

1. Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor
2. Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4766 FMI 10 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect the fuel system from fuel tank to Aftertreatment Fuel Injector (AFI) valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks, or physical damage. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Inlet (DOCIT) sensor, and Diesel Oxidation Catalyst Outlet (DOCOT) sensor. Key OFF, disconnect DOCIT and DOCOT sensor connectors. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are DOCIT and DOCOT sensor connectors, harnesses, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair damaged connector, harness, or terminal. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
4	Check for biased aftertreatment temperature sensor. Do Hot Run Sensor Comparison Test (page 72). Are the DOCIT, DOCOT, and DPFOT temperatures within 77°F (25°C) of each other?	Yes: Go to step 5. No: Replace sensors that are not reading as expected. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
5	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 6. No: Do Fuel Delivery Pressure (FDP) Test (page 167). After repairs are complete, retest for SPN 4766 FMI 10.

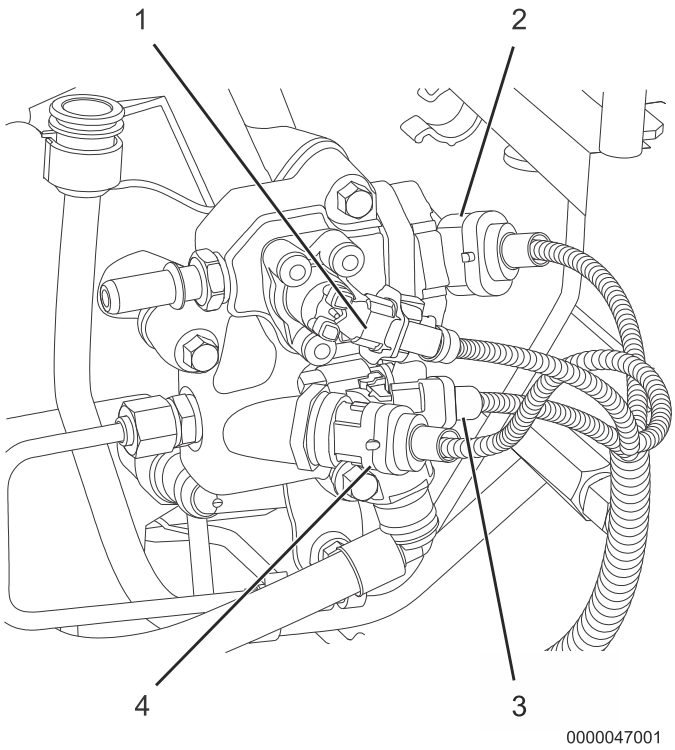


Figure 142 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
6	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location? (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Go to step 7. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
7	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 4766 FMI 10.
		AFTFP2 signal value does not rise properly then drop when AFI opens: Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. After repairs are complete, retest for SPN 4766 FMI 10.
		AFTFP2 signal value rises but does not drop. Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. Inspect for kinked AFI supply line. After repairs are complete, retest for SPN 4766 FMI 10.
		AFTFP1 signal value drops and AFTFP2 signal value rises, then drops when AFI is opened (correct operation): Go to step 8.

Step	Action	Decision
8	Using EST with ServiceMaxx software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 9.
		No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

Step	Action			Decision
9	While running OBFCT, inspect for exhaust leaks and monitor following signals during test: Are Parked Regen Checks within specification during OBFCT?			If Parked Regen Checks are within specification: Go to step 10.
	Parked Regen Checks	**Specifications**	**Pass / Fail**	
	Engine condition	Smooth, not stumbling		If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 4766 FMI 10.
	Engine Coolant Temp (ECT)	Above 122°F (50°C) per ServiceMaxx		
	DOCIT	After 5 - 10 minutes above 500°F (260°C)		If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 4766 FMI 10.
	DOCOT	After 5 – 10 minutes above 986°F (530°C)		
	DPFOT	Below 1292°F (700°C)		If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 4766 FMI 10.
	Aftertreatment Fuel Pressure 1 (AFTFP1)	> 110 psi during test		
	Aftertreatment Fuel Pressure 2 (AFTFP2)	Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.		

Step	Action	Decision
10	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Go to step 11.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
11	Check vehicle repair history for EGR cooler repairs (internal coolant leak), since last Diesel Oxidation Catalyst (DOC) replacement. Is vehicle history free of EGR cooler repairs (internal coolant leak), since last DOC replacement?	Yes: Go to step 12.
		No: Replace DOC. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
12	Inspect for coolant leak to exhaust. Do Coolant Leak to Exhaust (page 82) test and check for coolant leaks. Is exhaust system free of coolant leaks?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Repair coolant leak into exhaust system and replace DOC. After repairs are complete, retest for SPN 4766 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 4766 FMI 10 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4766 FMI 20 - DOC Outlet Temp above maximum desired

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Outlet Temperature (DOCOT) above desired operating temperature.	Oxidation Catalyst downstream temperature > 932°F (500°C)	Time after successful regen complete > 10 minutes Timer after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	10 seconds

Fault Overview

Fault code sets when the Diesel Oxidation Catalyst Outlet Temperature (DOCOT) reaches above 932°F (500°C) within a predetermined time frame by the Engine Control Module (ECM).

Malfunction Indicator Lamp (MIL) Reaction

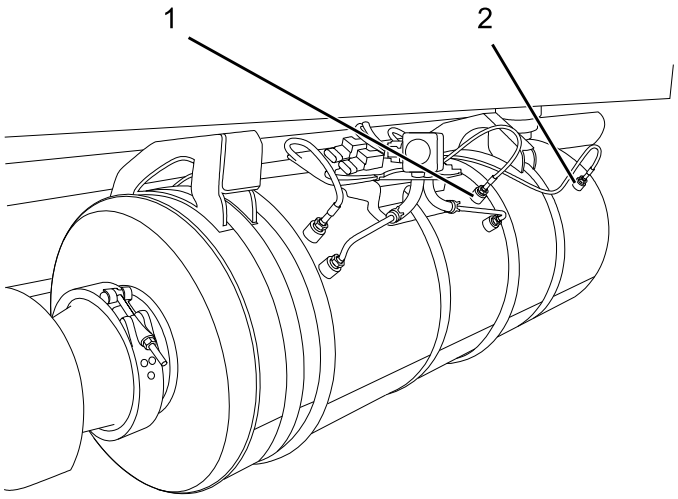
When fault is active, MIL will not illuminate.

Associated Faults

SPN's 94, 2659, 3251, 3480, 4077, 4765, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.



0000047042

Figure 143 DOCOT Sensor Location

1. Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4766 FMI 20 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 4766 FMI 20.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect the fuel system from fuel tank to Aftertreatment Fuel Injector (AFI) valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 4766 FMI 20.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor. Key OFF, disconnect DOCOT. Check DOCOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4766 FMI 20.

Step	Action	Decision
4	Check for biased aftertreatment temperature sensor. Do Hot Run Sensor Comparison Test (page 72). Are the DOCIT, DOCOT, and DPFOT temperatures within 77°F (25°C) of each other?	Yes: Go to step 5. No: Replace sensors that are not reading as expected. After repairs are complete, retest for SPN 4766 FMI 20.

Step	Action	Decision
5	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 6. No: Do Fuel Delivery Pressure (FDP) Test (page 167). After repairs are complete, retest for SPN 4766 FMI 20.

Step	Action	Decision
6	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 4766 FMI 20. No: Go to step 7.

Step	Action	Decision
7	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 8. No: Go to step 9.

Step	Action	Decision
8	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 4766 FMI 20. No: Repair failed valve train components. After repairs are complete retest for SPN 4766 FMI 20.

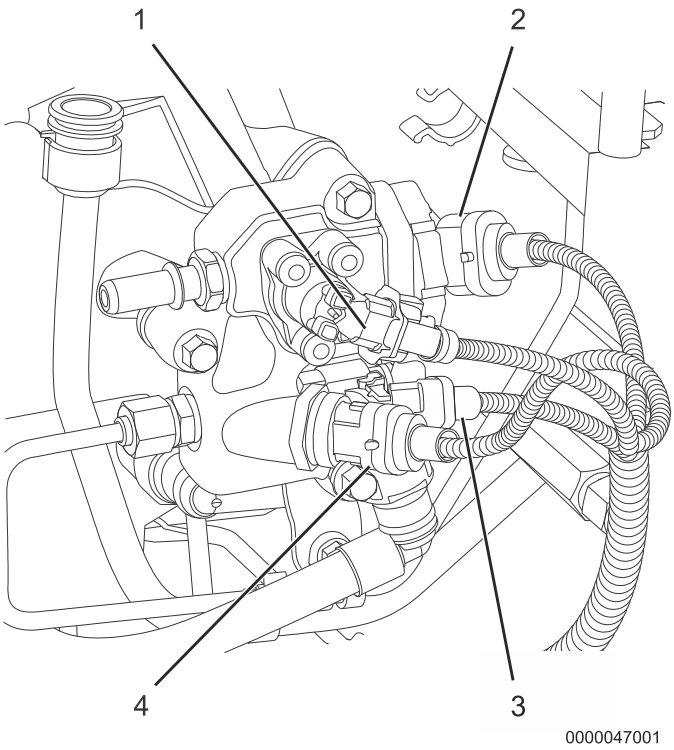


Figure 144 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
9	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location? (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Go to step 10. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 4766 FMI 20.

Step	Action	Decision
10	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 4766 FMI 20.
		AFTFP2 signal value does not rise properly then drop when AFI opens: Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. After repairs are complete, retest for SPN 4766 FMI 20.
		AFTFP2 signal value rises but does not drop. Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. Inspect for kinked AFI supply line. After repairs are complete, retest for SPN 4766 FMI 20.
		AFTFP1 signal value drops and AFTFP2 signal value rises, then drops when AFI is opened (correct operation): Go to step 11.

Step	Action	Decision
11	Using EST with ServiceMaxx software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 12.
		No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="10">12</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specification: Go to step 13.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="2">If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 4766 FMI 20.</td></tr>
<tr><td>Engine Coolant Temp (ECT)</td><td>Above 122°F (50°C) per ServiceMaxx</td><td></td></tr>
<tr><td>DOCIT</td><td>After 5 - 10 minutes above 500°F (260°C)</td><td></td><td rowspan="2">If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 4766 FMI 20.</td></tr>
<tr><td>DOCOT</td><td>After 5 – 10 minutes above 986°F (530°C)</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td><td rowspan="3">If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 4766 FMI 20.</td></tr>
<tr><td>Aftertreatment Fuel Pressure 1 (AFTFP1)</td><td>> 110 psi during test</td><td></td></tr>
<tr><td>Aftertreatment Fuel Pressure 2 (AFTFP2)</td><td>Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.</td><td></td></tr>
</table>

Step	Action	Decision
13	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 4766 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 4766 FMI 20 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4766 FMI 21 - DOC Outlet Temp below minimum desired

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Outlet Temperature (DOCOT) did not get above 392°F (200°C) for 10 seconds with enable conditions met. (start of regen)	Diesel Oxidation Catalyst (DOC) output temperature < 392°F (200°C)	Engine speed > 1400 rpm Injection quantity > 115 mg / stroke Intake Manifold Pressure (IMP) > 17.5 psi (120 kPa) In above conditions > 45 seconds Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	10 seconds

Fault Overview

Fault code sets when the Diesel Oxidation Catalyst Outlet Temperature (DOCOT), with enable conditions met, does not reach a minimum of 392°F (200°C) during exhaust injection.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN's 94, 3251, 3480, 4077, 4765, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

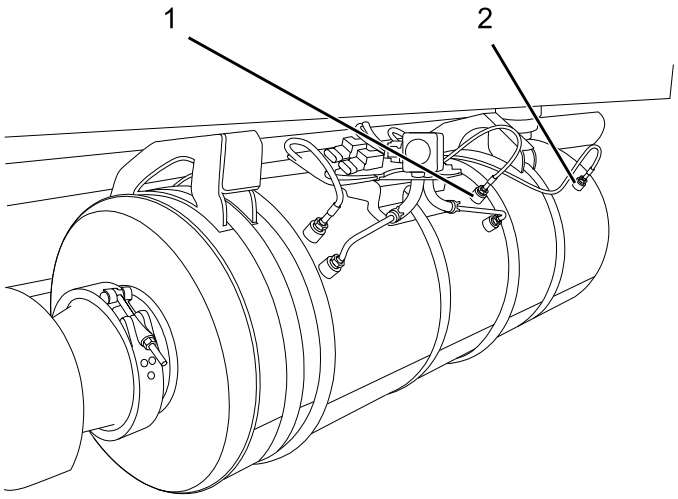


Figure 145 DOCOT Sensor Location

1. Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor
2. Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4766 FMI 21 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 4766 FMI 21.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect the fuel system from fuel tank to Aftertreatment Fuel Injector (AFI) valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 4766 FMI 21.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor. Key OFF, disconnect DOCOT. Check DOCOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4766 FMI 21.

Step	Action	Decision
4	Check for biased aftertreatment temperature sensor. Do Hot Run Sensor Comparison Test (page 72). Are the DOCIT, DOCOT, and DPFOT temperatures within 77°F (25°C) of each other?	Yes: Go to step 5. No: Replace sensors that are not reading as expected. After repairs are complete, retest for SPN 4766 FMI 21.

Step	Action	Decision
5	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 6. No: Do Fuel Delivery Pressure (FDP) Test (page 167). After repairs are complete, retest for SPN 4766 FMI 21.

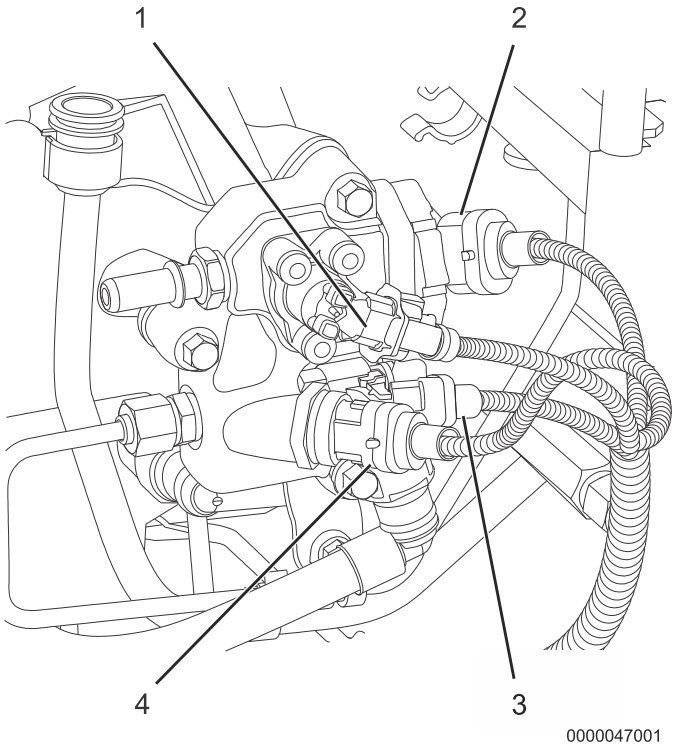


Figure 146 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
6	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location? (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Go to step 7. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 4766 FMI 21.

Step	Action	Decision
7	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 4766 FMI 21. AFTFP2 signal value does not rise properly then drop when AFI opens: Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. After repairs are complete, retest for SPN 4766 FMI 21. AFTFP2 signal value rises but does not drop. Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. Inspect for kinked AFI supply line. After repairs are complete, retest for SPN 4766 FMI 21. AFTFP1 signal value drops and AFTFP2 signal value rises, then drops when AFI is opened (correct operation): Go to step 8.

Step	Action	Decision
8	Using EST with ServiceMaxx software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 9. No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="10">9</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specification: Go to step 10.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="2">If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 4766 FMI 21.</td></tr>
<tr><td>Engine Coolant Temp (ECT)</td><td>Above 122°F (50°C) per ServiceMaxx</td><td></td></tr>
<tr><td>DOCIT</td><td>After 5 - 10 minutes above 500°F (260°C)</td><td></td><td rowspan="2">If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 4766 FMI 21.</td></tr>
<tr><td>DOCOT</td><td>After 5 – 10 minutes above 986°F (530°C)</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td><td rowspan="3">If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 4766 FMI 21.</td></tr>
<tr><td>Aftertreatment Fuel Pressure 1 (AFTFP1)</td><td>> 110 psi during test</td><td></td></tr>
<tr><td>Aftertreatment Fuel Pressure 2 (AFTFP2)</td><td>Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.</td><td></td></tr>
</table>

Step	Action	Decision
10	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Go to step 11.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 4766 FMI 21.

Step	Action	Decision
11	Check vehicle repair history for EGR cooler repairs (internal coolant leak), since last Diesel Oxidation Catalyst (DOC) replacement. Is vehicle history free of EGR cooler repairs (internal coolant leak), since last DOC replacement?	Yes: Go to step 12.
		No: Replace DOC. After repairs are complete, retest for SPN 4766 FMI 21.

Step	Action	Decision
12	Inspect for coolant leak to exhaust. Do Coolant Leak to Exhaust (page 82) test and check for coolant leaks. Is exhaust system free of coolant leaks?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Repair coolant leak into exhaust system and replace DOC. After repairs are complete, retest for SPN 4766 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 4766 FMI 21 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5298 FMI 2 - Reduced DOC Efficiency – De-Rate

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst (DOC) Efficiency low.	Difference between modeled DOCOT and average DOCOT > 275°F (135°C)	Demanded aftertreatment dosing quantity > 1000 mg/s Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts Injection quantity < 1 mg/stroke and Engine operating status = Running for 30 seconds DOCOT rate of change < 68°F (20°C) Modeled DOCOT rate of change < 122°F (50°C) Regeneration Active Exhaust gas volume flow < 750 cubic meters/hour and > 500 cubic meters/hour Engine operating in monitoring region	3 event

Fault Overview

Fault code sets when the Engine Control Module (ECM) determines Diesel Oxidation Catalyst (DOC) efficiency is low. The ECM calculates Modeled Diesel Oxidation Catalyst Outlet Temperature (DOCOT) rate of change based on an average of Aftertreament Fuel Injector (AFI) quantity and calculated O^2 quantity, and compares to average DOCOT.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN's 94, 3251, 3480, 4077, 4765, 4766, and 5456.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

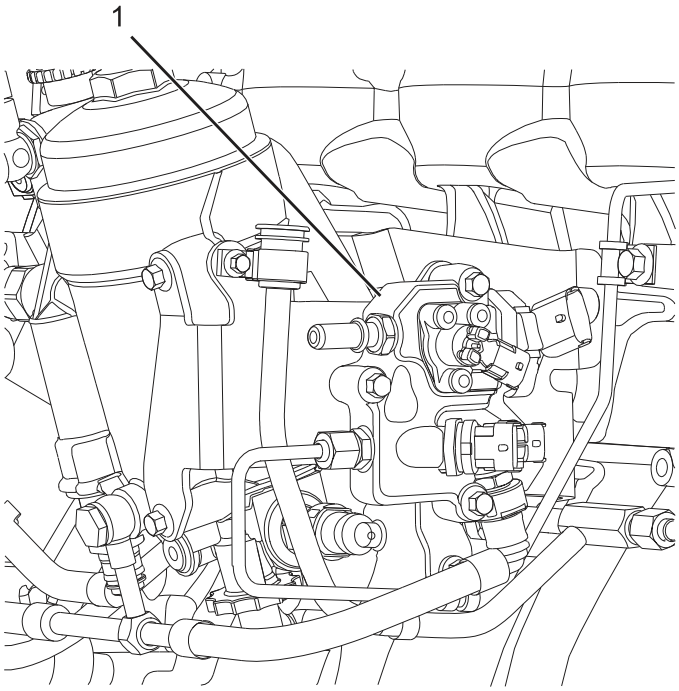


Figure 147 Downstream Injection (DSI) Unit Location

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 5298 FMI 2 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 5298 FMI 2.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect the fuel system from fuel tank to Aftertreatment Fuel Injector (AFI) valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 5298 FMI 2.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor. Key OFF, disconnect DOCOT. Check DOCOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5298 FMI 2.

Step	Action	Decision
4	Check for biased aftertreatment temperature sensor. Do Hot Run Sensor Comparison Test (page 72). Are the DOCIT, DOCOT, and DPFOT temperatures within 77°F (25°C) of each other?	Yes: Go to step 5. No: Replace sensors that are not reading as expected. After repairs are complete, retest for SPN 4766 FMI 10.

Step	Action	Decision
5	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 6. No: Do Fuel Delivery Pressure (FDP) Test (page 167). After repairs are complete, retest for SPN 5298 FMI 2.

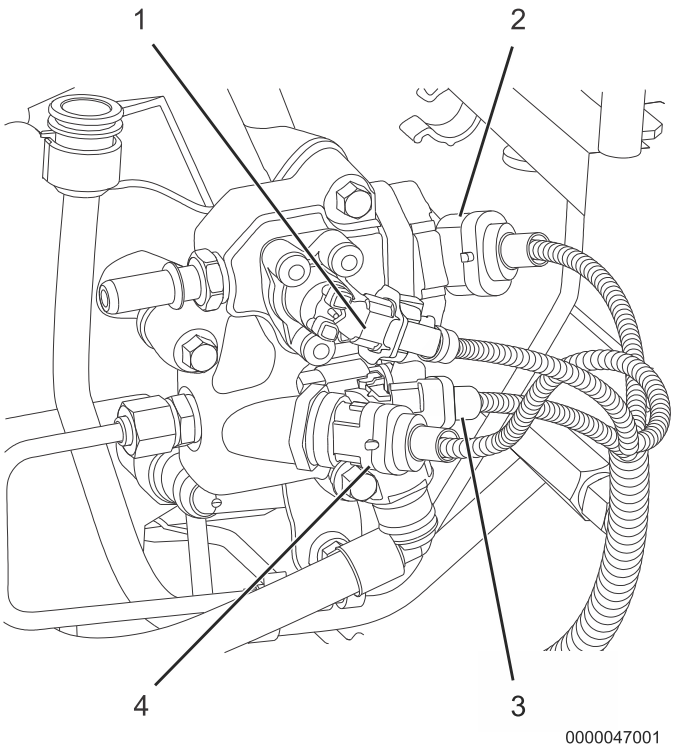


Figure 148 DSI Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
6	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location? (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Go to step 7. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 5298 FMI 2.

Step	Action	Decision
7	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 5298 FMI 2.
		AFTFP2 signal value does not rise properly then drop when AFI opens: Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. After repairs are complete, retest for SPN 5298 FMI 2.
		AFTFP2 signal value rises but does not drop. Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. Inspect for kinked AFI supply line. After repairs are complete, retest for SPN 5298 FMI 2.
		AFTFP1 signal value drops and AFTFP2 signal value rises, then drops when AFI is opened (correct operation): Go to step 8.

Step	Action	Decision
8	Using EST with ServiceMaxx software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 9.
		No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="11">9</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specification: Go to step 10.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="2">If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 5298 FMI 2.</td></tr>
<tr><td>Engine Coolant Temp (ECT)</td><td>Above 122°F (50°C) per ServiceMaxx</td><td></td></tr>
<tr><td>DOCIT</td><td>After 5 - 10 minutes above 500°F (260°C)</td><td></td><td rowspan="2">If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 5298 FMI 2.</td></tr>
<tr><td>DOCOT</td><td>After 5 – 10 minutes above 986°F (530°C)</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td><td rowspan="3">If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 5298 FMI 2.</td></tr>
<tr><td>Aftertreatment Fuel Pressure 1 (AFTFP1)</td><td>> 110 psi during test</td><td></td></tr>
<tr><td>Aftertreatment Fuel Pressure 2 (AFTFP2)</td><td>Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.</td><td></td></tr>
</table>

Step	Action	Decision
10	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Go to step 11.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 5298 FMI 2.

Step	Action	Decision
11	Check vehicle repair history for EGR cooler repairs (internal coolant leak), since last Diesel Oxidation Catalyst (DOC) replacement. Is vehicle history free of EGR cooler repairs (internal coolant leak), since last DOC replacement?	Yes: Go to step 12.
		No: Replace DOC. After repairs are complete, retest for SPN 5298 FMI 2.

Step	Action	Decision
12	Inspect for coolant leak to exhaust. Do Coolant Leak to Exhaust (page 82) test and check for coolant leaks. Is exhaust system free of coolant leaks?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Repair coolant leak into exhaust system and replace DOC. After repairs are complete, retest for SPN 5298 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 5298 FMI 2 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5319 FMI 31 - DPF Incomplete Regeneration

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Incomplete regeneration of the aftertreatment system has been detected.	Estimated soot burn < 75 grams	Number of allowable regeneration attempts since the last successful regeneration was completed < 50 Limp Home Mode = Inactive Diesel Particulate Filter (DPF) regeneration = Inactive Engine Coolant Temperature 1 (ECT1) > -44°F (-7°C) < 239°F (115°C) and Ambient Air Temperature (AAT) > -44°F (-7°C) < 131°F (55°C) Barometric pressure (BARO) > 11 psi (75 kPa) Engine is coasting (Disable) Injection quantity < 1 mg/stroke and Engine operating status = Running for 30 seconds Exhaust gas volume flow > 500 cubic meters/hour Distance since regeneration < 62 miles (100,000) meters Continuous simulated soot mass < 20 g DPF temperature < 788°F (420°C) Enable conditions met for > 300 seconds Fuel injection quantity (disable condition) < 5 mg/stroke for > 3 seconds	1 event

Fault Overview

The Diesel Particulate Filter Differential Pressure (DPFDP) sensor is a variable-capacitance sensor that measures pressure at two locations. The first location is between the Diesel Oxidation Catalyst (DOC) and the Diesel Particulate Filter (DPF). The second location is immediately after the DPF. DPFDP provides a feedback signal to the ECM indicating pressure difference between the inlet and outlet of the DPF.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN 27 (EGR), SPN 1173 (TC2CIT), SPN 1177 (TC2CIP), SPN 1189 (TC2WC)

SPN 94 (FDP); SPN 102 (IMP); SPN 157 (FRP); SPN 651-656 (INJ/CYL); SPN 3055 (FRP); SPN 3479 (AFTFD) SPN 3480 (AFTFP1); SPN 3481 (AFT); SPN 3482 (AFTFSV); SPN 4077 (AFTFP2); SPN 5456 (AFTFT); SPN 5541 (TC1TOP)

SPN 3251 FMI 2, 3, and 4 (DPFDP / outlet pressure)

Fault Facts

If aftertreatment system has had excess fuel, oil, coolant, metal, or other contamination; inspect the entire aftertreatment system for causal damage before re-installing. Inspect for overheated aftertreatment components, cracked exhaust system welds, leaking exhaust system seams, or other damage. Excessive ash accumulation in the Diesel Particulate Filter (DPF) will cause frequent regenerations of the aftertreatment system. If all step-based diagnostics have been completed with no failure found, inspect the ash load of the DPF.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low engine performance
- Failed fuel injector
- Engine mechanical
- Oil leak to exhaust
- Failed Diesel Particulate Filter Differential Pressure (DPFDP)
- Restricted DPFDP sensor hose(s)
- Damaged or failed Diesel Oxidation Catalyst (DOC)
- Restricted DOC (soot accumulation)
- Failed DSI

Step	Action	Decision
1	Using EST, check DTC list for SPN 27 (EGR); SPN 1173 (TC2CIT); SPN 1177 (TC2CIP); and SPN 1189 (TC2WC). Is EST DTC list free of SPN 27; SPN 1173; SPN 1177; and SPN 1189?	Yes: Go to step 2. No: Repair SPN 27; SPN 1173; SPN 1177; and SPN 1189. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
2	Using EST with ServiceMaxx™ software, check DTC list for SPN 94 (FDP); SPN 102 (IMP); SPN 157 (FRP); SPN 651-656 (INJ / CYL); SPN 3479 (AFTFD); SPN 3480 (AFTFP1); SPN 3481 (AFT); SPN 3482 (AFTFSV); SPN 4077 (AFTFP2); SPN 5456 (AFTFT); and SPN 5541 (TC1TOP). Is EST DTC list free of SPN 94; SPN 102; SPN 157; SPN 651-656; SPN 3055; SPN 3479; SPN 3480; SPN 3481; SPN 3482; SPN 4077; SPN 5456; and SPN 5541?	Yes: Go to step 3. No: Repair SPN 94; SPN 102; SPN 157; SPN 651-656; SPN 3055; SPN 3479; SPN 3480; SPN 3481; SPN 3482; SPN 4077; SPN 5456; and SPN 5541. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
3	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3251 FMI 2, 3, and 4 (DPFDP). Is EST DTC list free of SPN 3251 FMI 2, 3, and 4?	Yes: Go to step 4. No: Repair SPN 3251 FMI 2, 3, and 4. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor module. Key OFF, disconnect DPFDP sensor module. Check DPFDP sensor module and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor module connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
5	Monitor DPFDP signal following active regeneration of the aftertreatment system. Key-On Engine-Off (KOEO), using EST with ServiceMaxx software, load the Signals session and monitor DPFDP. Is DPFDP below 0.5 psi?	Yes: Go to step 7. No: Go to step 6.

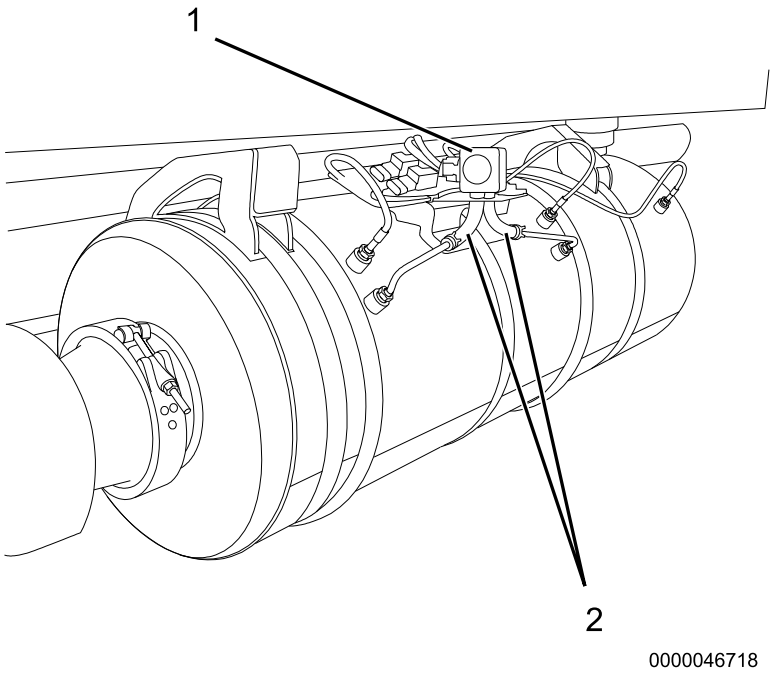


Figure 149 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

Step	Action	Decision
6	Check DPFDP / outlet pressure sensor module hoses for correct routing and restrictions. Inspect the DPFDP / outlet pressure sensor module hoses for kinks, improper hose routing, restrictions, or damage. Are the DPFDP / outlet pressure sensor module hoses routed correctly, free of damage, and unrestricted?	Yes: Replace DPFDP / outlet Pressure sensor. After repairs are complete, retest for SPN 5319 FMI 31. No: Repair or replace DPFDP / outlet pressure sensor hose(s). After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 5319 FMI 31. No: Go to step 8

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9. No: Go to step 10.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 5319 FMI 31. No: Repair failed valve train components. After repairs are complete retest for SPN 5319 FMI 31.

Step	Action	Decision
10	Check for lube oil leak to exhaust. Perform Lube Oil Leak to Exhaust (page 95). Was the exhaust free of lube oil contamination?	Yes: Go to step 11. No: Repair lube oil leak to exhaust. After repairs are complete, retest for SPN 5319 FMI 31.

Step	Action	Decision
11	Check for fuel leak to exhaust. Perform Fuel Leak to Exhaust (page 103). Was the exhaust free of fuel contamination?	Yes: Clean or replace DOC. Refer to fault facts. After repairs are complete, retest for SPN 5319 FMI 31. No: Repair fuel leak to exhaust. After repairs are complete, retest for SPN 5319 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 5319 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Aftertreatment System Overview

Types of Regens

Passive - Not initiated by operator or by control system. Occurs when exhaust gas temperatures are hot enough to ignite soot particles in the aftertreatment system.

Active - Initiated by control system. Occurs when exhaust gas temperatures are too low to ignite soot particles. The ECM will command the Aftertreatment Fuel Injector ON causing extra fuel to be injected into the aftertreatment system increasing exhaust gas temperatures.

Parked - Initiated by operator. Occurs when soot levels are too high for Passive or Active regen methods. During a Parked regen, engine RPM is raised, fuel is injected into the exhaust, and the Engine Throttle Valve (ETV) is positioned to restrict air flow. If equipped with an Exhaust Back Pressure Valve (EBPV), the valve is positioned to restrict exhaust gas flow.

AFT System Indicators

Fault codes that require a Regen are better understood as Alert codes. This is a normal condition used to alert the operator or technician that soot level in the DPF has reached a set point and the system is running or needs to run a DPF Regen.

Hot Exhaust Temperature (HET) Lamp



Figure 150 HET Lamp

Hot Exhaust System Temperature lamp indicates exhaust temperature is above
400 °C (752 °F) and vehicle speed is below 5 mph.

Operator Action: Beware of surroundings, the exhaust is very hot.

Technician Action: None

Diesel Particulate Filter (DPF) Lamp



Figure 151 DPF Lamp

DPF lamp on solid. This notifies the operator the Aftertreatment System is cleaning the DPF.

Operator Action: Drive at highway speed, until lamp goes out, or perform a Parked Regen.

Technician Action: None

If system is unable to finish the cleaning process due to driving conditions (Low load, short trip) or if there's a problem with the system, the soot level will continue to build in the DPF and trigger the next soot level DTC.

SPN 3719 FMI 15 – DPF Soot Load - Lowest (level 1/3)



Figure 152 DPF Lamp Flashing

DPF soot level 1, DPF lamp flashing. This notifies the operator the Aftertreatment System is cleaning the DPF.

Operator Action: Perform a Parked Regen.

Technician Action: Verify the system is working without fault. See below procedure.

DPF soot level 1, DPF lamp flashing. This notifies the operator the soot level is reaching a much higher level, and the system is not completing a Regen through the operators current drive cycle. If this is ignored, the soot level will continue to build to setting the next level DTC.

SPN 3719 FMI 16 – DPF Soot Load - Moderate (level 2/3)



Figure 153 DPF Lamp Flashing, Amber Warning Lamp On Solid

Operator Action: Perform a Parked Regen.

Technician Action: Verify the system is working without fault. See below procedure.

DPF soot level 2, DPF lamp flashing and the buzzer sounding. This notifies the operator the soot level has reached a critical level and the engine now de-rated engine is de-rated by 15% of normal engine power.

SPN 3719 FMI 0 DPF Soot Load - Highest (level 3/3)



Figure 154 DPF Lamp Flashing and Buzzer Sounding

Operator Action: Tow vehicle in for service.

Technician Action: The DPF must be replaced at soot level 3, when the DPF lamp is flashing and the buzzer sounding. This notifies the operator the soot level has reached a critical level and the engine is engine is de-rated by 85% of normal power.

Regen Inhibitors

A DPF Regen can be inhibited by disabling switches, or the entry conditions have not yet been met to start the regeneration process.

Fault Code Regen Inhibitors

Fault codes that can inhibit a Regen will not allow a Regen process to take place. The ECM continuously monitors for system faults. If a fault is detected the Malfunction Indicator Lamp (MIL) lamp will illuminate and a DTC will set.

Entry Conditions for a Rolling Regen

When the ECM determines the soot level threshold is reached, the system triggers DPF Regen.

NOTE: Short trips or stop and go driving could prevent a successful Regen.

The following conditions are required for a Rolling Regen:

- DPF Status signal displaying: Regen Needed
- Red stop engine lamp not on
- Engine Coolant Temperature is above or at least 75 ºC (170 ºF)
- Inhibiting DTCs must not be active (See Fault Code Regen Inhibitors (page 313)
- Regen Inhibit switch not active (switch must be off)
- PTO not active (switch must be off)
- Exhaust Temperature sensors below safe thresholds:
  - DOCIT below 500 °C (932 °F)
  - DOCOT below 650 °C (120 °F)
  - DPFOT below 750 °C (1382 °F)

If DPF Status displays "Regen needed" and vehicle is unable to perform a Rolling Regen, perform the Diagnostic Test Procedure (page 316).

Entry Conditions for a Parked Regen

A Parked Regen can only be performed when the DPF soot level threshold is reached. The DPF lamp will flash or stay on solid, signaling the need for Regen.

The following conditions are required for a Parked Regen:

- Engine Running
- DPF lamp is on
- Parked Regen switch on
- DPF Status signal displaying: Regen Needed
- Red stop engine lamp not on
- Engine Coolant Temperature is above or at least 75 ºC (170 ºF)
- Vehicle speed not rolling
- Inhibiting DTCs must not be active (See Fault Code Regen Inhibitors (page 313)
- Regen Inhibit switch not active (switch must be off)
- PTO not active (switch must be off)
- Exhaust Temperature sensors below safe thresholds:
  - DOCIT below 500 °C (932 °F)
  - DOCOT below 650 °C (1202 °F)
  - DPFOT below 750 °C (1382 °F)

Onboard Filter Cleanliness Test. DPF Status displays “Regen needed” and vehicle is unable to perform a Active Regen, go to appropriate aftertreatment system diagnostics section in this manual.

DPF Status Test

This test checks the status of the DPF if the Soot level is within a Regen Needed limit. The test will automatically start a Parked Regen.

NOTE: The KOER Standard Test must be run before performing this test.

This test will perform a complete Parked Regen.

Engine speed is ramped up to increase exhaust flow through the DPF while the DPFDP sensor monitors the pressure difference across the DPF. The test runs for about 15 minutes. If a Regen is needed, the engine ramps up for another 15 minutes, but this time to run DPF Regen cycle.

The following conditions are required for a Onboard Filter Cleanliness Test.

- Engine Running
- Engine Coolant Temperature is above or at least 75 ºC (170 ºF)
- Vehicle stationary
- Inhibit DTCs must not be active: Refer to Fault Code Regen Inhibitors (page 313)
- PTO not active (switch must be off)
- Regen inhibit switch not active (switch must be off)
- Parking brake must be applied
- Brake pedal not depressed
- Accelerator pedal not depressed
- Driveline disengaged

- If the Soot level is within normal range, the test completes and displays “Test Completed Successful.” No further action is required.
- If the test is aborted, perform the following Diagnostic Test Procedure.

Diagnostic Test Procedure

If engine does not start due to a restricted DPF:

1. Remove the DPF and inspect for oil or coolant in the exhaust. Repair problem found before continuing.
2. Run all of the below tests but the Parked Regen Test. Repair any problem found before continuing.
3. Interview the operator about their drive cycle. The system may not be able to finish DPF Regen due to driving conditions (Low load, short trip).
4. Install a new DPF and run the Onboard Filter Cleanliness Test.

Sensor Compare Checks

NOTE: This test is not dependent on engine temperature.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open Sessions / Aftertreatment / Temperatures.
3. Turn ignition switch ON, engine ON.
4. Compare Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Oxidation Catalyst Outlet Temperature (DOCOT), and Diesel Particulate Filter Outlet Temperature (DPFOT) sensors. Sensor temperatures should be within 15° C (25°) of each other.
   - If DOCIT, DOCOT or DPFOT is 15 °C (25 °F) above or below of each other, check for poor circuitry going to the out of range sensor.
   - If circuits are within specification, replace out of range sensor.
   - If sensors and circuits are within specifications, continue to Exhaust Restriction Test.

Exhaust Restriction Test

Connect EST, open the Performance session.

NOTE: Run engine at High Idle while monitoring DPF Differential Pressure and TC1 Turbine Outlet Pressure.

Checks	Specification	Comment – < Less than, > Greater than
DPFDP	< 1.5 psi	If > 1.5 psi, the DPF is restricted, go to Parked Regen.
TC1TOP	< 45 psi	If TC1TOP is > 45 psi and DPFDP is < 1.5 psi, remove DOC and inspect for face plugging.
If TC1TOP and DPFDP are within expected range, but the DPF Status reads “Regen Needed”, go to Parked Regen Checks (page 321).		

Regen Inhibitors

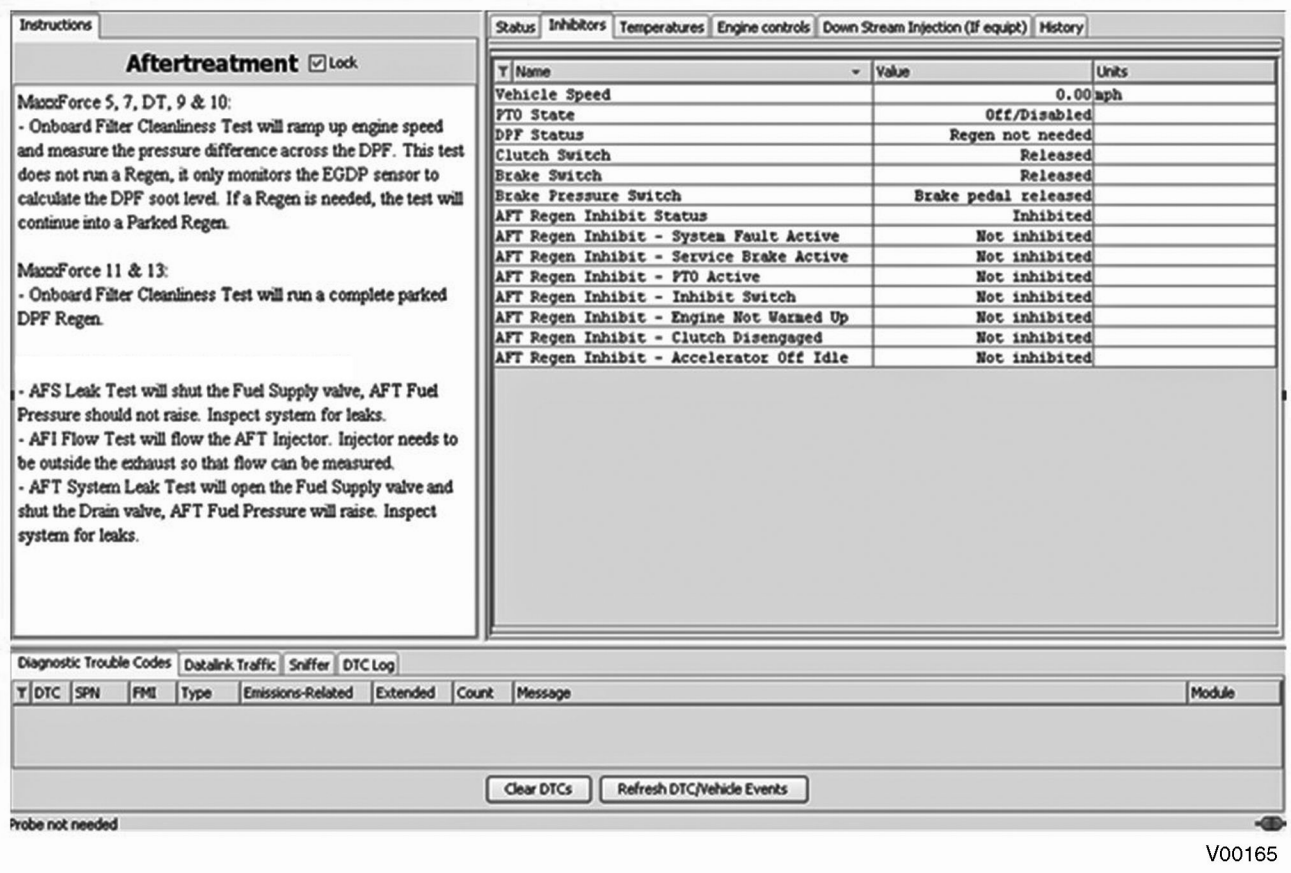


Figure 155 Aftertreatment session screen shot

Overview

A regen may not occur due to any of the following conditions:

- Inhibitors do not match their expected value
- Entry condition have not been met
- Active fault code (s)

To view the status of Regen inhibitors, use an EST with ServiceMaxx™ software, go to Tests > KOER Aftertreatment Tests > Onboard Filter Cleanliness Test. Select the Inhibitor tab.

Check Rolling Regen Inhibitors

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, load the Aftertreatment session.
3. Start engine and run vehicle speed above 5 mph.
4. Verify all listed inhibitors are displaying "Not Inhibited."

Check	Expected Results	Comment
AFT Regen Inhibit Status	Not Inhibited	If inhibited, correct the cause. Check switches and any DTC that may be causing the Regen inhibit.
Red Stop Alert Lamp	Off	If On, Regen can't be run. Go to appropriate aftertreatment system diagnostic section in this manual.
Regen Inhibit Switch	Off	If On, turn switch Off. If switch does not turn Off, then diagnose circuit fault.
PTO Enable Switch	Off	If On, turn switch Off. If switch does not turn Off, then diagnose circuit fault.
PTO Switch	Off	If On, turn switch Off. If switch does not turn Off, then diagnose circuit fault.
If no inhibitors are active and Regen is needed, go to Parked Regen Checks (page 321).		

Check Parked Regen Inhibitors

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, load the Aftertreatment session.
3. Verify all listed Inhibitors are displaying "Not Inhibited."

Checks	Expected Results	Comment
AFT Regen Inhibit status	Not Inhibited	If inhibited, correct the cause. Check switches and any DTC that may be causing the Regen inhibit.
Red Stop Alert lamp	Off	If On, Regen can't be run. Go to appropriate aftertreatment system diagnostic section in this manual.
Regen inhibit switch	Off	If On, turn switch Off. If switch does not turn Off, then diagnose circuit fault.
PTO enable switch	Off	If On, turn switch Off. If switch does not turn Off, then diagnose circuit fault.
PTO switch	Off	If On, turn switch Off. If switch does not turn Off, then diagnose circuit fault.
Parking brake switch	On	If Off, set parking brake, if switch does not turn On, then diagnose circuit fault.
Brake Pedal switch	Off	If On and foot is off pedal, then diagnose circuit fault.
Accelerator Pedal Position	0%	If above 0%, and foot is off pedal, then diagnose circuit fault.
Clutch Pedal Switch	Off	If On and foot is off pedal, then diagnose circuit fault.
Transmission Position	Park or Neutral	If engaged, disengage, or diagnose circuit fault.
If no inhibitors and a Regen is needed, go to the following Parked Regen Checks.		

Parked Regen Checks

During a Parked Regen the engine speed will ramp up to 1200-1800 rpm.

Typical readings:

- **ETV:** 80% (closed).
- **EGR Position:** 0% (closed)
- **DOCIT:** 250-300°C (482-572°F)
- **DOCOT:** 550-600°C (1022-1112°F) (after 5-10 minutes)
- **DPFOT:** 600-650°C (1112-1202°F) (after 10-15 minutes)
- **DPFDP:** Decreasing steadily once DPFIT and DPFOT are steady and above 550°C (1022°F).

Connect the EST, open the Aftertreatment session. Start a Parked Regen and monitor signals.

Parked Regen Checks

Connect EST, open the Aftertreatment session. Open the inhibitors tab and check for Inhibitors.

Checks	Expected Results	Comment
Engine condition	Smooth, not stumbling	If engine does not run smoothly, diagnose engine performance problem. See “PERFORMANCE DIAGNOSTICS."
DPF Status	Regen Needed	If signal reads “Not needed”, than a Regen cannot be commanded to run.
Engine Coolant Temp	Above 66 ºC (150 ºF)	If below 66 ºC (150 ºF), warm engine above set point.
AFT Regen Status	Active	If signal reads “Not Active”, check for fault codes and Parked Regen Inhibitors.
EGR Position	Closed	If not closed, see EGR Valve (page 621).
ETV Position	80% ±5%	If not within specifications, see ETV (page 640).
DOCIT	250 ºC (482 ºF) to 300ºC (572 ºF)	If below 250 ºC (482 ºF), using Electronic Service Tool (EST) with ServiceMaxx™ software, run the KOER Air Management Test. If above 300 ºC (572 ºF), check for proper ETV operation, and if engine is over fueling.
DOCOT	After 5-10 minutes above 530 ºC (986 ºF)	If below 530 ºC (986 ºF), diagnose and repair any active DOCOT fault code(s) (Ex. SPN 4766 FMI 10). If no active fault code(s), go to appropriate aftertreatment system diagnostics section in this manual.
DPFOT	Below 700 ºC (1292 ºF)	If above 700 ºC (1292 ºF), diagnose and repair any active DPFOT fault code(s). If no active fault code(s), go to appropriate aftertreatment system diagnostics section in this manual.
DPFDP	Below 0.5 psi (3.4 kPa)	If above 0.5 psi, after the system completes a full Parked Regen, diagnose and repair any active DPFDP fault code(s). If no active fault code(s), go to appropriate aftertreatment system diagnostics section in this manual.
If the DPF is face plugged, measure the distance between the filter and outlet. If not within specification, the filter cannot be cleaned and must be replaced.		

DPF Filter Inspection

Normal DPF Inlet

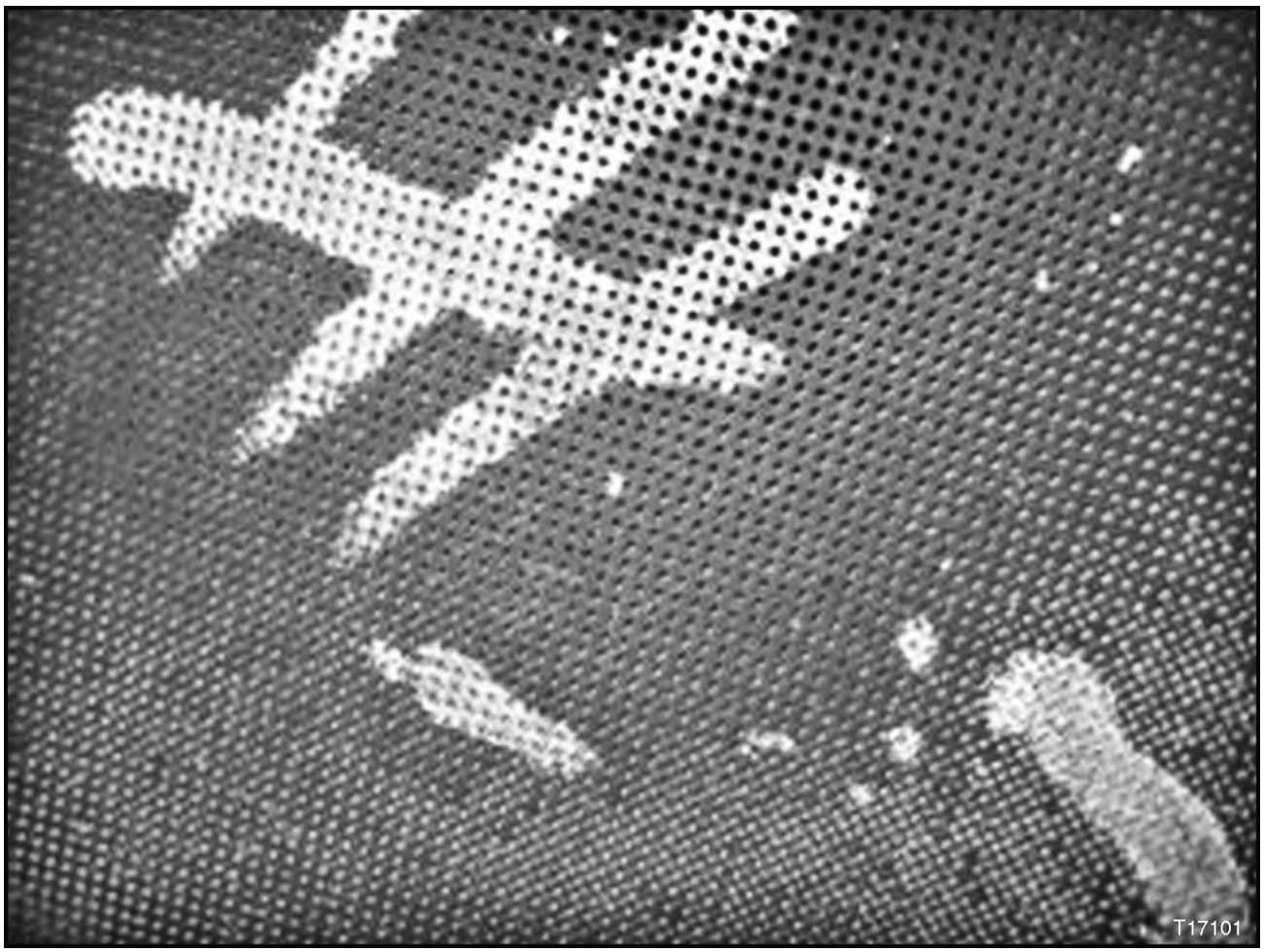


Figure 156 DPF Inlet (Normal)

Normal DPF Outlet

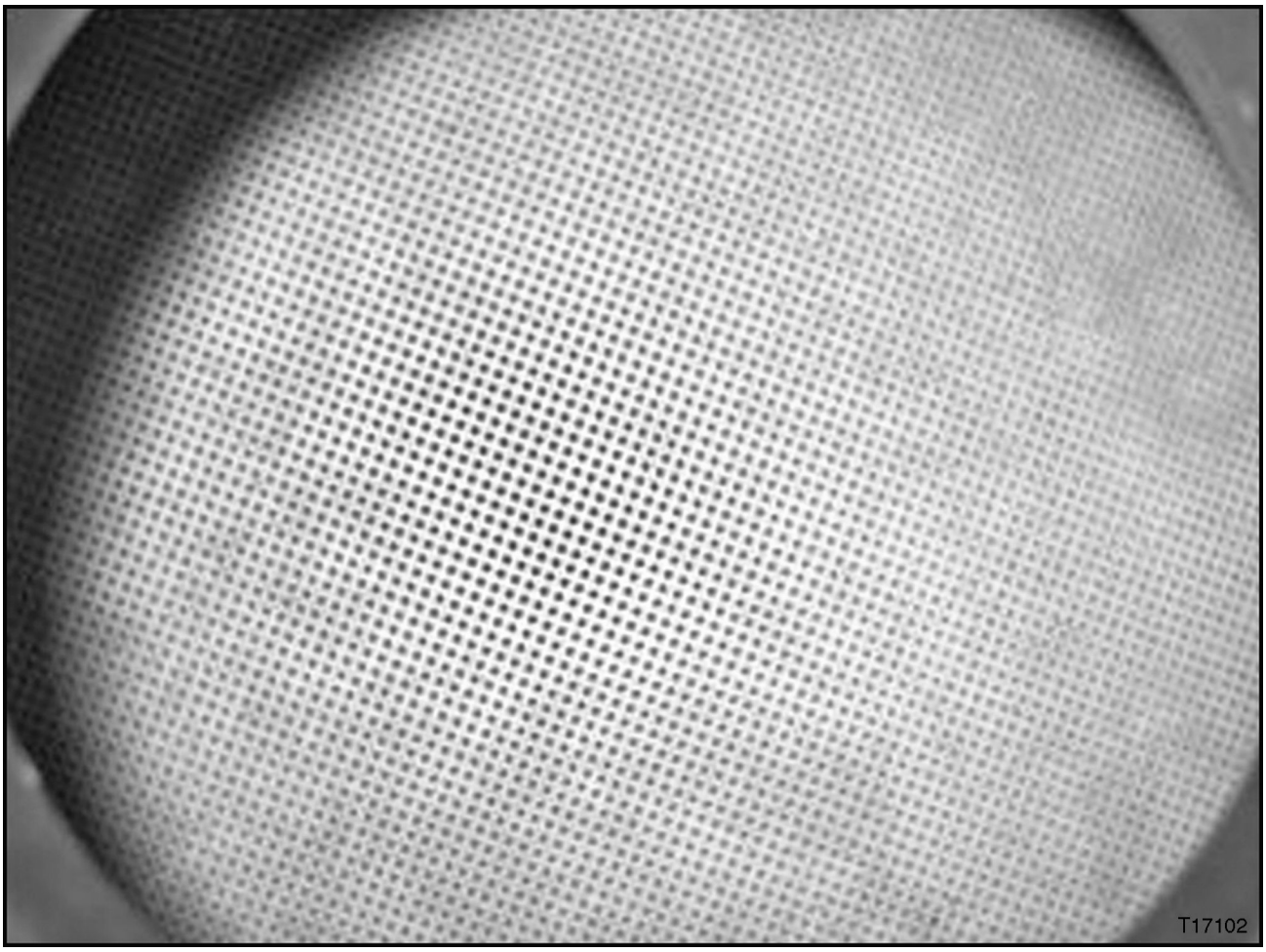


Figure 157 DPF Outlet (Normal)

Inspect the inlet and outlet of the DPF.

Insure all inlet channels are visible and the light soot coating over the whole inlet face easily wiped away with a finger. Soot amount on face may vary depending on the time since last DPF regeneration, but should be less than 1/8."

Possible Causes	Action
System is working correctly	None.

Restricted DPF Inlet

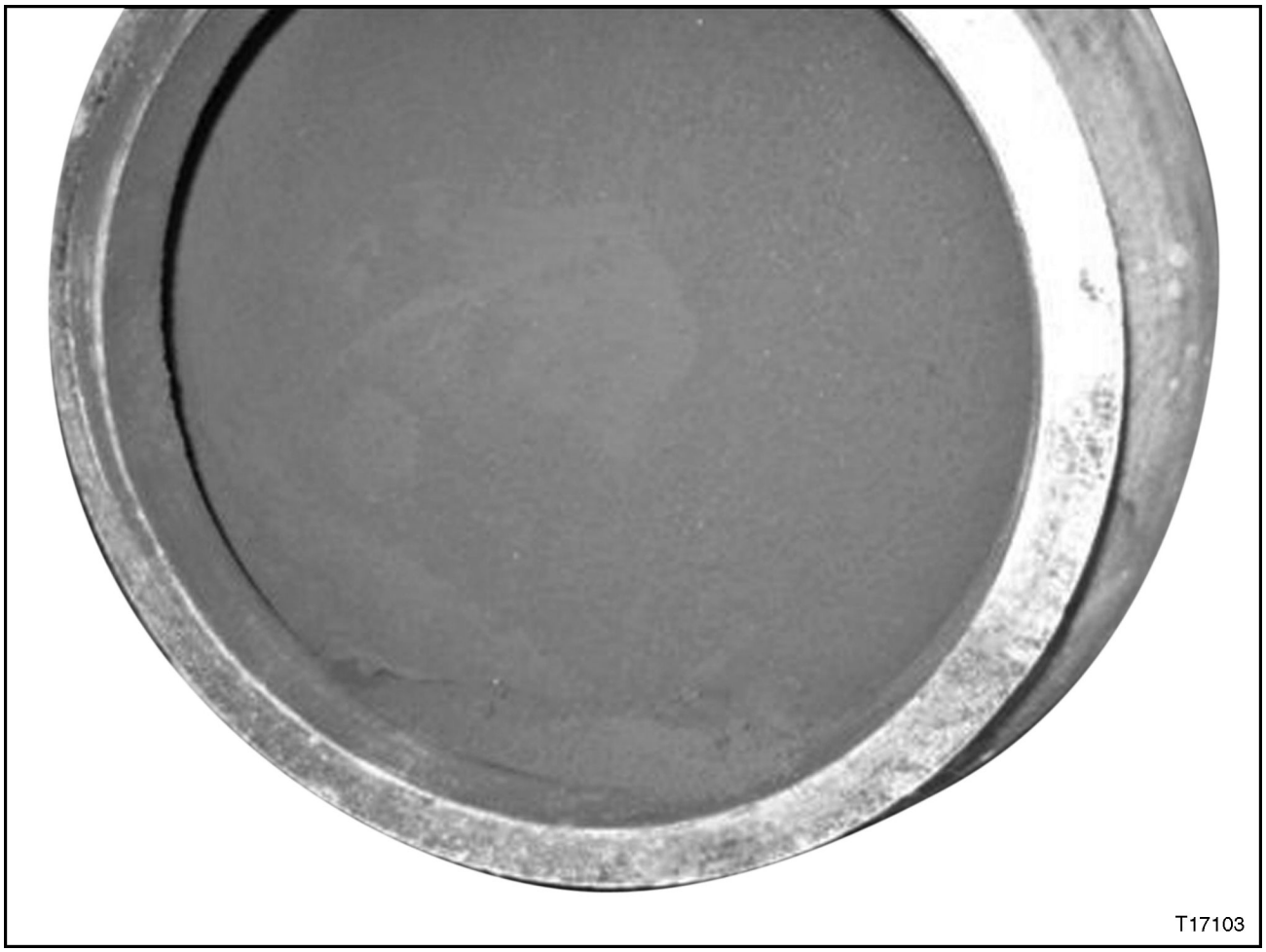


Figure 158 DPF Face Plugged

Inspect Inlet of the DPF.

If no channels are visible and the face of the DPF has a deep cake of soot greater than 1/8”, remove DPF for external cleaning.

Possible Causes	Action
• Drive cycle (Unable to complete Regen) • Engine over fueling • Boost problem • Intake throttle problem	1. Interview the operator about his drive cycle. 2. Verify there are no inhibitors (DTCs or switches). 3. Replace the DPF.

DPF Contaminated with Coolant

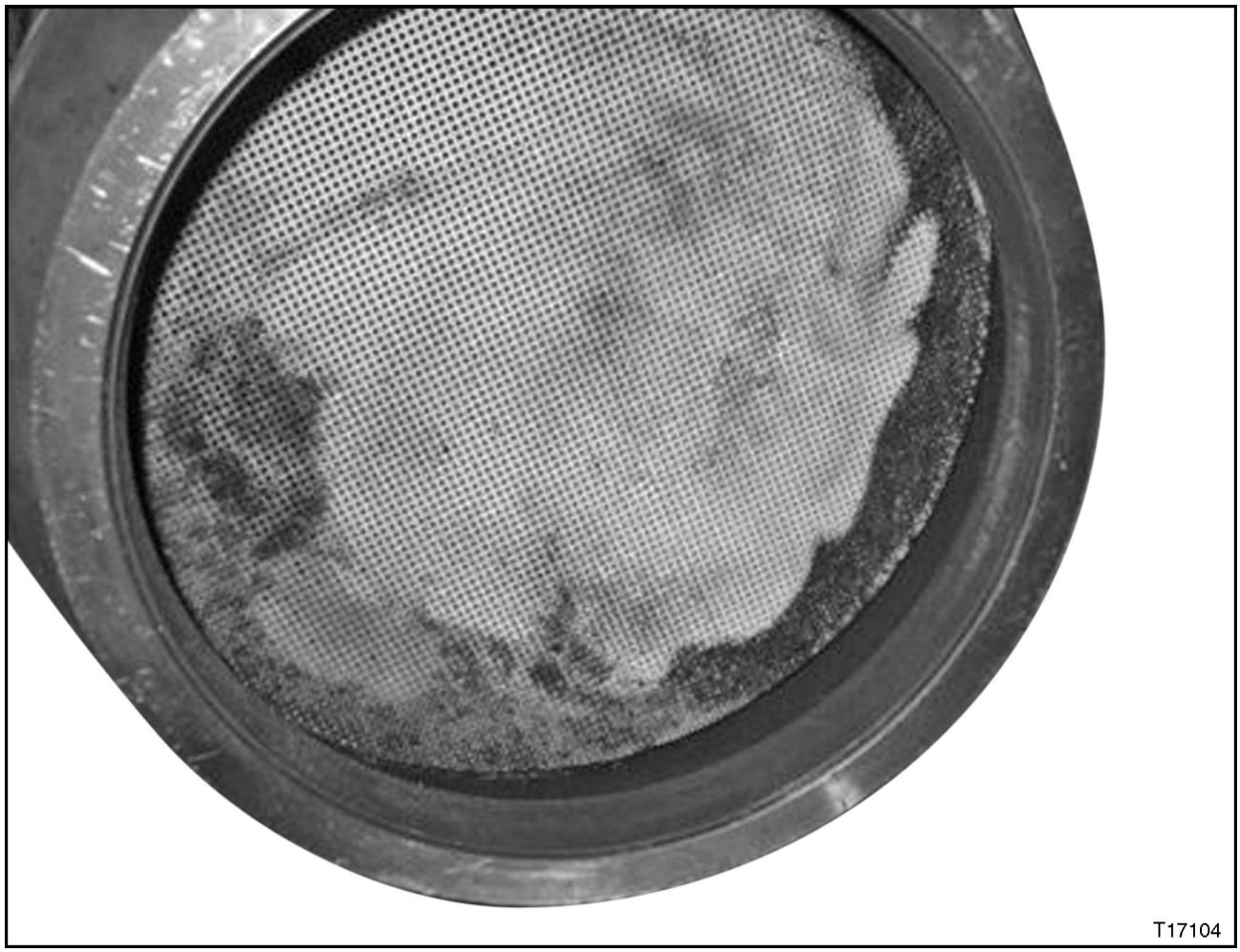


Figure 159 Coolant Contamination

Inspect the inlet and outlet of the DPF.

DPF will show signs of coolant flowing through exhaust system and contaminating the DPF.

Possible Causes	Action
• Coolant is flowing through exhaust • Failed Interstage cooler • Failed EGR cooler • Failed injector sleeve • Leaking cylinder head cup plugs • Cylinder head porosity	1. Repair coolant problem.

DPF Contaminated with Oil

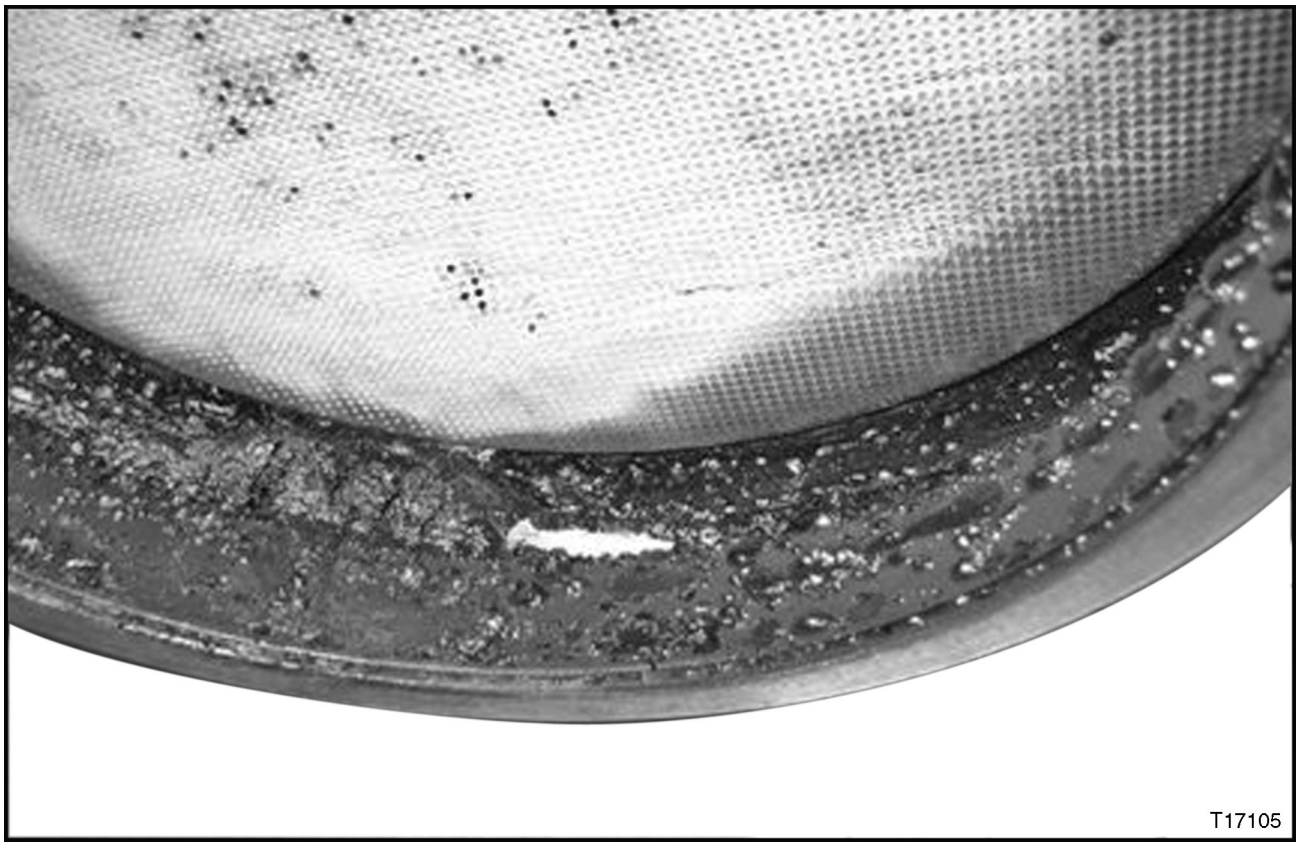


Figure 160 Engine Oil Contamination, Soot Leakage

Inspect the inlet and outlet of the DPF.

DPF will show signs of soot leakage and oil.

Possible Causes	Action
• Failed turbocharger • Failed piston rings • Failed cylinder sleeves • Failed valve guides	1. Repair engine oil to exhaust problem. 2. The DPF cannot be cleaned, it must be replaced. 3. Inspect the DOC for damage and replace if necessary.

DPF Outlet Leaking Soot

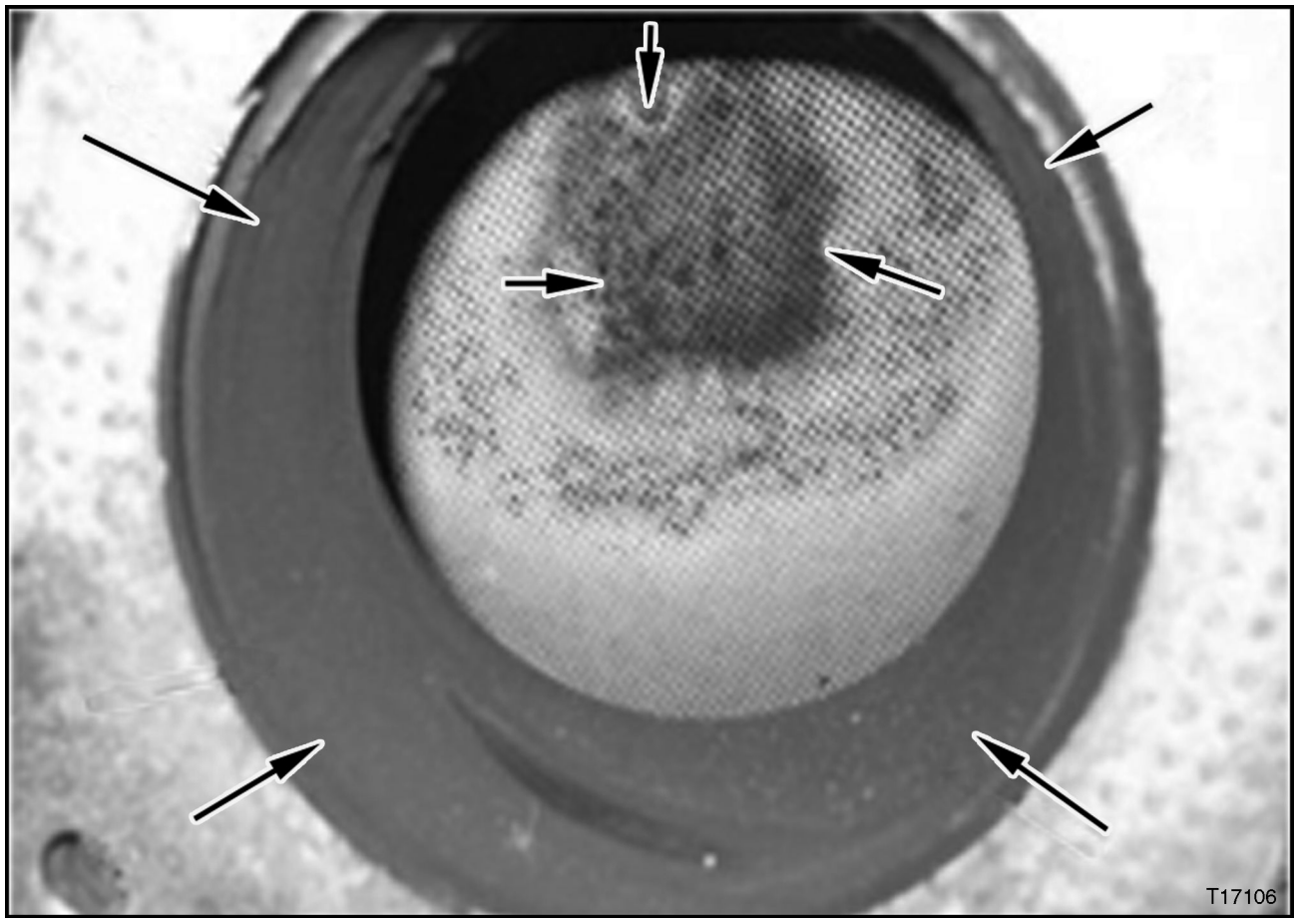


Figure 161 DPF Filter Damage, Soot Leakage

Inspect the outlet of the DPF.

DPF will show signs of soot leakage as indicated by the arrows in figure.

Possible Causes	Action
• DPF is damaged	1. The DPF cannot be cleaned, it must be replaced. 2. Inspect the DOC for damage and replace if necessary.

External Damage to DPF



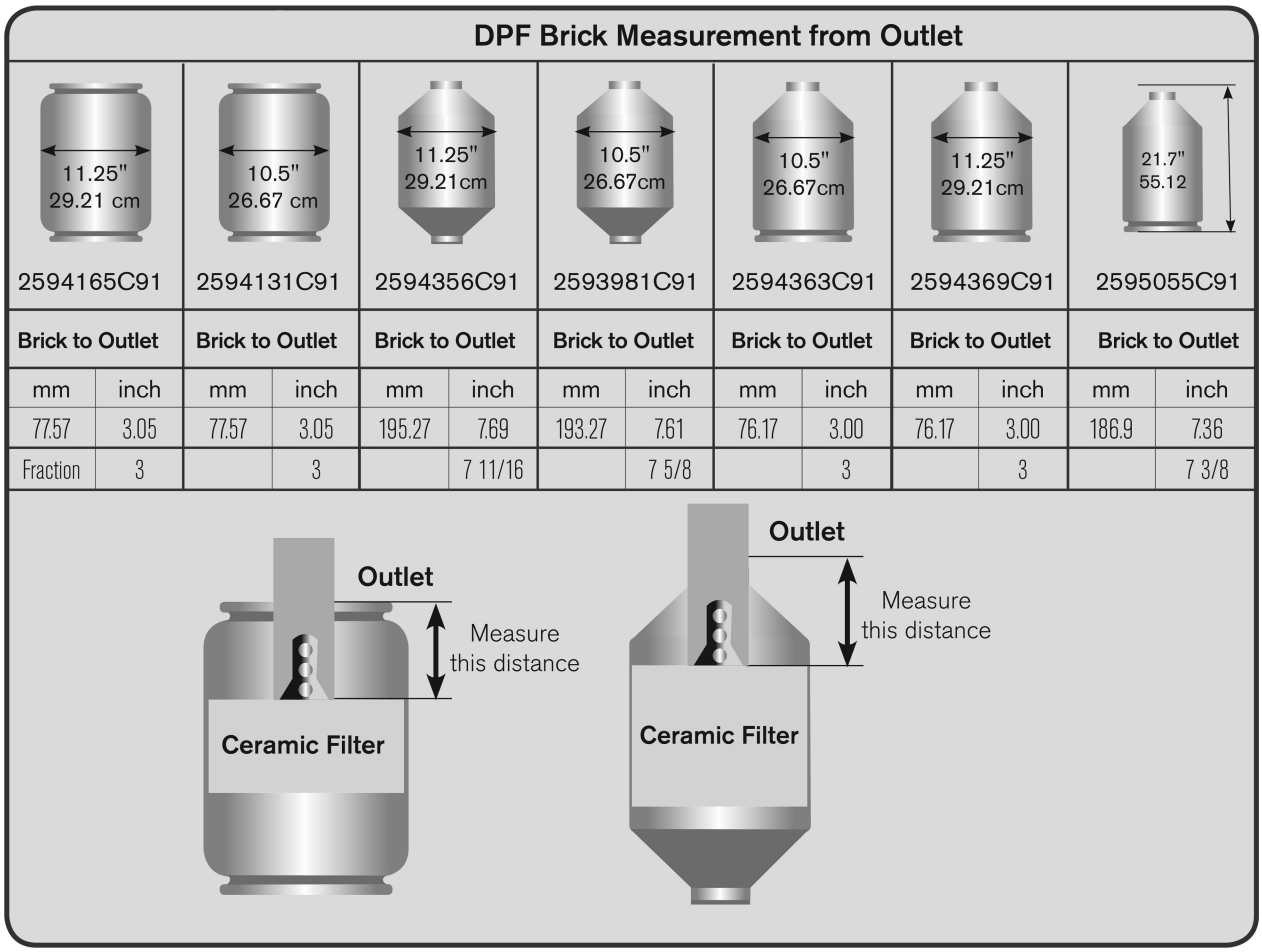
Figure 162 DPF Filter, Can Damage

Inspect the exterior of the DPF.

DPF will show signs of damage such as dents or cracks.

Possible Causes	Action
• Road debris • Vehicle accident	1. The DPF cannot be cleaned, it must be replaced.

DPF Ceramic Filter Brick Measurement



T01189

Figure 163 DPF Ceramic Filter Brick Measurement

Measure the distance between the ceramic filter brick and the outlet. If the distance is greater then the specification, the ceramic filter brick has moved out of its correct location. Replace the DPF Filter.

Possible Causes	Action
Face plugged	If the distance is greater then the specification, the DPF cannot be cleaned. It must be replaced.

AFTFD (Aftertreatment Fuel Doser)

SPN	FMI	Condition	Possible Causes
3479	3	AFT Fuel Doser Valve Short to PWR	• AFTFD circuit short to PWR • Failed AFTFD
3479	5	AFT Fuel Doser Valve open/load circuit	• AFT Fuel Doser valve circuit OPEN • Failed AFT Fuel Doser valve
3479	6	AFT Fuel Doser Valve High Side Short circuit	• AFTFD-H circuit short to GND • AFTFD-L circuit short to GND • Failed AFT Fuel Doser valve

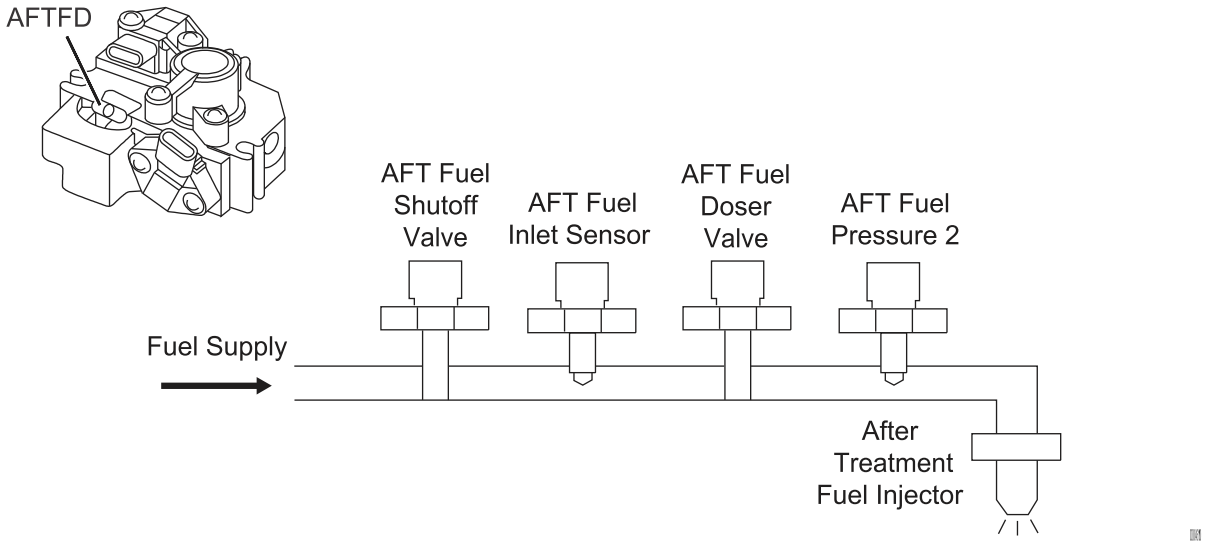


Figure 164 Functional diagram for AFTFD

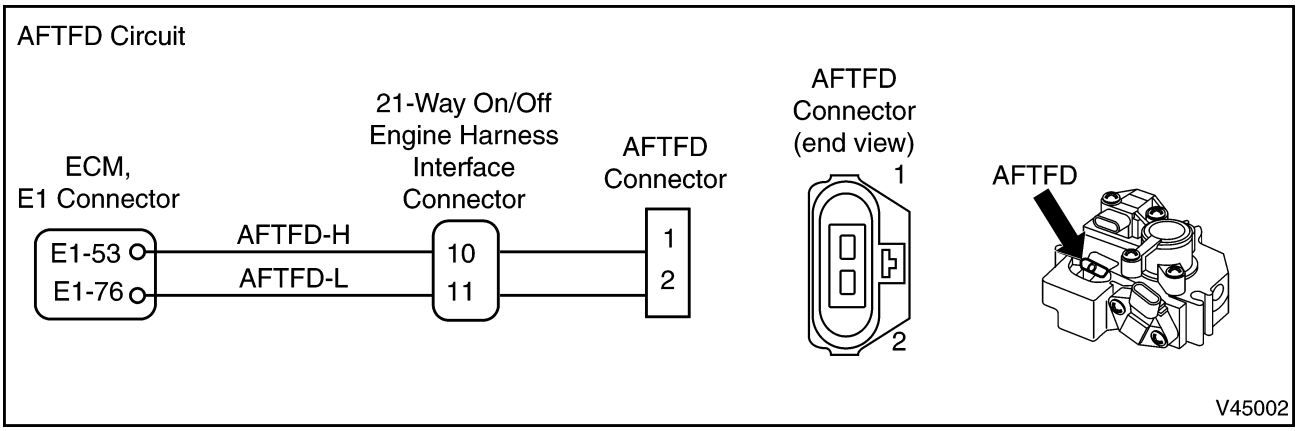


Figure 165 AFTFD circuit diagram

Tools Required

- 180-Pin Breakout Box 00-00956-08
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4828 (AFTFD)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Connector Voltage Check – AFTFD Disconnected

Connect Breakout Harness ZTSE4828 to engine harness. Leave AFTFD disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Spec	Comment – < Less than, > Greater than
1 to GND	12.0 V ± 2.0 V	If < 10.0 V, check for OPEN circuit. Do Harness Resistance Check
2 to GND	0 V - 1.0 V	If > 1.0 V, check for short to PWR. Do Harness Resistance Check.
If measurements are within specifications, go to Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE4828 between AFTFD and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the 2010 Actuator session.
3. Command AFT Fuel Doser On, then Off.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	On = 12.0 V ± 2.0 V	If < 10.0 V, check for OPEN circuit.
2 to GND	Off = 1.0 V ± 0.5 V	If > 1.5 V, check for OPEN circuit or failed AFTFD.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4828 to AFTFD and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to 2	16 Ω	If not within specification, replace AFTFD.
If measurements are within specifications, do Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE4828. Leave ECM and AFTFD disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
1 to E1-53	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
2 to E1-76	< 5 Ω	If > 5 Ω, check for OPEN circuit.

AFTFIS (Aftertreatment Fuel Inlet Sensor)

SPN	FMI	Condition	Possible Causes	Actions
3480	2	AFTFP1 pressure sensor plausibility error	• Failed AFTFIS • Down Stream Injection (DSI) unit or AFT Fuel Injector (AFI) fuel lines or connections loose, leaking, restricted, or damaged.	Step-Based Diagnostics (page 336)
3480	3	AFTFP1 signal Out of Range HIGH	• Failed AFTFIS • AFTFP1 circuit short to power • SIG GND circuit Open or high resistance	Step-Based Diagnostics (page 338)
3480	4	AFTFP1 signal Out of Range LOW	• Failed AFTFIS • AFTFP1 signal circuit short to GND • AFTFP1 signal circuit Open or high resistance • VREF-4 circuit Open or high resistance	Step-Based Diagnostics (page 341)
5456	3	AFTFT signal Out of Range HIGH	• AFTFT signal circuit OPEN or short to PWR • Failed AFTFIS	Pin-Point Diagnostics (page 344)
5456	4	AFTFT signal Out of Range LOW	• AFTFT signal circuit short to GND • Failed AFTFIS	Pin-Point Diagnostics (page 344)

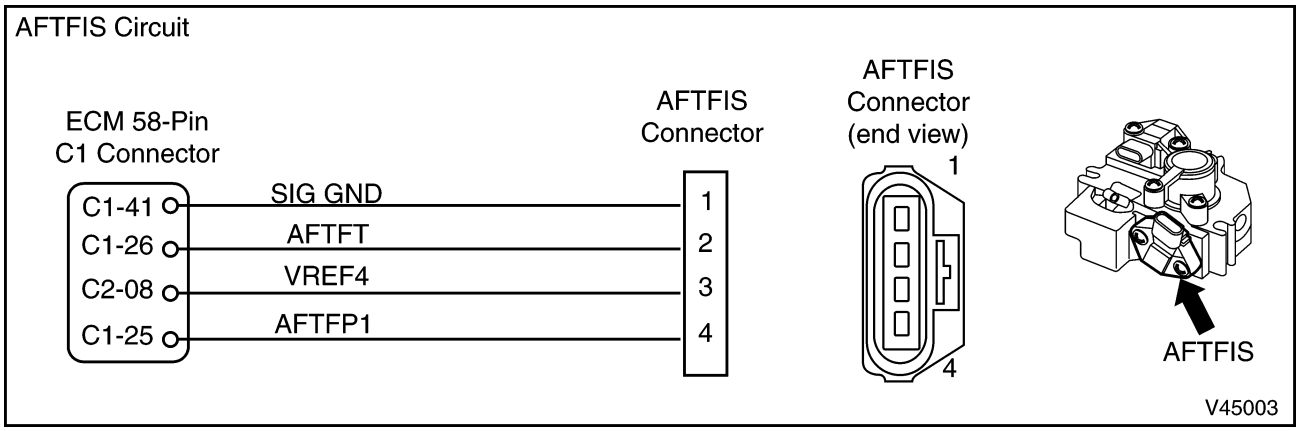


Figure 166 AFTFIS circuit diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Engine Control Module (ECM) monitors the Aftertreatment Fuel Pressure 1 (AFTFP1) signal voltage to calculate fuel pressure in the aftertreatment system feeding the Aftertreatment Fuel Injector (AFI). This is used during active and parked regeneration only.

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4830 (AFTFIS)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

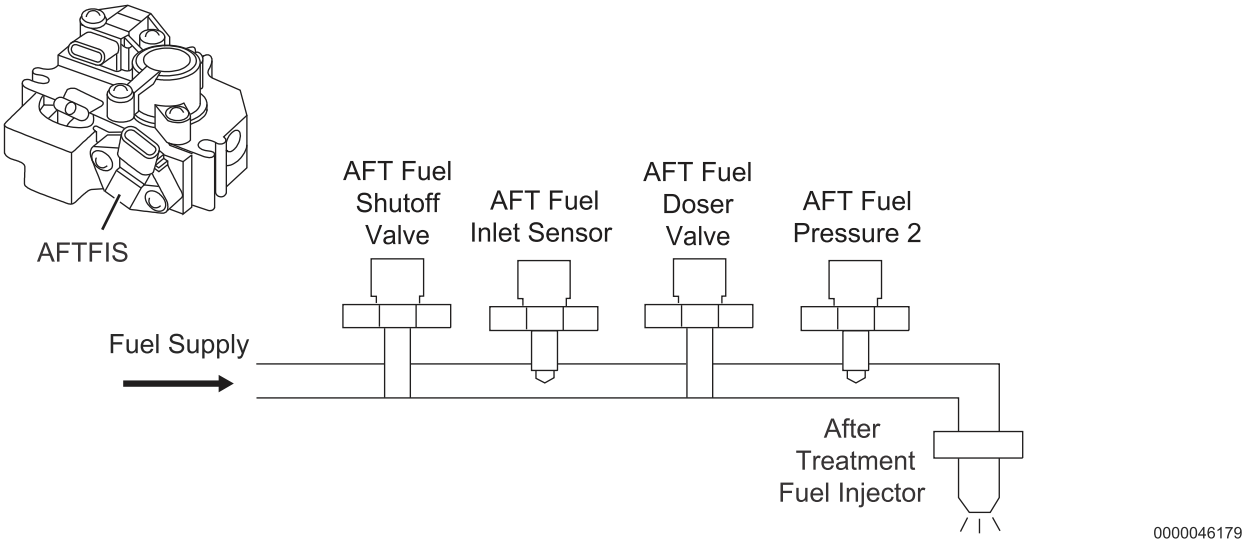


Figure 167 Functional diagram for AFTFIS

3480 FMI 2 - AFTFP1 signal erratic, intermittent or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Pressure 1 (AFTFP1) circuit voltage is in range, but not rational.	AFTFIS not reading as expected.	Inactive: SPN 3246 FMI 2, 3, 4 (DPFOT); SPN 3251 FMI 0 (DPFDP); SPN 3480 FMI 3, 4 (AFTFP1); SPN 3482 (AFTFSV); SPN 3556 (AFI); SPN 4765 FMI 2, 3, 4 (DOCIT); SPN 4766 (DOCOT)	3 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects Aftertreatment Fuel Inlet Sensor (AFTFIS) sensor stuck in-range fault. Diagnostics are only performed prior to starting an active regeneration of the DPF, or at Key ON if the active regeneration is continuing across key cycles. If the diagnostics fail, then the regeneration request is aborted. Active regeneration of the aftertreatment diesel particulate filter will be disabled until the next key cycle. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 108 (BARO); SPN 157 (FRP); SPN 3246 FMI 2, 3, 4 (DPFOT); SPN 3251 FMI 0 (DPFDP); SPN 3480 FMI 3, 4 (AFTFP1); SPN 3482 (AFTFSV); SPN 3512 FMI 14 (VREF-4); SPN 3556 (AFI); SPN 4765 FMI 2, 3, 4 (DOCIT); SPN 4766 (DOCOT)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

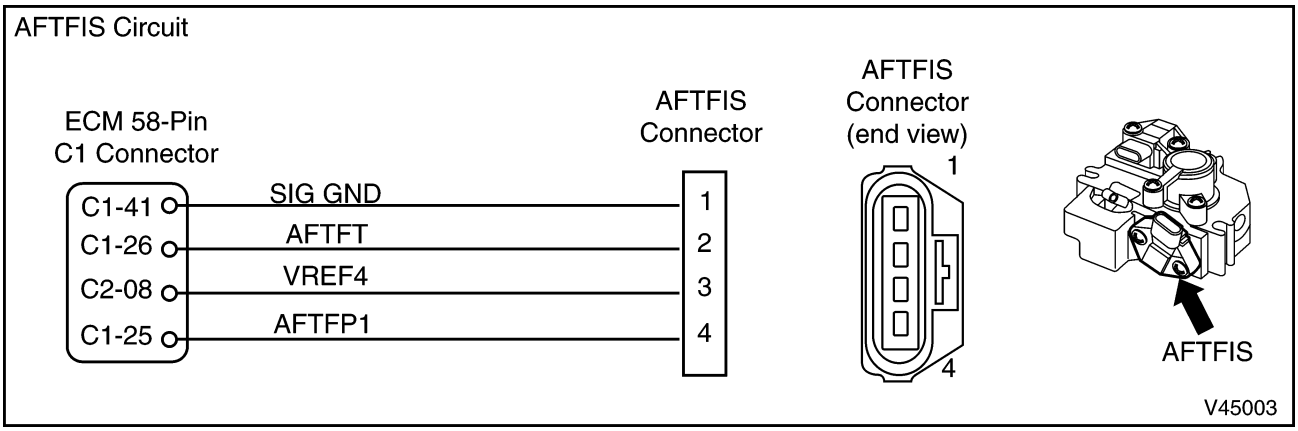


Figure 168 AFTFIS circuit diagram

Possible Causes

- Failed AFTFIS
- Down Stream Injection (DSI) unit or AFT Fuel Injector (AFI) fuel lines or connections loose, leaking, restricted, or damaged.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 108 (BARO); SPN 157 (FRP); SPN 3246 FMI 2, 3, 4 (DPFOT); SPN 3251 FMI 0 (DPFDP); SPN 3480 FMI 3, 4 (AFTFP1); SPN 3482 (AFTFSV); SPN 3512 FMI 14 (VREF-4); SPN 3556 (AFI); SPN 4765 FMI 2, 3, 4 (DOCIT); SPN 4766 (DOCOT). Is EST DTC list free of SPN 94; SPN 108; SPN 157; SPN 3246 FMI 2, 3, 4; SPN 3251 FMI 0; SPN 3480 FMI 3, 4; SPN 3482; SPN 3512 FMI 14; SPN 3556; SPN 4765 FMI 2, 3, 4; SPN 4766?	Yes: Go to step 2. No: Repair SPN 94; SPN 108; SPN 157; SPN 3246 FMI 2, 3, 4; SPN 3251 FMI 0; SPN 3480 FMI 3, 4; SPN 3482; SPN 3512 FMI 14; SPN 3556; SPN 4765 FMI 2, 3, 4; SPN 4766. After repairs are complete, retest for SPN 3480 FMI 2.

Step	Action	Decision
2	Check Down Stream Injection (DSI) unit and AFT Fuel Injector (AFI) fuel lines and connections for: loose connections, leaks, restrictions, or damage. Are the DSI unit and AFI fuel lines and connections leaking, restricted, or damaged?	Yes: Repair or replace leaking, restricted, or damaged fuel line or connection. After repairs are complete, retest for SPN 3480 FMI 2. No: Install new AFTFIS sensor. After repairs are complete, retest for SPN 3480 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 3480 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

3480 FMI 3 - AFTFP1 Signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Pressure 1 (AFTFP1) circuit voltage above normal or shorted to high source.	AFTFP1 circuit value > 4.8 V for more than 1 second	Key ON	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects Aftertreatment Fuel Pressure 1 (AFTFP1) signal voltage is more than 4.8 volts for more than 1 second. Engine torque may be reduced if the engine is operated for an extended period of time with this fault active. Active regeneration of the aftertreatment system may be disabled until the next key cycle.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3512 FMI 14 (VREF-4)

Fault Facts

The ECM monitors the (AFTFP1) signal voltage to calculate fuel pressure in the aftertreatment system.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

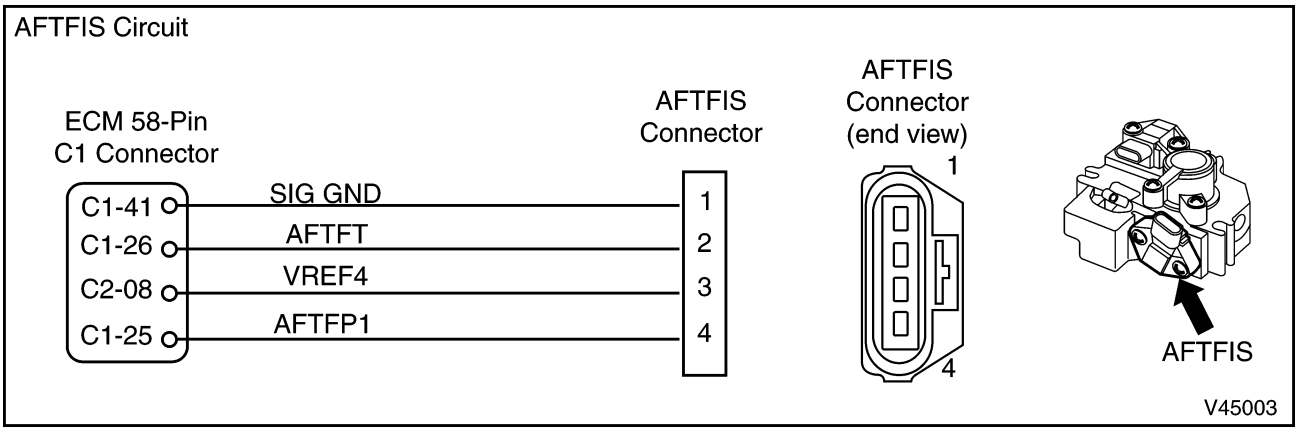


Figure 169 AFTFIS circuit diagram

Possible Causes

- Failed AFTFIS
- AFTFP1 circuit short to power
- SIG GND circuit Open or high resistance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3512 FMI 14 (VREF-4). Is EST DTC list free of SPN 3512 FMI 14?	Yes: Go to step 2. No: Repair SPN 3512 FMI 14. After repairs are complete, retest for SPN 3480 FMI 3.

Step	Action	Decision
2	Inspect connections at AFT Fuel Inlet Sensor (AFTFIS) sensor. Key OFF, disconnect AFTFIS connector. Check AFTFIS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AFTFIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3480 FMI 3.

Step	Action	Decision
3	Check AFTFP1 circuit for short to power. Key-On Engine-Off (KOEO), with Breakout Harness ZTSE4830 connected between AFTFIS and ECM, use a DMM to measure voltage between AFTFIS pin-4 and a known good ground. Is voltage with 0.5 volts of 5 volts?	Yes: Go to step 4. No: Repair short to power between AFTFIS connector pin-4 and ECM connector pin C1-25. After repairs are complete, retest for SPN 3480 FMI 3.

Step	Action	Decision
4	Check SIG GND circuit for Open or high resistance. Key OFF, Connect Breakout Harness ZTSE4830 to vehicle harness and leave AFTFIS disconnected. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness and leave ECM disconnected. Use a DMM to measure resistance from Breakout Harness ZTSE4830 pin-1 to 180-pin Breakout Box pin C1-41. Is resistance less than 5 ohms?	Yes: Replace AFTFIS. After repairs are complete, retest for SPN 3480 FMI 3. No: Repair Open or high resistance between AFTFIS pin-1 and ECM connector C1-41. After repairs are complete, retest for SPN 3480 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 3480 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

3480 FMI 4 - AFTFP1 Signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Pressure 1 (AFTFP1) circuit voltage below normal or shorted to low source.	AFTFP1 circuit < 0.25 volts	Key ON	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the signal from the Aftertreatment Fuel Pressure Fuel Pressure 1 (AFTFP1) circuit is less than 0.25 volts for 2 seconds. Active aftertreatment regeneration disabled until the next key cycle. Engine torque will be reduced if fault is active for an extended period of time.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3512 FMI 14 (VREF-4)

Fault Facts

The ECM monitors the (AFTFP1) signal voltage to calculate fuel pressure in the aftertreatment system.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

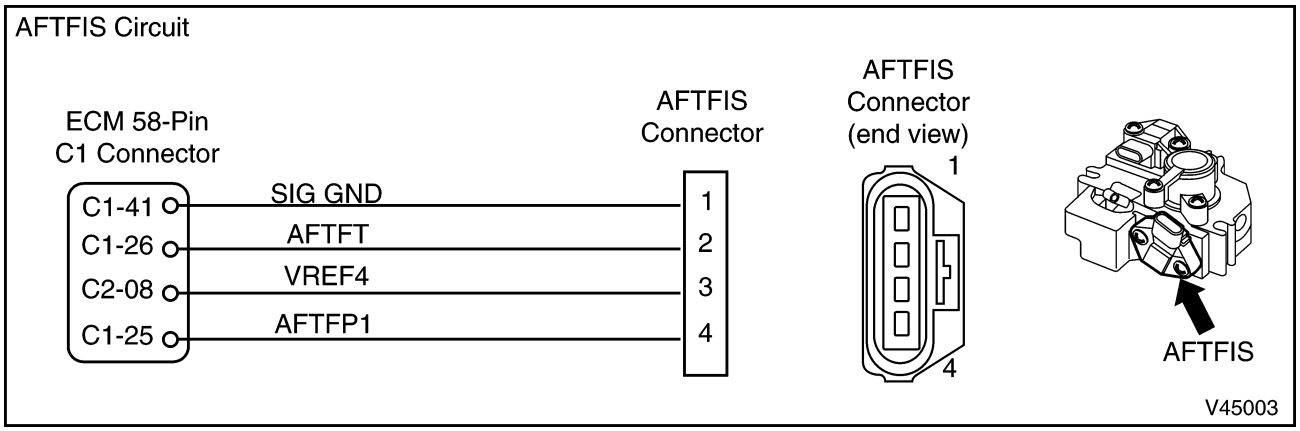


Figure 170 AFTFIS circuit diagram

Possible Causes

- Failed AFTFIS
- AFTFP1 signal circuit short to GND
- AFTFP1 signal circuit Open or high resistance
- VREF-4 circuit Open or high resistance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3512 FMI 14 (VREF-4). Is EST DTC list free of SPN 3512 FMI 14?	Yes: Go to step 2. No: Repair SPN 3512 FMI 14. After repairs are complete, retest for SPN 3480 FMI 4.

Step	Action	Decision
2	Inspect connections at AFT Fuel Inlet Sensor (AFTFIS). Key OFF, disconnect AFTFIS connector. Check AFTFIS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AFTFIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3480 FMI 4.

Step	Action	Decision
3	Check AFTFP1 circuit for short to ground. Connect Breakout Harness ZTSE4830 to vehicle harness and leave AFTFIS disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-4 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 4. No: Repair short to ground between AFTFIS pin-4 and ECM connector C1-25. After repairs are complete, retest for SPN 3480 FMI 4.

Step	Action	Decision
4	Check VREF-4 circuit for Open or high resistance. Connect Breakout Harness ZTSE4830 to vehicle harness and leave AFTFIS disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01467-00 to vehicle harness and leave ECM disconnected. Use a DMM to measure resistance between Breakout Harness pin-3 and 180-pin Breakout Box pin C2-08. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance between AFTFIS pin-3 and ECM connector C2-08. After repairs are complete, retest for SPN 3480 FMI 4.

Step	Action	Decision
5	Check AFTFP1 circuit for Open or high resistance. Connect Breakout Harness ZTSE4830 to vehicle harness and leave AFTFIS disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01467-00 to vehicle harness and leave ECM disconnected. Use a DMM to measure resistance between Breakout Harness pin-4 and 180-pin Breakout Box pin C1-25. Is resistance less than 5 ohms?	Yes: Replace AFTFIS. After repairs are complete, retest for SPN 3480 FMI 4. No: Repair Open or high resistance between AFTFIS pin-4 and ECM connector C1-25. After repairs are complete, retest for SPN 3480 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 3480 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pinpoint Diagnostics With ServiceMaxx™ software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Cold Soak Sensor Compare Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Sensor Circuit Check

Connect Breakout Harness ZTSE4830 and leave sensor disconnected. Turn ignition switch to ON.		
Test Point	**Specification**	**Comment – < Less than, > Greater than**
EST – Monitor AFTFP1v	4.5 V - 5.0 V	If < 4.5 V check AFTFP1 circuit for short to GND.
EST – Monitor AFTFTv	4.5 V - 5.0 V	If < 4.5 V check AFTFT circuit for short to GND.
DMM – Measure volts 3 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF4 for short to PWR. If < 4.5 V, check VREF4 for OPEN or short to GND, go to Harness Resistance Check.
DMM — Measure voltage 1 to B+	B+	If < B+, check SIG GND circuit for OPEN.
EST - Monitor AFTFTv short 1 to 2	0 V	If > 0.5 V, check AFTFT circuit for OPEN.
EST - Monitor AFTFP1v short 1 to 4	0 V	If > 0.5 V, check AFTFIS circuit for OPEN.
If checks are within specification, connect sensor, clear DTCs, and cycle the accelerator pedal a few times. If active code returns, replace sensor.		

Pinpoint Diagnostics Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4830. Leave sensor disconnected. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to B+	B+	If < B+, check for OPEN in SIG GND circuit.
2 to GND	5 V	If < 4.5 V, check for OPEN in AFTFT circuit.
3 to GND	5 V	If < 4.5 V, check for OPEN in VREF4 circuit.
4 to GND	5 V	If < 4.5 V, check for OPEN in AFTFP1 circuit.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and sensor Breakout Harness ZTSE4830. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check SIG GND circuit for short to GND.
1 to C1-41	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
2 to GND	> 1k Ω	If < 1k Ω, check AFTFT circuit for short to GND.
2 to C1-26	< 5 Ω	If > 5 Ω, check AFTFT circuit for OPEN.
3 to GND	> 1k Ω	If < 1k Ω, check VREF4 circuit for short to GND.
3 to C2-08	< 5 Ω	If > 5 Ω, check VREF4 circuit for OPEN.
4 to GND	> 1k Ω	If < 1k Ω, check AFTFP1 circuit for short to GND.
4 to C1-25	< 5 Ω	If > 5 Ω, check AFTFP1 circuit for OPEN.

AFTFP2 (Aftertreatment Fuel Pressure 2 Sensor)

SPN	FMI	Condition	Possible Causes
4077	3	AFTFP2 signal Out of Range HIGH	• AFTFP2 signal circuit OPEN or short to PWR • Failed AFTFP2 sensor
4077	4	AFTFP2 signal Out of Range LOW	• AFTFP2 signal circuit short to GND • Failed AFTFP2 sensor
4077	14	AFTFP2 Sensor plausibility error	• Biased AFTFP2 signal

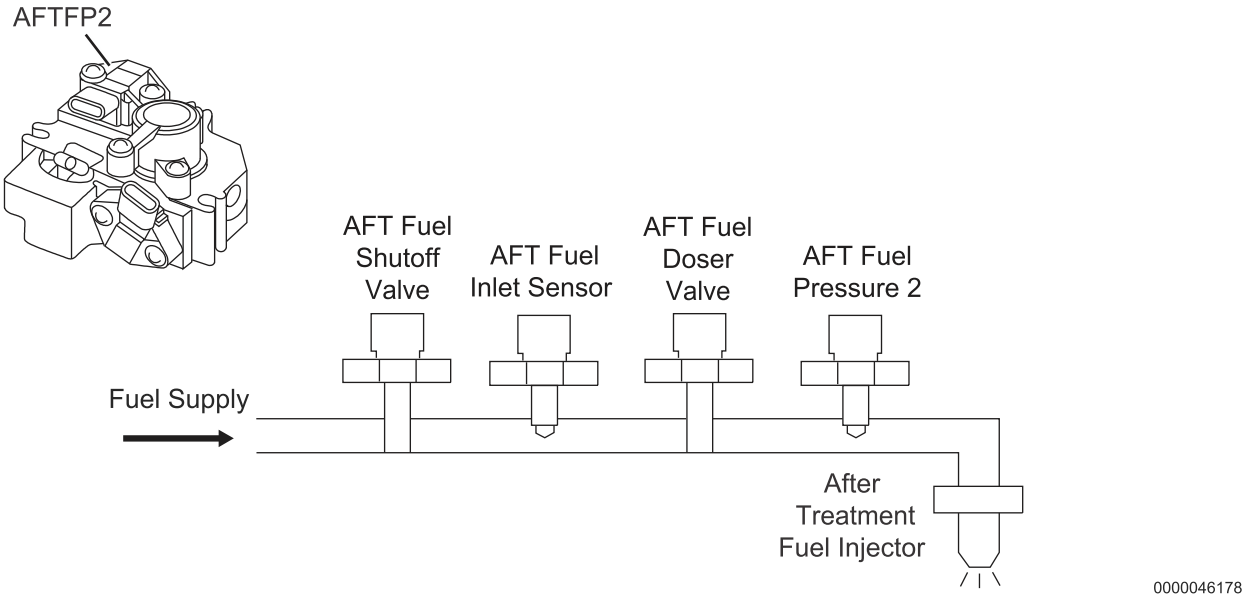


Figure 171 Functional diagram AFTFP2 sensor

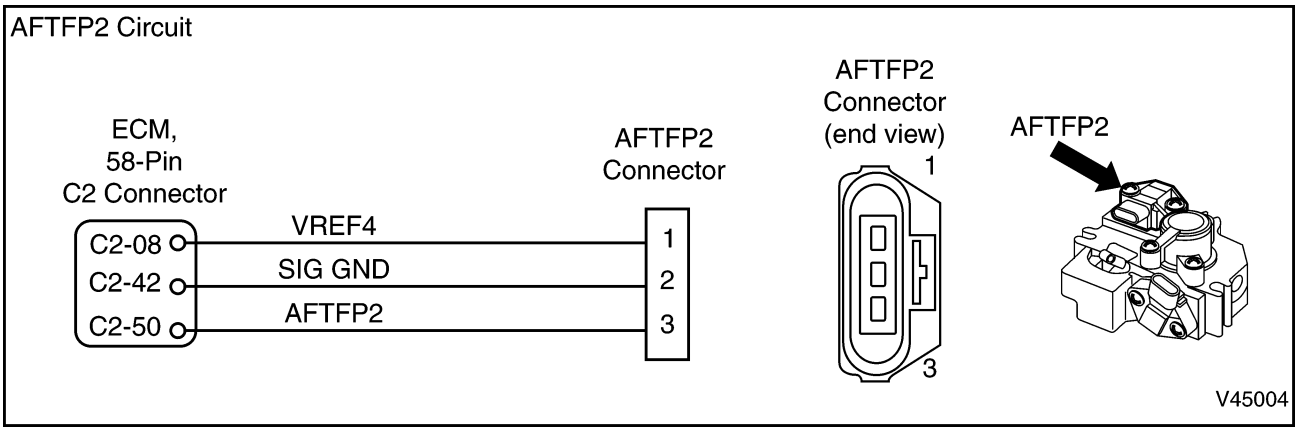


Figure 172 AFTFP2 sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6027 (AFTFP2)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Sensor Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Sensor Circuit Check

Disconnect engine harness from sensor.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor AFTFP2v	0 V	If > 0 V, check AFTFP2 signal circuit for short to PWR.
DMM — Measure volts	5.0 V ± 0.5 V	If > 5.5 V, check VREF4 for short to PWR.
1 to GND		If < 4.5 V, check VREF 4 for OPEN or short to GND. Do Harness Resistance Check.
DMM — Measure voltage	5 V ± 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check.
1 to 2		
EST – Monitor AFTFP2v	0 V	If > 0.5 V, check AFTFP2 signal circuit for OPEN. Do Harness Resistance Check.
Short across Breakout Harness ZTSE6027 pins 2 and 3		
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace AFTFP2 sensor.		

Pinpoint Diagnostics Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE6027. Leave sensor disconnected. Turn ignition switch to ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5 V	If > 5.5 V, check VREF4 for short to PWR.
		If < 4.5 V, check VREF4 for OPEN or short to GND. Do Harness Resistance Check.
2 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
3 to GND	0 V	If > 0.25 V, check AFTFP2 circuit for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and sensor Breakout Harness ZTSE6027. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
1 to C2-08	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
2 to C2-42	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
3 to C2-50	< 5 Ω	If > 5 Ω, check for OPEN circuit.

AFTFSV (Aftertreatment Fuel Shutoff Valve)

SPN	FMI	Condition	Possible Causes	
3482	3	AFT Fuel Shutoff Valve short to PWR (Open or high resistance)	• AFTFSV-H circuit short to PWR • AFTFSV-H circuit Open or high resistance • AFTFSV-L circuit Open or high resistance • Failed Aftertreatment Fuel Shutoff Valve (AFTFSV)	Step-Based Diagnostics (page 351)
3482	4	AFT Fuel Shutoff Valve short to GND	• AFTFSV-H short to GND • AFTFSV-H shorted to AFTFSV-L • Failed Aftertreatment Fuel Shutoff Valve (AFTFSV)	Step-Based Diagnostics (page 354)

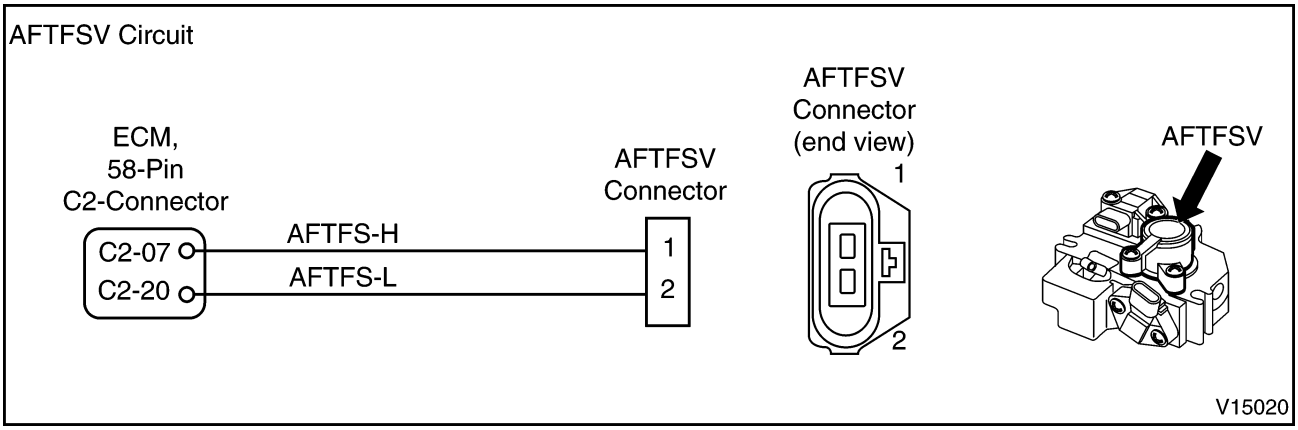


Figure 173 AFTFSV circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4602 (AFTFSV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

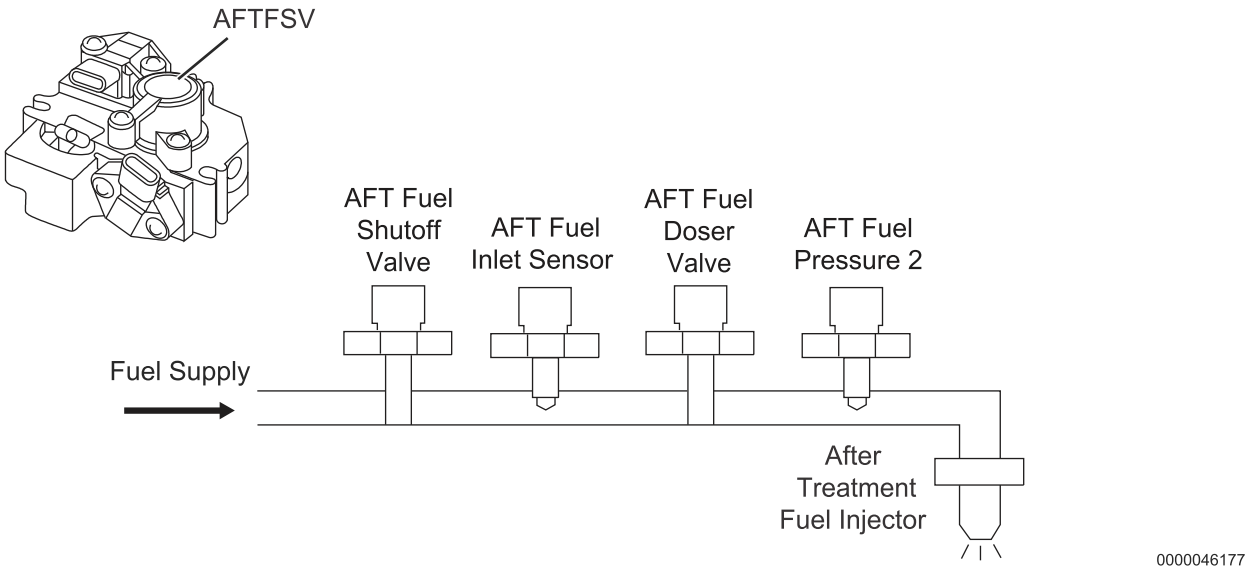


Figure 174 Functional diagram AFTFSV

3482 FMI 3 - AFT Fuel Shutoff Valve short to PWR (Open or High Resistance)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Shutoff Valve (AFTFSV) circuit voltage above normal, shorted to high source, or open or high resistance. High signal voltage detected at the AFTFSV.	The resistance between AFTFSV-H circuit and AFTFSV-L circuit > 500,000 ohms	Key ON	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the voltage signal from the Aftertreatment Fuel Shutoff Valve (AFTFSV) is high. Active regeneration of the aftertreatment system is disabled. Engine torque will be reduced if fault is active for an extended period of time.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 1 in 2013 HD-OBD Diagnostic Reference Manual.

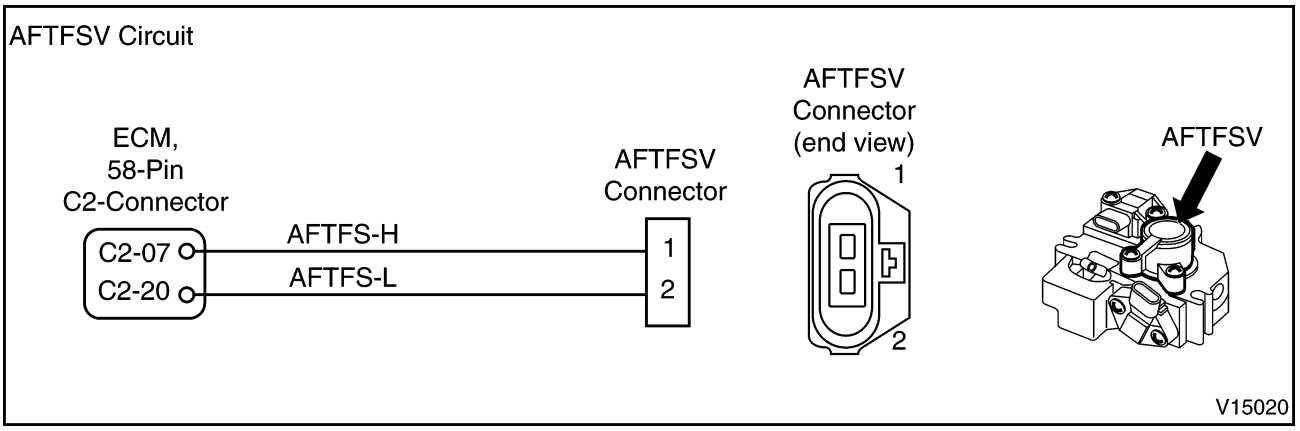


Figure 175 AFTFSV circuit diagram

Possible Causes

- AFTFSV-H circuit short to PWR
- AFTFSV-H circuit Open or high resistance
- AFTFSV-L circuit Open or high resistance
- Failed Aftertreatment Fuel Shutoff Valve (AFTFSV)

Step	Action	Decision
1	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3482 FMI 3.

Step	Action	Decision
2	Check Aftertreatment Fuel Shutoff Valve (AFTFSV) circuit for Open or high resistance. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness and leave ECM disconnected. Key OFF, use a DMM to measure resistance between Breakout Box pin C2-07 and C2-20. Is resistance less than 20 ohms?	Yes: Go to step 6. No: Go to step 3.

Step	Action	Decision
3	Inspect connections at AFTFSV. Key OFF, disconnect AFTFSV. Check AFTFSV and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AFTFSV connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3482 FMI 3.

Step	Action	Decision
4	Check AFTFSV-H circuit for Open or high resistance. Connect Breakout Harness ZTSE4602 to vehicle harness and leave AFTFSV disconnected. With 180-pin Breakout Box with Breakout Harness 00-01467-00 connected to vehicle harness and ECM disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and Breakout Box pin C2-07. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance between ECM pin C2-07 and AFTFSV pin-1. After repairs are complete, retest for SPN 3482 FMI 3.

Step	Action	Decision
5	Check AFTFSV-L circuit for Open or high resistance. Connect Breakout Harness ZTSE4602 to vehicle harness and leave AFTFSV disconnected. With 180-pin Breakout Box with Breakout Harness 00-01467-00 connected to vehicle harness and ECM disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-2 and Breakout Box pin C2-20. Is resistance less than 5 ohms?	Yes: Go to step 6. No: Repair Open or high resistance between ECM pin C2-20 and AFTFSV pin-2. After repairs are complete, retest for SPN 3482 FMI 3.

Step	Action	Decision
6	Check Aftertreatment Fuel Shutoff Valve (AFTFSV-H) circuit for short to PWR. Connect Breakout Harness ZTSE4602 to vehicle harness and leave AFTFSV disconnected. With 180-pin Breakout Box with Breakout Harness 00-01467-00 connected to vehicle harness and ECM disconnected. Key-On Engine-Off (KOEO), use a DMM to measure resistance between Breakout Harness pin-1 and Breakout Box pin C2-07. Is voltage less than 0.5 Volts?	Yes: Replace AFTFSV. After repairs are complete, retest for SPN 3482 FMI 3 No: Repair short to PWR between ECM pin C2-07 and AFTFSV pin-1. After repairs are complete, retest for SPN 3482 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 3482 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

3482 FMI 4- AFT Fuel Shutoff Valve short to GND

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Aftertreatment Fuel Shutoff Valve (AFTFSV) driver control line is shorted to ground.	The resistance between the AFTFSV driver line and ground < 0.2 Ohms	Key ON The AFTFSV is commanded ON	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects a short to ground in the Aftertreatment Fuel Shutoff Valve (AFTFSV) circuit. Active regeneration of the Diesel Particulate Filter (DPF) is disabled until the next key cycle, and engine torque will be reduced if fault is active for an extended period of time.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

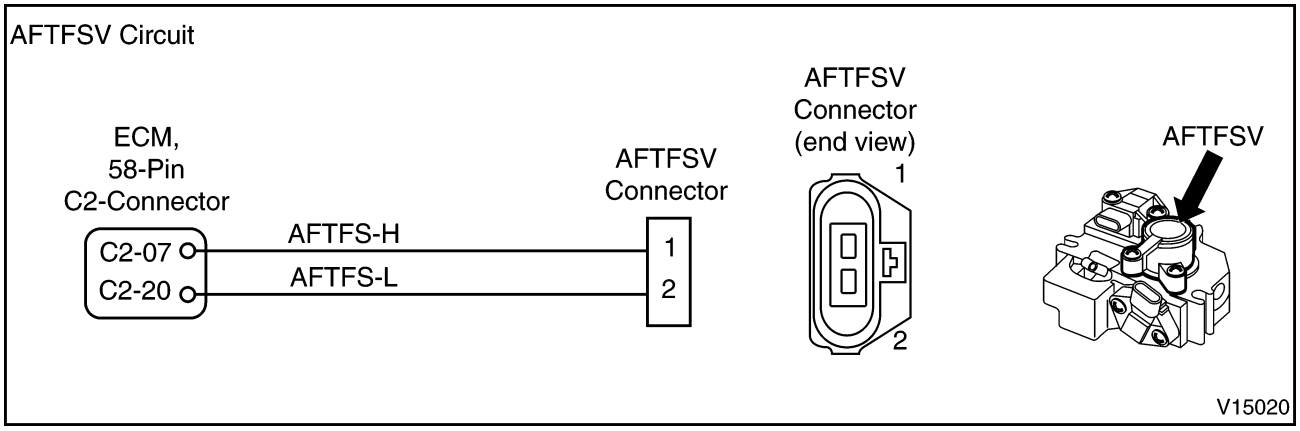


Figure 176 AFTFSV circuit diagram

Possible Causes

- AFTFSV-H short to GND
- AFTFSV-H shorted to AFTFSV-L
- Failed Aftertreatment Fuel Shutoff Valve (AFTFSV)

Step	Action	Decision
1	Inspect connections at AFTFSV. Key OFF, disconnect AFTFSV. Check AFTFSV and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the AFTFSV connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3482 FMI 4.

Step	Action	Decision
2	Check AFTFSV-H circuit for short to GND. Connect Breakout Harness ZTSE4602 to vehicle harness and leave AFTFSV disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and a known good ground. Is resistance less than 1000 ohms?	Yes: Go to step 3. No: Repair short to PWR between ECM pin C2-07 and AFTFSV pin-1. After repairs are complete, retest for SPN 3482 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3482 FMI 4.

Step	Action	Decision
4	Check for AFTFSV-H circuit shorted to AFTFSV-L circuit. Connect Breakout Harness ZTSE4602 to vehicle harness and leave AFTFSV disconnected. With ECM disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and Breakout Harness pin-2. Is resistance greater than 1000 ohms?	Yes: Replace AFTFSV. After repairs are complete, retest for SPN 3482 FMI 4. No: Repair short between AFTFSV-H circuit and AFTFSV-L circuit. After repairs are complete, retest for SPN 3482 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 3482 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

AMS (Air Management System)

SPN	FMI	Condition	Possible Causes	Actions
102	16	Intake Manifold Pressure Overboost	• Turbocharger 2 (TC2) wastegate stuck closed	Pin-Point Diagnostics (page 358)
102	18	Intake Manifold Pressure Underboost	• TC2 wastegate stuck open • Restricted intake air system • Charge Air Cooler (CAC) hose leaking • CAC leak • Failed turbocharger	Pin-Point Diagnostics (page 358)
1173	16	TC2CIT signal above desired (Interstage CAC under cooling)	• Failed Coolant Flow Valve (CFV) or circuit • Failed Coolant Mixer Valve (CMV) or circuit • Restricted interstage CAC • Inoperative engine fan • Restricted low-temperature radiator • Engine fan or shroud problem	Pin-Point Diagnostics (page 358)

2659	20	EGR High Flow Rate detected	• Biased O_2S or circuit • Biased Turbocharger 1 Turbo Outlet Pressure (TC1TOP) sensor or circuit • Exhaust Gas Recirculation (EGR) Valve stuck open • Low boost pressure	Step Based Diagnostics (page 360)
2659	21	EGR Low Flow Rate detected	• Biased O_2S or circuit • Biased TC1TOP sensor or circuit • EGR Valve stuck closed • Restricted EGR cooler • Restricted Diesel Oxidation Catalyst (DOC) or Diesel Particulate Filter (DPF)	Pin-Point Diagnostics (page 359)

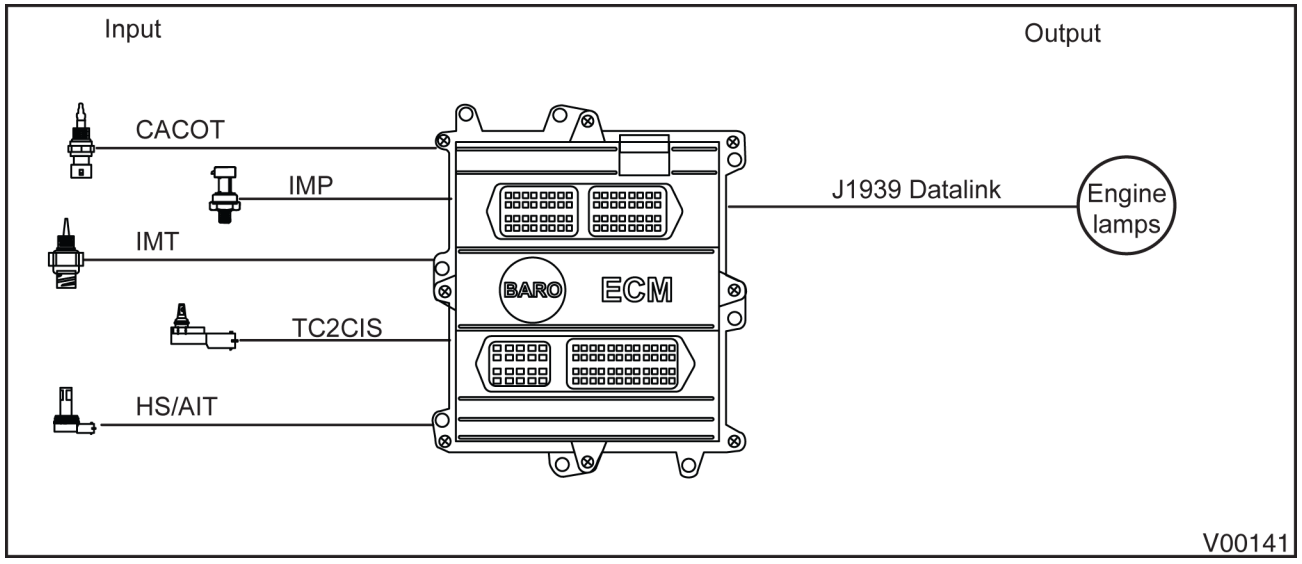


Figure 177 Functional diagram for the AMS

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN 102 FMI 16 – Intake Manifold Pressure Overboost

Pin-point AMS System Fault

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure.
2. Check for biased IMP sensor. Verify BAP and IMP are within KOEO specification. See applicable engine horsepower in “APPENDIX A: PERFORMANCE SPECIFICATIONS."
3. Run Air Management test while monitoring IMP sensor signal.
   - If IMP does not change state when TC1WC and TC2WC are cycled, proceed to TC1WC (page 835) and TC2WC (page 838).

SPN 102 FMI 18 – Intake Manifold Pressure Underboost

Pin-point AMS System Fault

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure.
2. Check for biased IMP sensor. Verify BAP and IMP are within KOEO specification. See applicable engine horsepower in “APPENDIX A: PERFORMANCE SPECIFICATIONS."
3. Run Air Management test while monitoring IMP sensor signal.
   - If IMP does not change state when TC1WC, and TC2WC are cycled, proceed to TC1WC (page 835) and TC2WC (page 838).
4. Inspect for leaks in the intake air system.
5. Inspect turbochargers in the *Engine Service Manual*.

SPN 1173 FMI 16 – TC2CIT signal above desired (Interstage CAC under cooling)

Pin-point AMS System Fault

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure.
2. Check for biased TC2CIT sensor. Repair as necessary.
3. Using ServiceMaxx™ software, run Engine Fan Procedure to verify correct operation.
4. Need CFV and CMV procedure diagnostics.

SPN 2659 FMI 21 – EGR Low Flow Rate detected

Pin-point AMS System Fault

1. Check for other active or inactive DTCs. Repair any electrical fault before continuing with this procedure. If SPN 5298 is active, correct and then retest for SPN 2659 FMI 21.
2. Check for biased TC1TOP or DPFDP sensor.
3. Run Air Management test while monitoring IMP, during EGR portion of test.
   - If IMP does not change state during EGR portion of Air Management test, proceed to EGR Valve (page 621) diagnostics.
4. See EGR Cooler Leak Inspection in “ENGINE SYMPTOM DIAGNOSTICS."

SPN 2659 FMI 20 - EGR High Flow Rate Detected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
High flow by O_2control error, valve closing.	O_2% in exhaust > 1.4%	Actual EGR Valve Position < 35% Desired EGR Valve Position < 27% Actual EGR Valve Position deviation limit (from set point) < 100% Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts Limp Home Mode = Inactive DPF Regeneration = Inactive Power Takeoff (PTO) Mode = Inactive Engine Coolant Temperature 1 (ECT1) > -44°F (–7°C) and < 239°F (115°C) Ambient Air Temperature (AAT) > -44°F (–7°C) <131°F (55°C) Barometric pressure (BARO) > 11 psi (75 kPa) O_2 sensor at operating temp. > 1400°F (760°C) and < 1472°F (800°C) Engine operating in monitoring region Function of engine speed and load: 700-1700 rpm and 50-60% load	2.4 seconds

Fault Overview

The Exhaust Gas Recirculation (EGR) valve is a variable position actuator used to control exhaust flow through the EGR cooler. The EGR valve contains an internal position sensor that monitors valve position. Valve position changes in response to Engine Control Module (ECM) signals.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN's 27, 91, 724, 2623, 2791, 3223, 5298, and 5541. If SPN 5298 is active, correct and then retest for SPN 2659 FMI 20.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2659 FMI 20 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 2659 FMI 20.

Step	Action	Decision
2	Check for biased Oxygen Sensor (O_2S). Do O_2S Biased Sensor or Circuit Check (page 819). Does O_2 sensor pass biased sensor or circuit check?	Yes: Go to step 3. No: Repair O_2 sensor or circuits. After repairs are complete, retest for SPN 2659 FMI 20.

Step	Action	Decision
3	Check for biased Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor or circuit. Using EST with ServiceMaxx™ software, run the Continuous Monitor test. Use the KOEO values found in “Appendix A: Performance Specifications”. Is TC1TOP within specifications?	Yes: Go to step 4. No: Do TC1TOP sensor circuit and voltage checks (page 833). After repairs are complete, retest for SPN 2659 FMI 20.

Step	Action	Decision
4	Determine if Intake Manifold Pressure (IMP) sensor or circuit is out of specifications. Using EST with ServiceMaxx™ software, do IMP Biased Sensor Circuit Check (page 717). Is IMP sensor within specifications?	Yes: Go to step 5. No: Repair IMP sensor or circuit. After repairs are complete, retest for SPN 2659 FMI 20.

Step	Action	Decision
5	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC) and Exhaust Gas Recirculation (EGR) valve are commanded On. Key-On Engine-Running (KOER). Run Air Management Test while monitoring IMP sensor signal. While monitoring IMP signal: • Does IMP pressure decrease when TC2WC is commanded On? • Does IMP pressure decrease when EGR valve is commanded On? • Does IMP pressure decrease when Exhaust Back Pressure Valve (EBPV) is commanded On?	No IMP pressure decrease when TC2WC is commanded On: Do Air Control Valve (ACV) TC2WC test (page 164). After repairs are complete, retest for SPN 2659 FMI 20.
		No IMP pressure decrease when EGR is commanded On: Do EGR Pinpoint Diagnostic (page 622) with ServiceMaxx. After repairs are complete, retest for SPN 2659 FMI 20.
		No IMP pressure increase when EBPV is commanded On: Do Air Control Valve (ACV) EBPV test (page 163). After repairs are complete, retest for SPN 2659 FMI 20.
		IMP signal does not change when any of the valves are commanded On: Go to step 6.

Step	Action	Decision
6	Verify IMP sensor and bore are not restricted due to carbon buildup. Remove and inspect IMP sensor and bore for carbon buildup. Is IMP sensor and bore free of carbon buildup?	Yes: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Clean IMP sensor bore of carbon deposits. After repairs are complete, retest for SPN 2659 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 2659 FMI 20 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

APP Sensor (Accelerator Pedal Position)

SPN	FMI	Condition	Possible Causes
91	2	APP1 and APP2 signal conflict	• APP1 and APP2 mismatched • Biased APP sensor or circuit
91	3	APP1 signal Out of Range HIGH	• APP1 signal circuit short to PWR • SIG GND circuit OPEN • Failed APP sensor
91	4	APP1 signal Out of Range LOW	• APP1 signal circuit OPEN or short to GND • VREF5 circuit OPEN • Failed APP sensor
2623	3	APP2 signal Out of Range HIGH	• APP2 signal circuit short to PWR • SIG GND circuit OPEN • Failed APP sensor
2623	4	APP2 signal Out of Range LOW	• APP2 signal circuit OPEN or short to GND • VREF1 circuit OPEN • Failed APP sensor

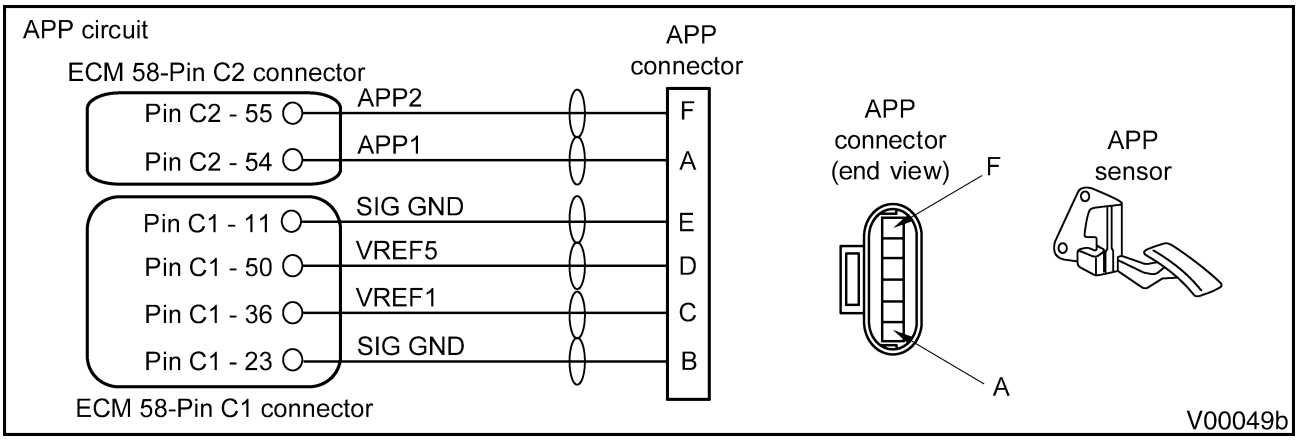


Figure 178 APP circuit diagram

Overview

The Accelerator Pedal Position (APP) sensor is a variable-resistance sensor that increases or decreases resistance as the accelerator pedal position changes. No mechanical attachment is present from the accelerator pedal to the engine. The ECM compares signals from two potentiometers to determine accelerator pedal position, APP1 and APP2. APP1 is supplied 5 volts while APP2 is supplied 2.5 volts. As the pedal is pressed, resistance decreases and change in voltage is interpreted by the ECM.

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4485A (APP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

The ECM determines accelerator pedal position by processing input signals from APP1 and APP2.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Sensor Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Sensor Circuit Check

Connect Breakout Harness ZTSE4485A to APP vehicle harness, and leave APP sensor disconnected. Turn ignition ON

Test Point	Specification	Comment – < Less than, > Greater than
EST - Monitor APP1v	0 V	If > 0.5 V, check APP1 circuit for short to PWR.
EST - Monitor APP2v	0 V	If > 0.5 V, check APP2 circuit for short to PWR.
DMM – Measure volts C to GND	5 V ± 0.5 V	If > 5.5 V, check VREF5 for short to PWR. If < 4.5 V, check VREF5 for OPEN or short to GND, go to Harness Resistance Check.
DMM – Measure volts D to GND	5 V ± 0.5 V	If > 5.5 V, check VREF1 for short to PWR. If < 4.5 V, check VREF1 for OPEN or short to GND, go to Harness Resistance Check.
EST - Monitor APP1v Short Pin A to C	5 V	If < 4.5 V, check APP1 circuit for OPEN, go to Harness Resistance check.
EST - Monitor APP2v Short Pin D to F	5 V	If is < 4.5 V, check APP2 circuit for OPEN, go to Harness Resistance Check.
DMM – Measure Volts B to Battery positive	B+	If < B+, check SIG GND for OPEN, go to Harness Resistance Check.
DMM – Measure Volts E to Battery positive	B+	If < B+, check SIG GND for OPEN, go to Harness Resistance Check.
If checks are within specification, connect sensor, clear DTCs, and cycle the accelerator pedal a few times. If active DTC returns, replace sensor.		

Pinpoint Diagnostics Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4485A to APP vehicle harness, and leave APP sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
A to B+	B+	If < B+, check APP1 for short to PWR.
B to Battery positive	B+	If < B+, check SIG GND for OPEN circuit.
C to GND	5 V	If > 5.5 V, check VREF5 for short to PWR. If < 4.5 V, check VREF5 for OPEN or short to GND.
D to GND	5 V	If > 5.5 V, check VREF5 for short to PWR. If < 4.5 V, check VREF5 for OPEN or short to GND.
E to Battery positive	B+	If < B+, check SIG GND for OPEN circuit.
F to B+	B+	If < B+, check APP2 for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4485A to APP vehicle harness, and leave APP sensor disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
A to GND	> 1k Ω	If < 1k Ω, check for short circuit.
A to C2-54	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
B to C1-23	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C to GND	> 1k Ω	If < 1k Ω, check for short circuit.
C to C1-36	< 5 Ω	If > 5 Ω, check for OPEN circuit.
D to GND	> 1k Ω	If < 1k Ω, check for short circuit.
D to C1-50	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E to C1-11	< 5 Ω	If > 5 Ω, check for OPEN circuit.
F to GND	> 1k Ω	If < 1k Ω, check for short circuit.
F to C2-55	< 5 Ω	If > 5 Ω, check for OPEN circuit.

Operational Voltage Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4485A to APP vehicle harness, and leave APP sensor disconnected. Use DMM to measure voltage or EST to read signal.

Test Point	Condition	DMM	EST Value
APP1	Foot off pedal	1.14 V ± 0.25V	0%
A to GND or C2-54 to GND	Pedal to floor	4.32 V ± 0.25V	99.6%
APP2	Foot off pedal	0.56 V ± 0.25 V	0%
F to GND or C2-55 to GND	Pedal to floor	2.16 V ± 0.25 V	99.6%

CACOT Sensor (Charge Air Cooler Outlet Temperature)

SPN	FMI	Condition	Possible Causes	Actions
2630	2	CACOT signal does not agree with other sensors	• Biased CACOT sensor or circuit	Pin-Point Diagnostics (page 371)
2630	3	CACOT signal Out of Range HIGH	• CACOT signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed CACOT sensor	Pin-Point Diagnostics (page 370)
2630	4	CACOT signal Out of Range LOW	• CACOT signal circuit short to GND • Failed CACOT sensor	Pin-Point Diagnostics (page 370)
2630	7	CACOT signal not responding as expected	• Biased CACOT sensor or circuit	Pin-Point Diagnostics (page 370)
2630	16	CACOT Undercooling	• Restricted CAC • Engine fan and/or engine fan shroud failure • Inoperative engine fan • Winter front installed outside recommended temperatures • Failed Coolant Control Valve (CCV)	Step-Based Diagnostics (page 373)

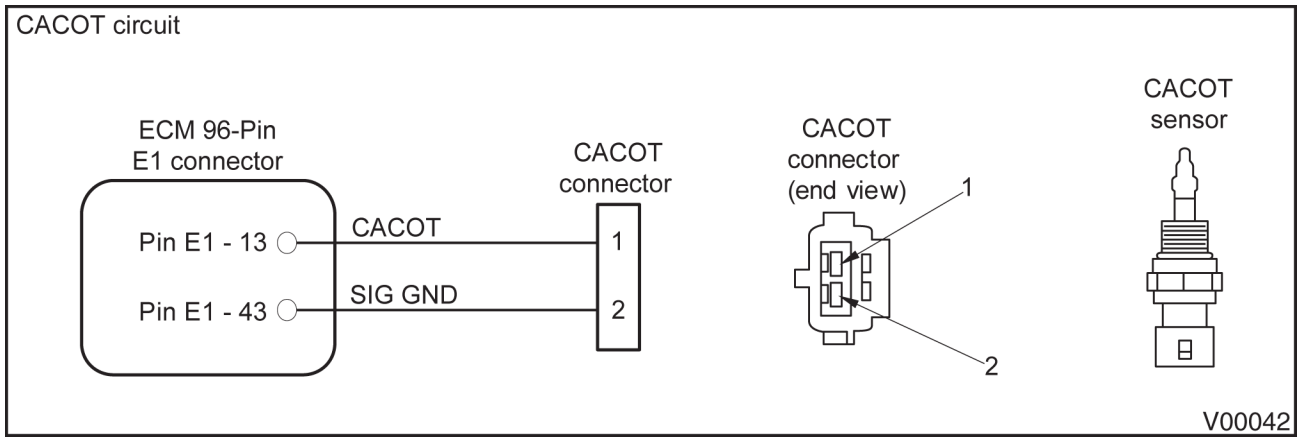


Figure 179 CACOT sensor circuit diagram

Overview

The Charge Air Cooler Outlet Temperature (CACOT) is a thermistor sensor that measures charged-air temperature entering the Engine Throttle Valve (ETV). As temperature increases, resistance drops, causing the voltage signal interpreted by the Engine Control Module (ECM) to vary. The ECM monitors this signal for Exhaust Gas Recirculation (EGR) system control and CAC performance.

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4993 (CACOT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

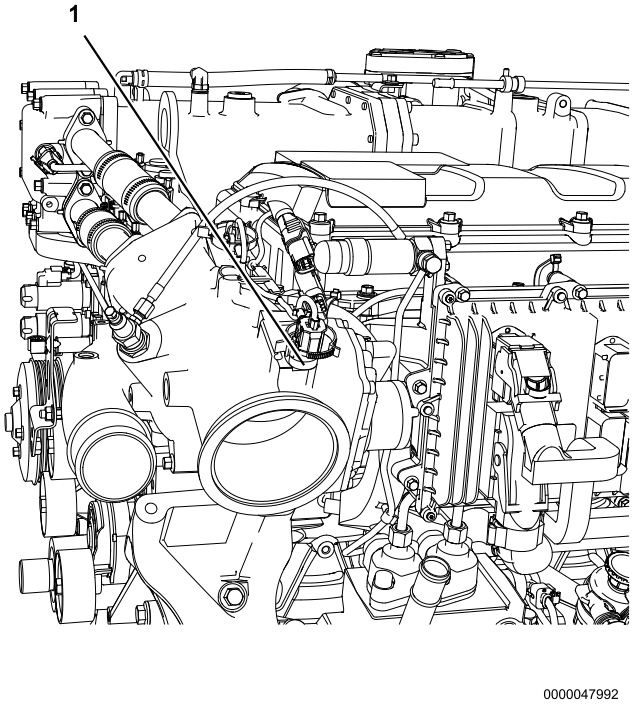


Figure 180 CACOT Sensor Location

1. Charge Air Cooler Outlet Temperature (CACOT) sensor

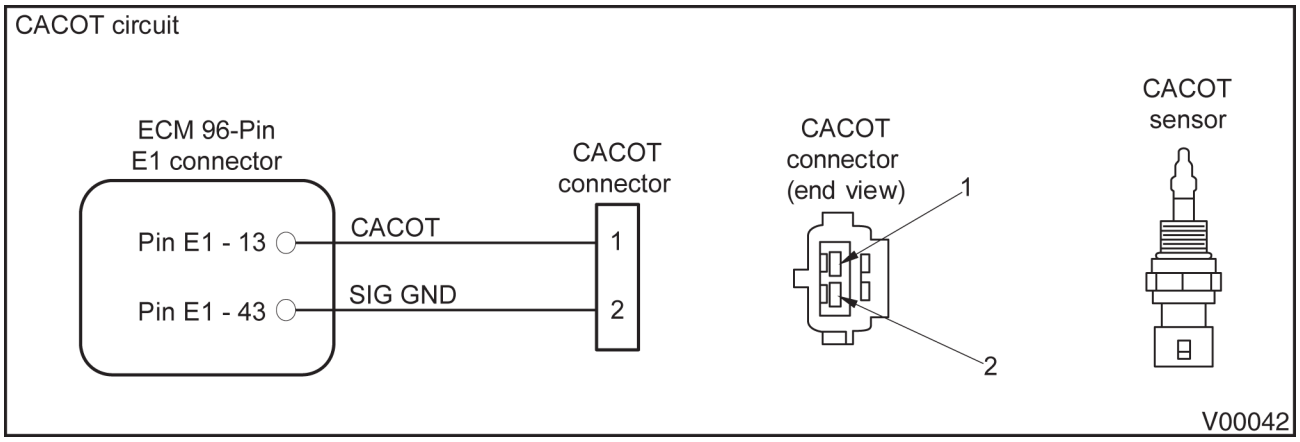


Figure 181 CACOT sensor circuit diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is pending or active, continue to Cold Soak Sensor Compare Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

SPN 2630 FMI 2 – CACOT signal does not agree with other sensors

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 8 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Default session.
3. Compare CACOT to Ambient Air Temperature (AAT), Air Intake Temperature (IAT), and Intake Manifold Temperature (IMT). Sensor temperatures should be within 5 °C (10 °F) of each other.
   - If CACOT is 5 °C (10 °F) above or below AAT, IAT, or IMT, check for poor circuitry going to the CACOT sensor.
   - If circuits are within specification, replace CACOT sensor.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4993 to CACOT engine harness, and leave CACOT sensor disconnected. Turn ignition ON.

Test Point	Specifications	Comment– < Less than, > Greater than
EST – Monitor CACOTv	5 V	If <4.5 V, check CACOT signal circuit for short to GND.
EST – Monitor CACOTv Short pin 1 to 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 372).
EST – Monitor CACOTv Short 500 Ω resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check CACOT signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace CACOT sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4993 to CACOT engine harness, and leave CACOT sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to GND	4.5 V to 5 V	If < 4.5 V, check for OPEN or short to GND. Do Harness Resistance Check (page 372).
2 to B+	B+	If < B+, check for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4993 to CACOT engine harness, and leave CACOT sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-13	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-43	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 2630 FMI 16 - CACOT Undercooling

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Comparison of Charge Air Cooler Outlet Temperature (CACOT) sensor reading to modeled value. Actual cooler effectiveness is less than the threshold effectiveness.	CAC system cooling efficiency less then 55% of modeled value.	Function of engine speed and load: 100-1600 rpm and 30-90% load > 0 Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts Vehicle speed > 6.2 mph Limp Home Mode = Inactive DPF Regeneration = Inactive Power Takeoff (PTO) Mode = Inactive Ambient Air Temperature (AAT) >50°F (10°C) and <131°F (55°C) Barometric pressure (BARO) > 11 psi (75 kPa)	3 events

Fault Overview

Fault sets when the Engine Control Module (ECM) determines the Charge Air Cooler Outlet Temperature (CACOT) sensor reading is greater than a predetermined value. The ECM uses vehicle speed and Ambient Air Temperature (AAT) to determine CAC effectiveness.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN 647

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

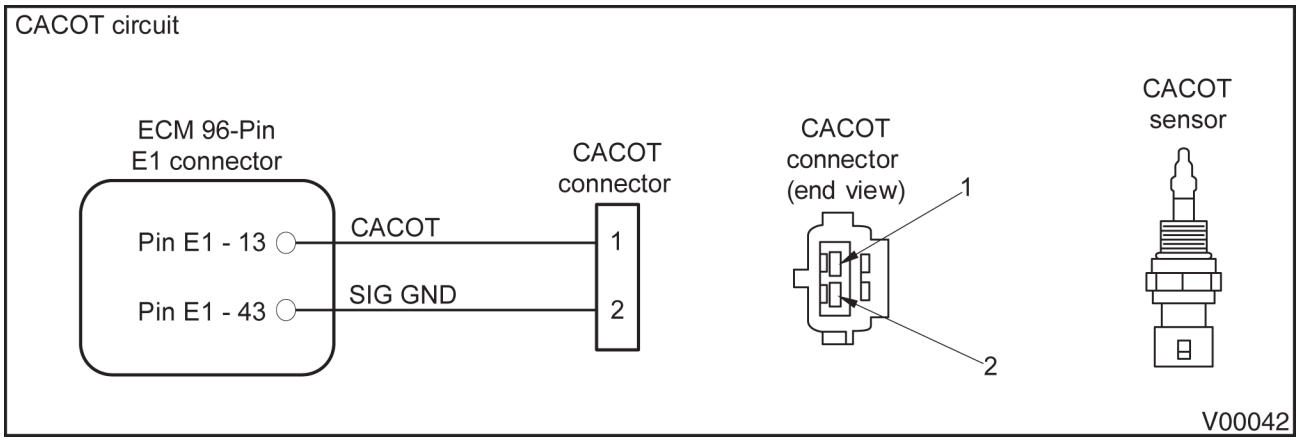


Figure 182 CACOT sensor circuit diagram

Possible Causes

- Restricted CAC
- Engine fan and/or engine fan shroud failure
- Inoperative engine fan
- Winter front installed outside recommended temperatures
- Failed Coolant Control Valve (CCV)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 2630 FMI 16 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
2	Determine if a winter front (grill cover) is installed during warm temperatures. Is winter front (grill cover) removed during warm temperatures outside the recommended range?	Yes: Go to step 3. No: Remove winter front. After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
3	Inspect Charge Air Cooler (CAC) for damage, blockage, or anything that could prevent proper air flow through the CAC. Is the CAC undamaged, not blocked, and is air able to flow through it properly?	Yes: Go to step 4. No: Repair CAC damage or blockage. After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
4	Inspect for damage to the engine cooling fan and shroud. Are the engine cooling fan and shroud in good condition and not damaged?	Yes: Go to step 5. No: Repair engine cooling fan or shroud damage. After repairs are made, retest for SPN 2630 FMI 16.

Step	Action	Decision
5	Determine if engine cooling fan is working when engine is hot. Using EST with ServiceMaxx go to: Tests > KOER Tests > Engine Fan Test. Does engine cooling fan come ON when the engine gets hot (approximately 205°F (96°C) to 225°F (107°C) and above)?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Diagnosis and repair engine cooling fan or circuit. See EFC (Engine Fan Control) Voltage and Harness resistance checks (page 617). After repairs are complete, retest for SPN 2630 FMI 16.

Step	Action	Decision
6	Determine if Coolant Flow Valve (CFV) and Coolant Mixture Valve (CMV) are working correctly. Perform Coolant Control Valve (CCV) Test (page 93). Are the CFV and CMV operating correctly?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action. No: Repair CCV. After repairs are complete, retest for SPN 2630 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 2630 FMI 16 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

CCOSS Sensor (Crankcase Oil Separator Speed)

SPN	FMI	Condition	Possible Causes
4227	7	CC Oil Separator Speed: Not spinning	• Crankcase Oil Separator failure • Crankcase Oil Separator circuit or sensor fault

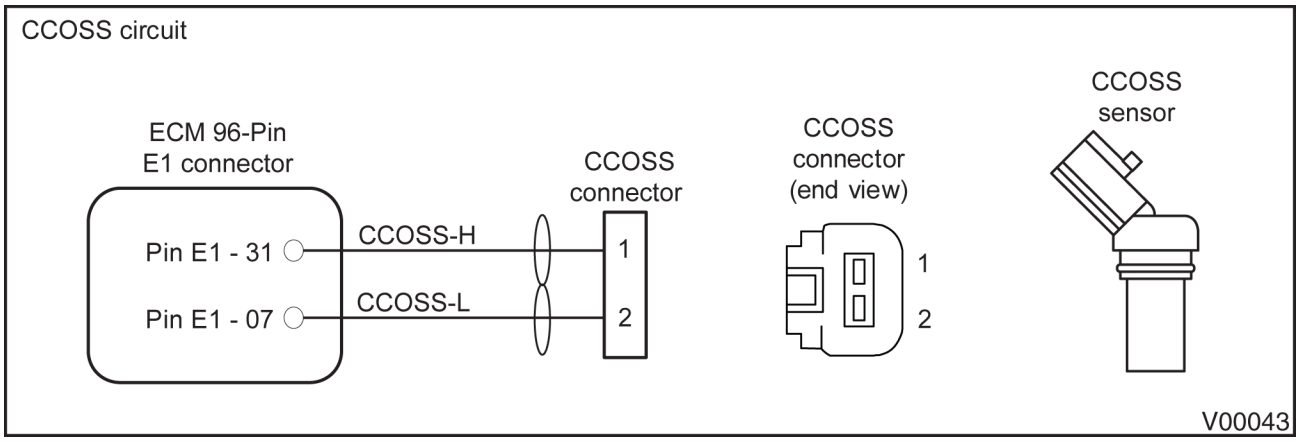


Figure 183 CCOSS circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4951 (CCOSS)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Pinpoint Crankcase Oil Separator: Not spinning fault

1. Using ServiceMaxx™ software, monitor Crankcase Oil Separator signal while running the engine.
   - If CC Oil Separator signal stays at 0 rpm, verify sensor and voltage to sensor are within specification, go to Connector Voltage Check and Sensor Resistance Check.
   - If sensor resistance and sensor connector voltage are within specification, go to Crankcase Oil Breather Separator Test in “PERFORMANCE DIAGNOSTICS."

Sensor Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4951 to CCOSS sensor and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to 2	300 Ω to 400 Ω	If not within specification, replace CCOSS sensor.

Connector Voltage Check Without ServiceMaxx™ software

Connect Breakout Harness ZTSE4951 to CCOSS engine harness, and leave CCOSS sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to GND	2.0 V – 2.5 V	If < 2.0 V, check for OPEN of short to GND. Do Harness Resistance Check.
2 to GND	2.0 V – 2.5 V	If < 2.0 V, check for OPEN of short to GND. Do Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4951 to CCOSS engine harness, and leave CCOSS sensor disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
E1-07 to 2	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E1-07 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
E1-31 to 1	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E1-31 to GND	> 1k Ω	If < 1k Ω, check for short to GND.

CCS (Cruise Control System)

SPN	FMI	Condition	Possible Causes
None			

Function

The CCS is a function of the Engine Control Module (ECM). Using the cruise control switches, the operator is able to set, resume, accelerate, or coast to any desired vehicle speed within range of the system.

The ECM continuously monitors the clutch, brake, and accelerator pedals before cruise can be activated, and is used to deactivate after cruise speed has been set.

CCS Operation

The cruise control switches are wired to the Body Controller (BC). The switch state is communicated to the ECM through the J1939 Data Link network.

CCS Pinpoint Diagnostics – With ServiceMaxx™ Software

Programmable Parameters

Turn ignition switch ON. Connect EST to vehicle Diagnostic Connector. Using ServiceMaxx™ software, open the Programming session and verify all Parameters are set correctly.

Test Point	Specification	Comment
Cruse Control Mode	Enabled	If Disabled, change to Enabled

Switch Checks

Using ServiceMaxx™ software, open the Driver Switch Controls session to monitor signals.

NOTE:

- **If signals are not within specification, diagnose switch interface with Body Controller (BC) or Multiplex System Module (MSM) module. See *Chassis Electrical Circuit Diagnostic Manual* and *Electrical System Troubleshooting Guides*.**
- **If signals are within specification, go to next test point.**

Test Point	Specification	Comment
Brake Switch	Normal state = Released	See Note
	Depressed = Applied	
Park brake	Normal state = OFF	See Note
	Depressed = ON	
Cruise On/Off	Unlatched = OFF	See Note
	Latched = ON	
Cruise Set	Normal state = OFF	See Note
	Depressed = ON	
Cruise Resume/Accel	Normal state = OFF	See Note
	Depressed = ON	
If all switches are within specifications, drive the vehicle and verify the Vehicle Speed Sensor (VSS) is working.		

CFV (Coolant Flow Valve)

SPN	FMI	Condition	Possible Causes
5547	3	CFV short to PWR	• CFV circuit short to PWR • Failed CFV
5547	4	CFV short to GND	• CFV circuit short to GND • Failed CFV
5547	5	CFV open load/circuit	• CFV circuit OPEN • Failed CFV

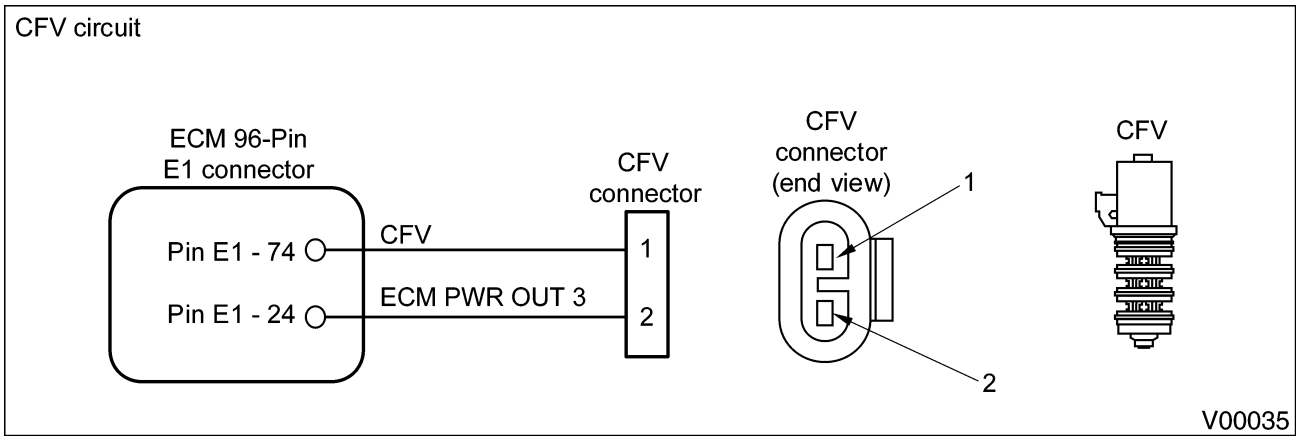


Figure 184 CFV circuit diagram

Connector Voltage Check

Connect Breakout Harness ZTSE4871 to CFV engine harness and leave CFV disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
Pin 1 to GND	4 V ± 1 V	If < 3 V, check for OPEN or short to GND in CFV circuit. If > 5 V, check for short to PWR in CFV circuit.
Pin 2 to GND	B+	If < B+, check for OPEN in ECM PWR OUT 3 circuit.
If measurements are within specifications, go to Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE4871 between CFV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the 2010 Actuator session.
3. Command Coolant Flow Valve to 5%, then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5% = 12.0 V ± 2.0 V	If < 10.0 V, check for OPEN circuit.
1 to GND	95% = 1.5 V ± 0.5 V	If > 2.0 V, check for OPEN circuit or failed CFV.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4871 to CFV and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment
1 to 2	4 Ω to 8 Ω	If not within specification, replace the CFV.
If measurements are within specifications, go to Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4871 to CFV engine harness, and leave CFV disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to E1-74	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-24	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
If voltage and resistance checks are within specifications, the CFV is working correctly. See Coolant System (page 79) in “ENGINE SYMPTOMS DIAGNOSTICS” to diagnose a mechanical fault.		

CKP Sensor (Crankshaft Position)

SPN	FMI	Condition	Possible Causes	Actions
637	8	CKP signal noise	• Debris accumulation on the Crankshaft Position (CKP) sensor • CKP-L circuit intermittent high resistance • CKP-H circuit intermittent high resistance • CKP-L circuit intermittent short to GND • CKP-H circuit intermittent short to GND • CKP-L circuit intermittent short to CKP-H circuit • Failed CKP sensor	Step-Based Diagnostics (page 385)
637	10	CKP signal inactive	• Debris accumulation on the Crankshaft Position (CKP) sensor • CKP-L circuit Open or high resistance • CKP-H circuit Open or high resistance • CKP-L circuit short to GND • CKP-H circuit short to GND • CKP-L circuit shorted to CKP-H circuit • Failed CKP sensor	Step-Based Diagnostics (page 389)

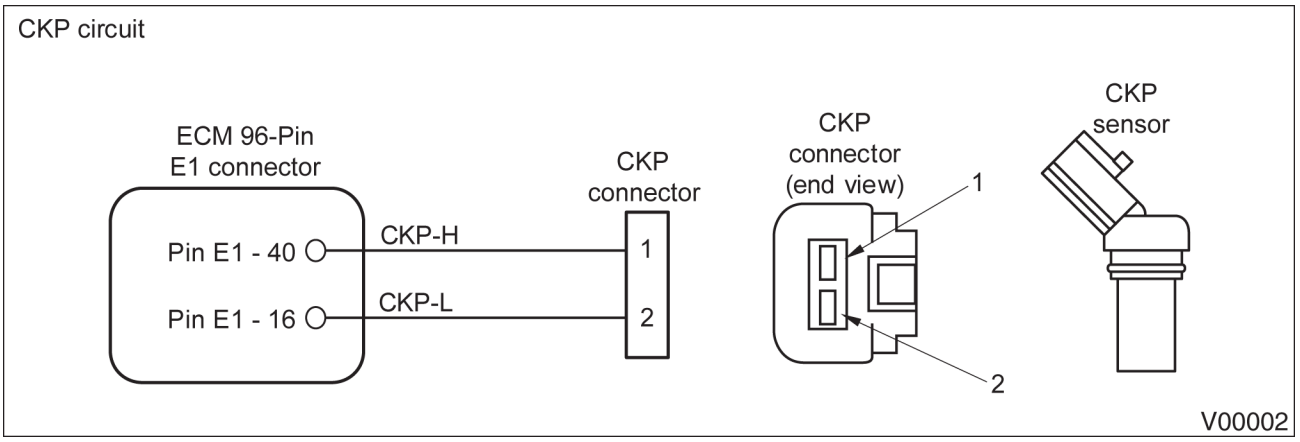


Figure 185 CKP sensor circuit diagram

Overview

The Crankshaft Position (CKP) sensor is a magnetic pickup sensor that indicates crankshaft speed and position. The CKP sensor is compared with the Camshaft Position (CMP) sensor by the Engine Control Module (ECM) to calculate the RPM and timing of the engine. The engine will still start with a failed CKP or CMP sensor, but will have a longer crank time.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- ECM Breakout Harness 00-01468-00
- Breakout Harness ZTSE6021 (CKP)
- International Electrical Engine. Terminal Test Kit ZTSE4435C
- 500 Ohm Resistor Jumper Harness ZTSE4497
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

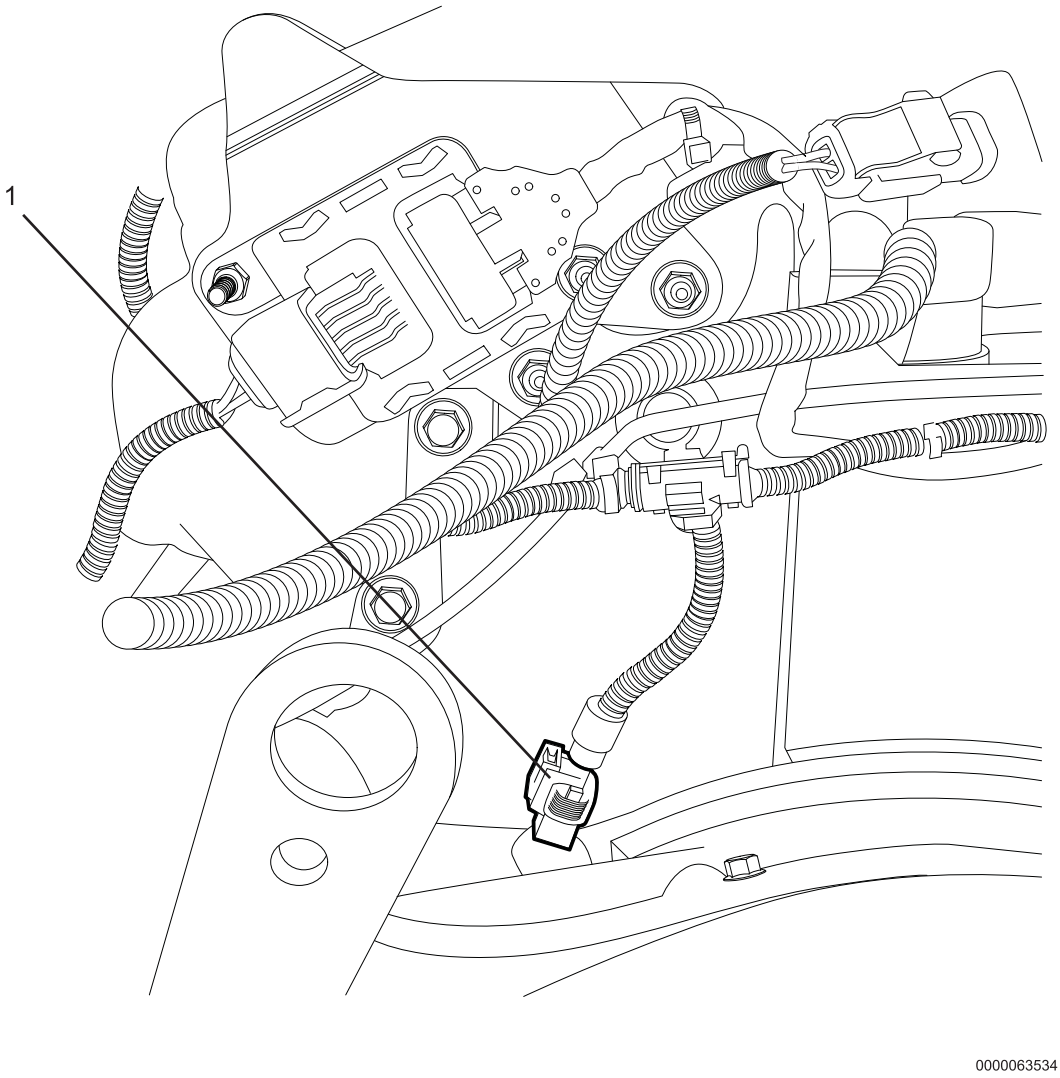


Figure 186 CKP Sensor Location (Back of engine)

1. Crankshaft Position (CKP) sensor

SPN 637 FMI 8 - CKP signal noise

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft Position (CKP) sensor signal greater than expected.	CKP signal > 8000 rpm	Engine cranking OR Key-On Engine-Running (KOER)	8 engine revolutions (per cam signal)

Fault Overview

Fault Code sets when the Engine Control Module (ECM) detects the signal from the Crankshaft Position (CKP) sensor indicates engine speed is greater than 8000 rpm.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

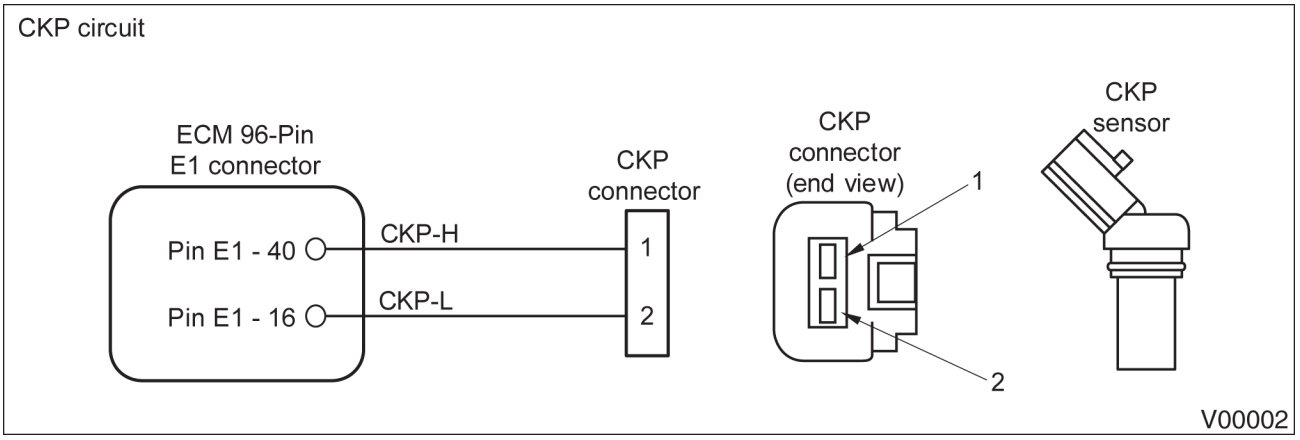


Figure 187 CKP sensor circuit diagram

Possible Causes

- Debris accumulation on the Crankshaft Position (CKP) sensor
- CKP-L circuit intermittent high resistance
- CKP-H circuit intermittent high resistance
- CKP-L circuit intermittent short to GND
- CKP-H circuit intermittent short to GND
- CKP-L circuit intermittent short to CKP-H circuit
- Failed CKP sensor

Step	Action	Decision
1	Inspect connections at Crankshaft Position (CKP) sensor. Key OFF, disconnect CKP sensor. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the CKP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 637 FMI 8.

CAUTION: To prevent damage, do not use chemical cleaners to clean crankshaft position sensor.

Step	Action	Decision
2	Remove CKP sensor. Inspect sensor for debris build up on the sensor. Is the sensor free of damage or debris on the sensor surface?	Yes: Go to step 3. No: Clean CKP sensor with a rag or towel. After repairs are complete, retest for SPN 637 FMI 8.

Step	Action	Decision
3	Check for a failed CKP sensor. Connect Breakout Harness ZTSE6021 to CKP sensor, and leave vehicle harness disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and pin-2. Is resistance 774 - 946 Ohms?	Yes: Go to step 4. No: Replace CKP sensor. After repairs are complete, retest for SPN 637 FMI 8.

Step	Action	Decision
4	Check for intermittent short to GND in CKP-H circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave CKP sensor disconnected. Key OFF Use a DMM to measure resistance between Breakout Harness pin-1 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 5. No: Repair short to GND between CKP connector pin-1 and ECM pin E1-10. After repairs are complete, retest for SPN 637 FMI 8.

Step	Action	Decision
5	Check for intermittent short to GND in CKP-L circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave CKP sensor disconnected. Key OFF, Use a DMM to measure resistance between Breakout Harness pin-2 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 6. No: Repair short to GND between CKP connector pin-2 and ECM pin E1-16. After repairs are complete, retest for SPN 637 FMI 8.

Step	Action	Decision
6	Check CKP-H circuit for intermittent high resistance (voltage drop). 1. Key OFF, disconnect CKP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CKP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-1 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-40. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to pin previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-1 and ECM pin E1-40. Is voltage less than 0.3 volts?	Yes: Go to step 7. No: Repair intermittent high resistance between CKP connector pin-1 and ECM pin E1-40. After repairs are complete, retest for SPN 637 FMI 8.

Step	Action	Decision
7	Check CKP-L circuit for intermittent high resistance (voltage drop). 1. Key OFF, disconnect CKP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CKP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-2 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-16. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to pin previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-2 and ECM pin E1-16. Is voltage less than 0.3 volts?	Yes: Go to step 8. No: Repair intermittent high resistance between CKP connector pin-2 and ECM pin E1-16. After repairs are complete, retest for SPN 637 FMI 8.

Step	Action	Decision
8	Check for intermittent short CKP-L to CKP-H. With ECM Disconnected, connect Breakout Harness ZTSE6021 to vehicle harness, and leave CKP sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 to pin-2. Is resistance greater than 1000 ohms?	Yes: Go to step 9. No: Repair short between CKP-L and CKP-H circuits. After repairs are complete, retest for SPN 637 FMI 8.

Step	Action	Decision
9	Check for incorrect output from the CKP sensor. With ECM connected, connect Breakout Harness ZTSE6021 between CMP sensor and vehicle harness. Using DMM set to AC Volts - RPM2. Measure RPM between pin-1 and pin-2 during cranking, low idle, and high idle. Is RPM measured 99 RPM to 250 RPM at cranking, 549 RPM to 700 RPM at low idle, and 1250 RPM to 1500 RPM at high idle?	Yes: Clear code and retest for SPN 637 FMI 8. No: Replace CKP sensor. After repairs are complete, retest for SPN 637 FMI 8.

NOTE: After performing all diagnostic steps, if SPN 637 FMI 8 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 637 FMI 10 - CKP signal inactive

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
No Crankshaft Position (CKP) signal	CKP circuit voltage < 0.40 volts	Engine cranking OR Key-On Engine-Running (KOER)	10 camshaft revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) receives no signal from the Crankshaft Position (CKP) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

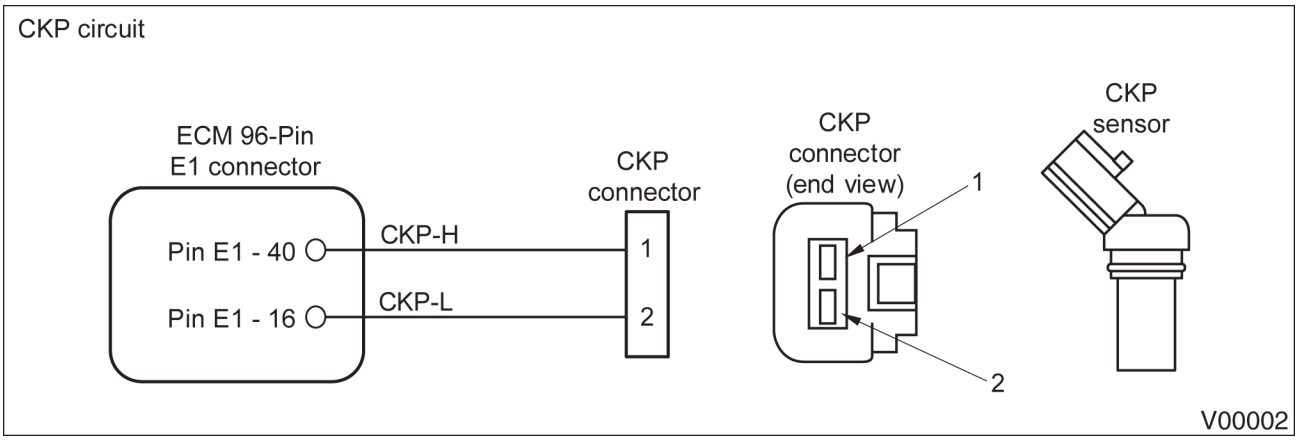


Figure 188 CKP sensor circuit diagram

Possible Causes

- Debris accumulation on the Crankshaft Position (CKP) sensor
- CKP-L circuit Open or high resistance
- CKP-H circuit Open or high resistance
- CKP-L circuit short to GND
- CKP-H circuit short to GND
- CKP-L circuit shorted to CKP-H circuit
- Failed CKP sensor

Step	Action	Decision
1	Inspect connections at Crankshaft Position (CKP) sensor. Key OFF, disconnect CKP sensor. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the CKP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 637 FMI 10.

CAUTION: To prevent damage, do not use chemical cleaners to clean crankshaft position sensor.

Step	Action	Decision
2	Remove CKP sensor. Inspect sensor for debris build up on the sensor. Is the sensor free of damage or debris on the sensor surface?	Yes: Go to step 3. No: Clean CKP sensor with a rag or towel. After repairs are complete, retest for SPN 637 FMI 10.

Step	Action	Decision
3	Check for a failed CKP sensor. Connect Breakout Harness ZTSE6021 to CKP sensor and leave Breakout Harness disconnected from vehicle. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and pin-2. Is resistance 774 – 946 Ohms?	Yes: Go to step 4. No: Replace CKP sensor. After repairs are complete, retest for SPN 637 FMI 10.

Step	Action	Decision
4	Check for short to GND in CKP-H circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave CKP sensor disconnected. Key OFF Use a DMM to measure resistance between Breakout Harness pin-1 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 5. No: Repair short to GND between CKP connector pin-1 and ECM pin E1-10. After repairs are complete, retest for SPN 637 FMI 10.

Step	Action	Decision
5	Check for short to GND in CKP-L circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave CKP sensor disconnected. Key OFF, Use a DMM to measure resistance between Breakout Harness pin-2 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 6. No: Repair short to GND between CKP connector pin-2 and ECM pin E1-16. After repairs are complete, retest for SPN 637 FMI 10.

Step	Action	Decision
6	Check CKP-H circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect CKP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CKP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-1 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-40. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to pin previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-1 and ECM pin E1-40. Is voltage less than 0.3 volts?	Yes: Go to step 7. No: Repair Open or high resistance between CKP connector pin-1 and ECM pin E1-40. After repairs are complete, retest for SPN 637 FMI 10.

Step	Action	Decision
7	Check CKP-L circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect CKP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CKP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-2 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-16. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to pin previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-2 and ECM pin E1-16. Is voltage less than 0.3 volts?	Yes: Go to step 8. No: Repair Open or high resistance between CKP connector pin-2 and ECM pin E1-16. After repairs are complete, retest for SPN 637 FMI 10.

Step	Action	Decision
8	Check for CKP-H shorted to CKP-L. With ECM Disconnected, connect Breakout Harness ZTSE6021 to vehicle harness and leave CMP sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Go to step 9. No: Repair short between CKP-H and CKP-L circuits. After repairs are complete, retest for SPN 637 FMI 10.

Step	Action	Decision
9	Check for a failed CKP sensor. Reconnect ECM. Connect Breakout Harness ZTSE6021 between CKP sensor and vehicle harness. Using a DMM set to measure AC frequency (Hz), measure the voltage of the sensor when cranking, low idle, and high idle (100-250 RPM). Is RPM measured 99 RPM to 250 RPM at cranking, 549 RPM to 700 RPM at low idle, and 1250 RPM to 1500 RPM at high idle?	Yes: Clear code and retest for SPN 637 FMI 10. No: Replace CKP sensor. After repairs are complete, retest for SPN 637 FMI 10.

NOTE: After performing all diagnostic steps, if SPN 637 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

CMP Sensor (Camshaft Position)

SPN	FMI	Condition	Possible Causes	Actions
636	2	CMP and CKP Synchronization Error	• Debris accumulation on the Camshaft Position (CMP) sensor • CMP-L high resistance • CMP-H high resistance • CMP-L short to GND • CMP-H short to GND • CMP-L shorted to CMP-H • Camshaft and Crankshaft not synchronized • Failed CMP	Step-Based Diagnostics (page 397)

636	8	CMP signal noise	• Debris accumulation on the Camshaft Position (CMP) sensor • CMP-L intermittent high resistance • CMP-H intermittent high resistance • CMP-L intermittent short to GND • CMP-H intermittent short to GND • CMP-L intermittent short to CMP-H • Failed CMP	Step-Based Diagnostics (page 401)
636	10	CMP signal inactive	• Debris accumulation on the Camshaft Position (CMP) sensor • CMP-L Open or high resistance • CMP-H Open or high resistance • CMP-L short to GND • CMP-H short to GND • CMP-L shorted to CMP-H • Failed CMP	Step-Based Diagnostics (page 405)

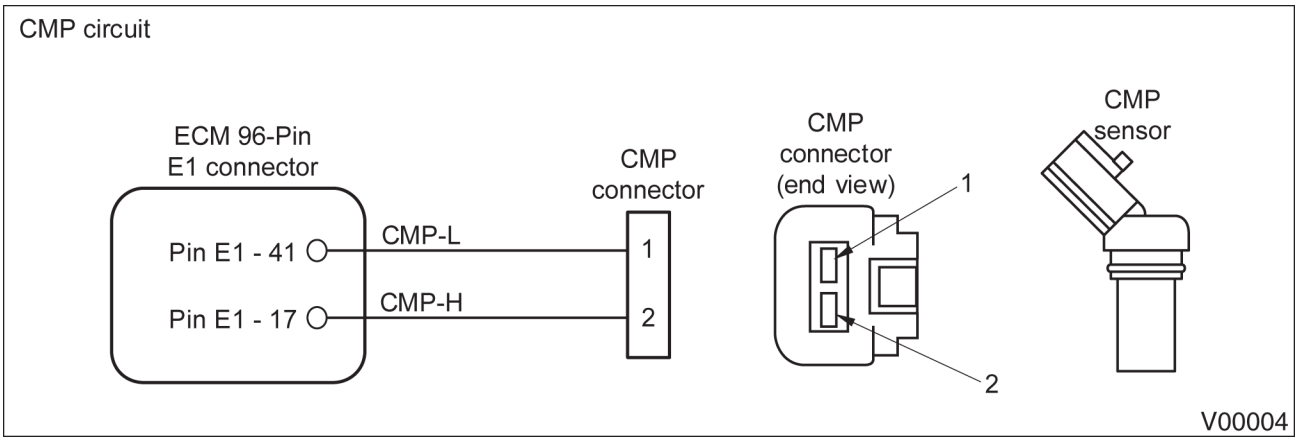


Figure 189 CMP sensor circuit diagram

Overview

The Camshaft Position (CMP) sensor is a magnetic pickup sensor that indicates camshaft speed and position. The CMP sensor is compared with the Crankshaft Position (CKP) sensor by the Engine Control Module (ECM) to calculate the RPM and timing of the engine. The engine will still start with a failed CMP or CKP sensor, but will have a longer crank time.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- ECM Breakout Harness 00-01468-00
- Breakout Harness ZTSE6021
- International Electrical Engine. Terminal Test Kit ZTSE4435C
- 500 Ohm Resistor Jumper Harness ZTSE4497
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

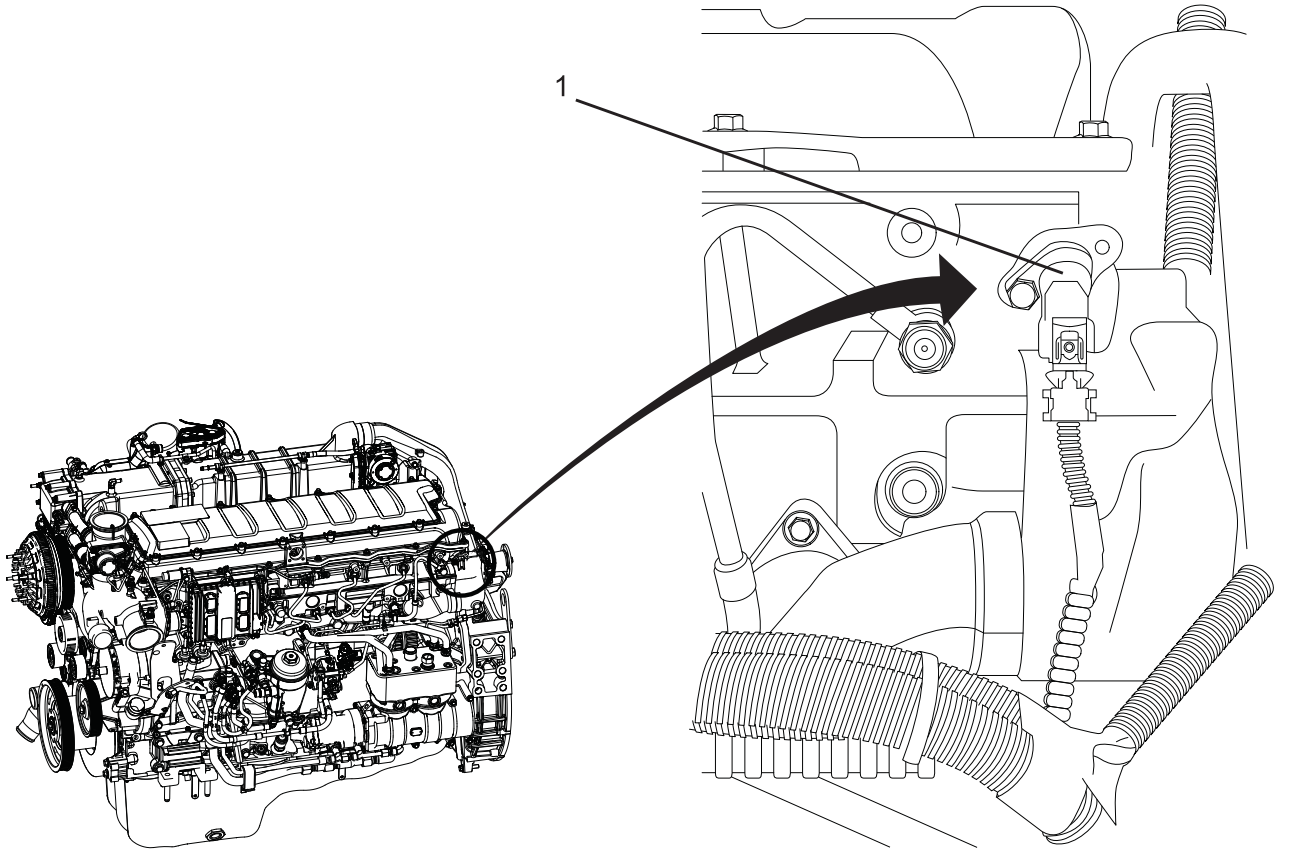


Figure 190 CMP Sensor Location

1. Camshaft Position (CMP) sensor

SPN 636 FMI 2 - CMP and CKP Synchronization Error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Camshaft position signal error	Camshaft position signal error > 20 crank degrees OR < -20 crank degrees	Engine cranking OR Key-On Engine-Running (KOER)	2 consecutive camshaft revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the difference between the camshaft and crankshaft position signals is > 20 degrees.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

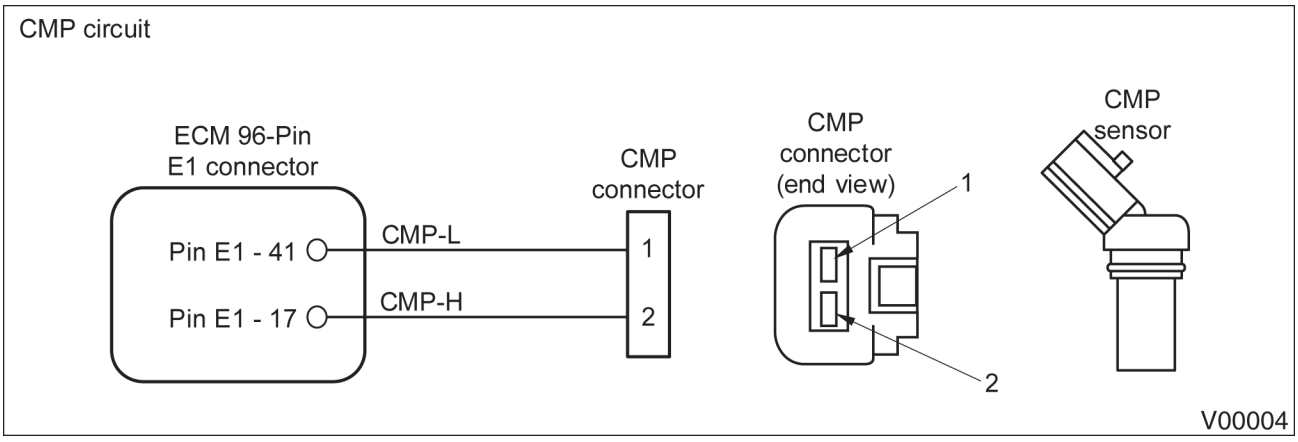


Figure 191 CMP sensor circuit diagram

Possible Causes

- Debris accumulation on the Camshaft Position (CMP) sensor
- CMP-L high resistance
- CMP-H high resistance
- CMP-L short to GND
- CMP-H short to GND
- CMP-L shorted to CMP-H
- Camshaft and Crankshaft not synchronized
- Failed CMP

Step	Action	Decision
1	Inspect connections at Camshaft Position (CMP) sensor. Key OFF, disconnect CMP sensor. Check CMP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the CMP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 636 FMI 2.

CAUTION: To prevent damage, do not use chemical cleaners to clean camshaft position sensor.

Step	Action	Decision
2	Inspect CMP sensor and bore for damage or debris build up. Remove CMP sensor and inspect sensor and bore. Is the sensor and bore free of damage or debris?	Yes: Go to step 3. No: Clean or replace CMP sensor with a rag or towel and clean sensor bore. After repairs are complete, retest for SPN 636 FMI 2.

Step	Action	Decision
3	Check for a failed CMP sensor. Connect Breakout Harness ZTSE6021 to CMP sensor and leave Breakout Harness disconnected from vehicle harness. Key OFF, use a DMM to measure resistance between pin-1 and pin-2. Is CMP sensor resistance 774 to 946 ohms?	Yes: Go to step 4. No: Replace the CMP sensor. After repairs are complete, retest for SPN 636 FMI 2.

Step	Action	Decision
4	Check for short to GND in CMP-H circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-2 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 5. No: Repair short to GND between CMP connector pin-2 and ECM pin E1-17. After repairs are complete, retest for SPN 636 FMI 2.

Step	Action	Decision
5	Check for short to GND in CMP-L circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 6. No: Repair short to GND between CMP connector pin-1 and ECM pin E1-41. After repairs are complete, retest for SPN 636 FMI 2.

Step	Action	Decision
6	Check CMP-L circuit for high resistance (voltage drop). 1. Key OFF, disconnect CMP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CMP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-1 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-41. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-1 and ECM pin E1-41. Is voltage less than 0.3 volts?	Yes: Go to step 7. No: Repair high resistance between CMP connector pin-1 and ECM pin E1-41. After repairs are complete, retest for SPN 636 FMI 2.

Step	Action	Decision
7	Check CMP-H circuit for high resistance (voltage drop). 1. Key OFF, disconnect CMP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CMP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-2 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-17. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-2 and ECM pin E1-17. Is voltage less than 0.3 volts?	Yes: Go to step 8. No: Repair high resistance between CMP connector pin-2 and ECM pin E1-17. After repairs are complete, retest for SPN 636 FMI 2.

Step	Action	Decision
8	Check for CMP-L shorted to CMP-H. With ECM Disconnected, connect Breakout Harness ZTSE6021 to vehicle harness and leave CMP sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Go to step 9. No: Repair short between CMP-L and CMP-H. After repairs are complete, retest for SPN 636 FMI 2.

Step	Action	Decision
9	Check for incorrect output from the CMP sensor. With ECM connected, connect Breakout Harness ZTSE6021 between CMP sensor and vehicle harness. Using DMM set to AC Volts - RPM2. Measure RPM between pin-1 and pin-2 during cranking, low idle, and high idle. Is RPM measured 99 RPM to 250 RPM at cranking, 549 RPM to 700 RPM at low idle, and 1250 RPM to 1500 RPM at high idle?	Yes: Go to step 10. No: Replace the CMP sensor. After repairs are complete, retest for SPN 636 FMI 2.

Step	Action	Decision
10	Check for correct camshaft / crankshaft synchronization (see Engine Service Manual, "Cylinder Head, Camshaft and Valve Train" section). Are the camshaft and crankshaft timed properly?	Yes: Clear code and retest for SPN 636 FMI 2. No: Check for damage and re-time the camshaft and crankshaft. (see Engine Service Manual). After repairs are complete, retest for SPN 636 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 636 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 636 FMI 8 - CMP signal noise

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Camshaft Position (CMP) sensor signal difference greater than expected.	CMP signal difference	Engine cranking OR Key-On Engine-Running (KOER)	4 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects Camshaft Position (CMP) sensor signal difference is greater than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

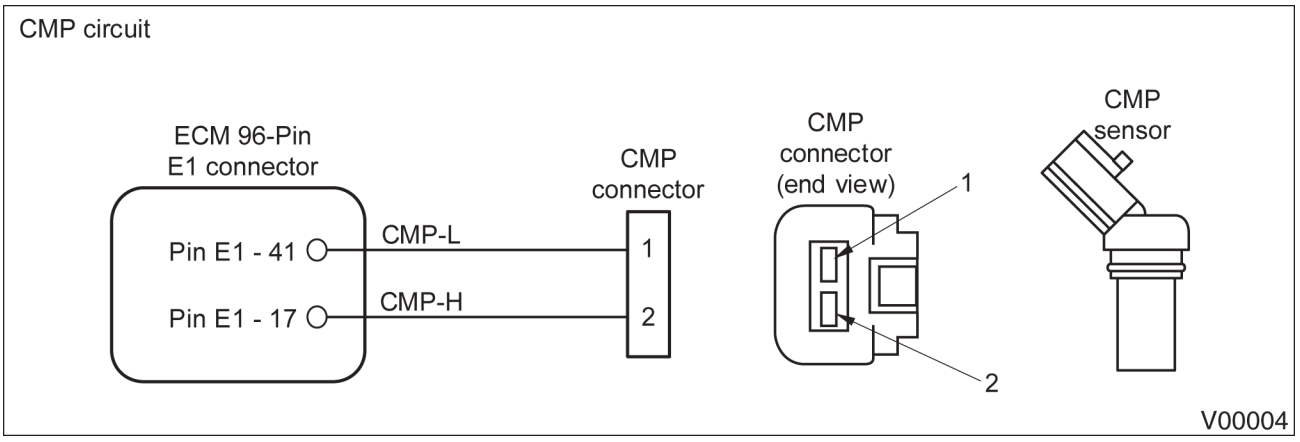


Figure 192 CMP sensor circuit diagram

Possible Causes

- Debris accumulation on the Camshaft Position (CMP) sensor
- CMP-L intermittent high resistance
- CMP-H intermittent high resistance
- CMP-L intermittent short to GND
- CMP-H intermittent short to GND
- CMP-L intermittent short to CMP-H
- Failed CMP

Step	Action	Decision
1	Inspect connections at Camshaft Position (CMP) sensor. Key OFF, disconnect CMP sensor. Check CMP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the CMP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 636 FMI 8.

CAUTION: To prevent damage, do not use chemical cleaners to clean camshaft position sensor.

Step	Action	Decision
2	Remove CMP sensor. Inspect sensor for damage or debris build up on the sensor. Is the sensor free of damage or debris on the sensor surface?	Yes: Go to step 3. No: Clean CMP sensor with a rag or towel. After repairs are complete, retest for SPN 636 FMI 8.

Step	Action	Decision
3	Check for a failed CMP sensor. Connect Breakout Harness ZTSE6021 to CMP sensor and leave Breakout Harness disconnected from vehicle. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and pin-2. Is resistance 774 to 946 ohms?	Yes: Go to step 4. No: Replace the CMP sensor. After repairs are complete, retest for SPN 636 FMI 8.

Step	Action	Decision
4	Check for intermittent short to GND in CMP-H circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-2 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 5. No: Repair intermittent short to GND between CMP connector pin-2 and ECM pin E1-17. After repairs are complete, retest for SPN 636 FMI 8.

Step	Action	Decision
5	Check for short to GND in CMP-L circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 6. No: Repair intermittent short to GND between CMP connector pin-1 and ECM pin E1-41. After repairs are complete, retest for SPN 636 FMI 8.

Step	Action	Decision
6	Check CMP-L circuit for intermittent high resistance (voltage drop). 1. Key OFF, disconnect CMP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CMP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-1 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-41. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-1 and ECM pin E1-41. Is voltage less than 0.3 volts?	Yes: Go to step 7. No: Repair intermittent high resistance between CMP connector pin-1 and ECM pin E1-41. After repairs are complete, retest for SPN 636 FMI 8.

Step	Action	Decision
7	Check CMP-H circuit for intermittent high resistance (voltage drop). 1. Key OFF, disconnect CMP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CMP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-2 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-17. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-2 and ECM pin E1-17. Is voltage less than 0.3 volts?	Yes: Go to step 8. No: Repair intermittent high resistance between CMP connector pin-2 and ECM pin E1-17. After repairs are complete, retest for SPN 636 FMI 8.

Step	Action	Decision
8	Check for intermittent short CMP-L to CMP-H. With ECM disconnected, connect Breakout Harness ZTSE6021 to vehicle harness and leave CMP sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Go to step 9. No: Repair short between CMP-L and CMP-H circuits. After repairs are complete, retest for SPN 636 FMI 8.

Step	Action	Decision
9	Check for incorrect output from the CMP sensor. Connect Breakout Harness ZTSE6021 between CMP sensor and vehicle harness. Using DMM set to AC Volts - RPM2. Measure RPM between pin-1 and pin-2 during cranking, low idle, and high idle. Is RPM measured 99 RPM to 250 RPM at cranking, 549 RPM to 700 RPM at low idle, and 1250 RPM to 1500 RPM at high idle?	Yes: Clear code and retest for SPN 636 FMI 8. No: Replace the CMP Sensor. After repairs are complete, retest for SPN 636 FMI 8.

NOTE: After performing all diagnostic steps, if SPN 636 FMI 8 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 636 FMI 10 - CMP signal inactive

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
No Camshaft Position (CMP) signal.	CMP circuit voltage < 0.405 volts	Engine cranking OR Key-On Engine-Running (KOER)	4 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) receives no signal from the Camshaft Position (CMP) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

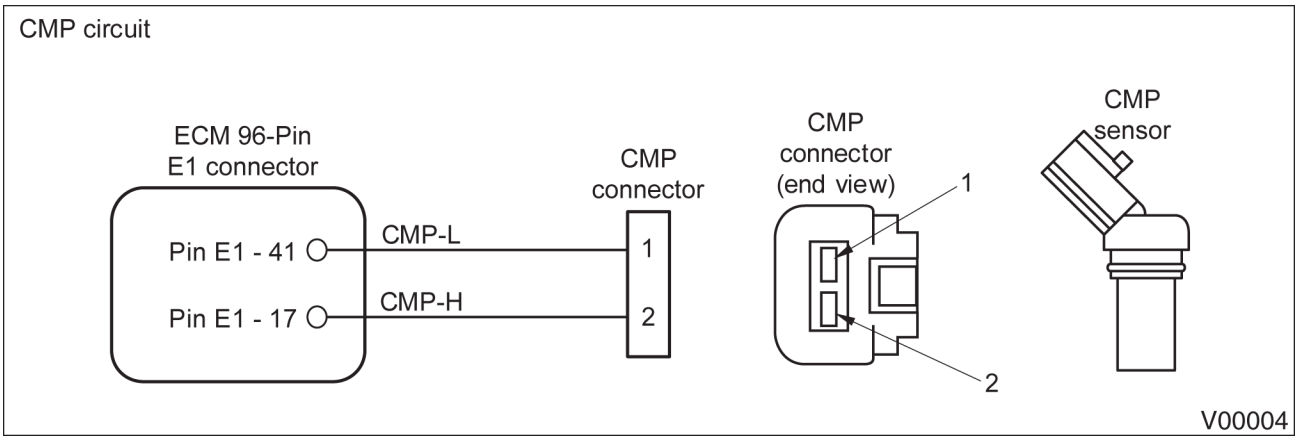


Figure 193 CMP sensor circuit diagram

Possible Causes

- Debris accumulation on the Camshaft Position (CMP) sensor
- CMP-L Open or high resistance
- CMP-H Open or high resistance
- CMP-L short to GND
- CMP-H short to GND
- CMP-L shorted to CMP-H
- Failed CMP

Step	Action	Decision
1	Inspect connections at Camshaft Position (CMP) sensor. Key OFF, disconnect CMP sensor. Check CMP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the CMP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 636 FMI 10.

CAUTION: To prevent damage, do not use chemical cleaners to clean camshaft position sensor.

Step	Action	Decision
2	Remove CMP sensor. Inspect sensor for damage or debris build up on the sensor. Is the sensor free of damage or debris on the sensor surface?	Yes: Go to step 3. No: Clean CMP sensor with a rag or towel. After repairs are complete, retest for SPN 636 FMI 10.

Step	Action	Decision
3	Check for a failed CMP sensor. Connect Breakout Harness ZTSE6021 to CMP sensor and leave Breakout Harness disconnected from vehicle. Using DMM, measure resistance between pin-1 and pin-2. Is resistance 774 – 946 ohms?	Yes: Go to step 4. No: Replace the CMP sensor. After repairs are complete, retest for SPN 636 FMI 10.

Step	Action	Decision
4	Check for short to GND in CMP-H circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-2 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 5. No: Repair short to GND between CMP connector pin-2 and ECM pin E1-17. After repairs are complete, retest for SPN 636 FMI 10.

Step	Action	Decision
5	Check for short to GND in CMP-L circuit. Connect Breakout Harness ZTSE6021 to vehicle harness and leave sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 6. No: Repair short to GND between CMP connector pin-1 and ECM pin E1-41. After repairs are complete, retest for SPN 636 FMI 10.

Step	Action	Decision
6	Check CMP-L circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect CMP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CMP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-1 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-41. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-1 and ECM pin E1-41. Is voltage less than 0.3 volts?	Yes: Go to step 7. No: Repair Open or high resistance between CMP connector pin-1 and ECM pin E1-41. After repairs are complete, retest for SPN 636 FMI 10.

Step	Action	Decision
7	Check CMP-H circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect CMP sensor and Engine Control Module (ECM). 2. Connect Breakout Harness ZTSE6021 to vehicle harness, and leave CMP sensor disconnected. 3. Using a jumper wire, connect Breakout Harness pin-2 to a known good ground. 4. Insert proper terminal into the ECM vehicle harness pin E1-17. 5. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal previously installed, and the other end to PWR (use a jumper wire if needed). 6. Using a DMM, measure voltage between Breakout Harness pin-2 and ECM pin E1-17. Is voltage less than 0.3 volts?	Yes: Go to step 8. No: Repair Open or high resistance between CMP connector pin-2 and ECM pin E1-17. After repairs are complete, retest for SPN 636 FMI 10.

Step	Action	Decision
8	Check for CMP-L shorted to CMP-H. With ECM Disconnected, connect Breakout Harness ZTSE6021 to vehicle harness and leave CMP sensor disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Go to step 9. No: Repair short between CMP-L and CMP-H. After repairs are complete, retest for SPN 636 FMI 10.

Step	Action	Decision
9	Check for incorrect output from the CMP sensor. Connect Breakout Harness ZTSE6021 between CMP sensor and vehicle harness. Using DMM set to AC Volts - RPM2. Measure RPM between pin-1 and pin-2 during cranking, low idle, and high idle. Is RPM measured 99 RPM to 250 RPM at cranking, 549 RPM to 700 RPM at low idle, and 1250 RPM to 1500 RPM at high idle?	Yes: Clear code and retest for SPN 636 FMI 10. No: Replace the CMP sensor. After repairs are complete, retest for SPN 636 FMI 10.

NOTE: After performing all diagnostic steps, if SPN 636 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

CMV (Coolant Mixer Valve)

SPN	FMI	Condition	Possible Causes
5546	3	CMV short to PWR	• CMV circuit short to PWR • Failed CMV
5546	4	CMV short to GND	• CMV circuit short to GND • Failed CMV
5546	5	CMV open load/circuit	• CMV circuit OPEN • Failed CMV

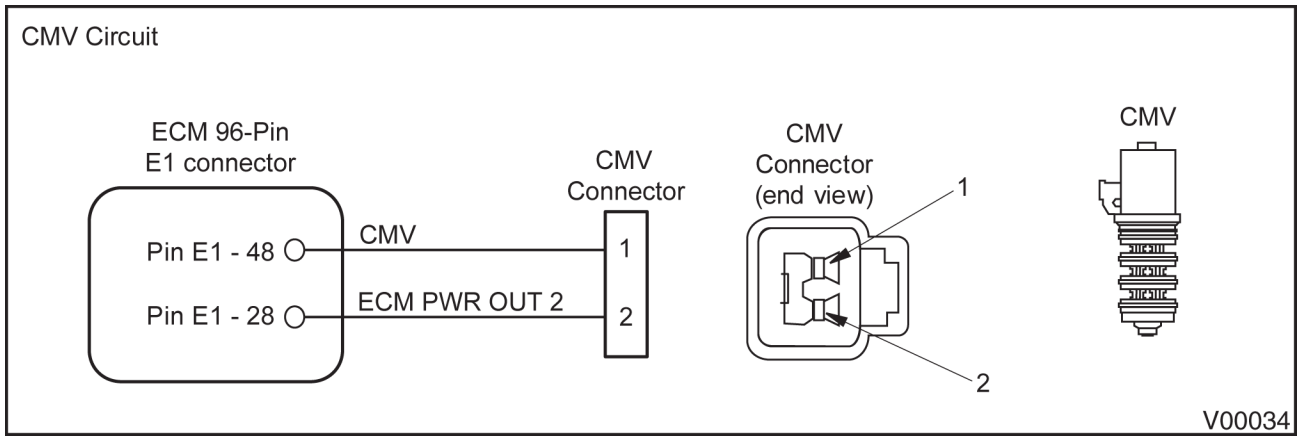


Figure 194 CMV sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4870 (CMV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Connector Voltage Check

Connect Breakout Harness ZTSE4870 to CMV engine harness and leave CMV disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
Pin 1 to GND	4 V ± 1 V	If < 3 V, check for OPEN or short to GND in CMV circuit.
		If > 5 V, check for short to PWR in CMV circuit.
Pin 2 to GND	B+	If < B+, check for OPEN in ECM PWR OUT 2 circuit.
If measurements are within specifications, go to Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE4870 between CMV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Coolant Mixer Valve from the drop-down menu.
3. Command Coolant Mixer Valve to 5%, then 95%.
4. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5% = 12.0 V ± 2.0 V	If < 10.0 V, check for OPEN circuit.
1 to GND	95% = 1.5 V ± 0.5 V	If > 2.0 V, check for OPEN circuit or failed CMV.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4870 to CMV and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment
1 to 2	4 Ω to 8 Ω	If not within specification, replace CMV.
If measurements are within specifications, go to Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4870 to CMV engine harness, and leave CMV disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to E1-48	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-28	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
If voltage and resistance checks are within specifications, the CMV is working correctly. See Coolant System in the “ENGINE SYMPTOMS DIAGNOSTICS” section in this manual, to diagnose a mechanical fault.		

IAHFI (Inlet Air Heater Fuel Igniter)

SPN	FMI	Condition	Possible Causes	Actions
626	18	Inlet Air Heater fault: Lack of heat in the Intake Manifold	• Biased IMT sensor or circuit • Inlet air heater system failure • Failed Inlet Air Heater Fuel Solenoid (IAHFS) • Failed IAHFI • Failed Inlet Air Heater Relay (IAHR) • Inlet air heater circuit faults • Aftermarket engine block heater	Pin-Point Diagnostics (page 416)
5548	3	IAHFI short to PWR	• IAHFI circuit short to PWR • Failed IAHFI	Circuit Checks (page 416)
5548	4	IAHFI short to GND	• OUT1 short to GND • OUT2 short to GND • IAHRE short to GND • IAHRD / IAHRE shorted together • Failed IAHFI	Step-Based Diagnostics (page 413)
5548	5	IAHFI open load/circuit	• IAHFI circuit OPEN • Failed IAHFI	Circuit Checks (page 416)
5548	7	Inlet Air Heater Relay return (relay, or igniter, or circuit failure)	• IAHR circuit fault • Failed IAHR	Circuit Checks (page 416)

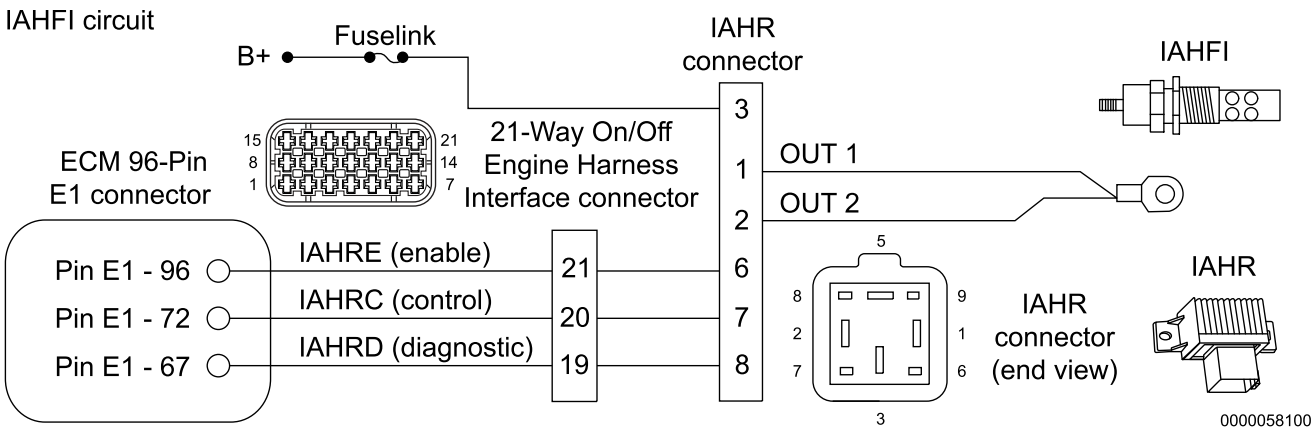


Figure 195 IAHFI circuit diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Inlet Air Heater (IAH) system warms the incoming air to aid emissions reduction. When inlet air heating is needed, the Engine Control Module (ECM) sends a signal to the IAH relay (IAHR). The IAHR then supplies B+ to the IAH fuel ignitor (IAHFI). The IAHFI is grounded through the intake manifold.

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4885 (IAHR)
- Amp clamp
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

5548 FMI 4- Inlet Air Heater Fuel Ignitor short to GND

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
IAH circuit short to GND	The resistance between the IAHRE or OUT1 / OUT2 circuits and ground < 0.2 Ohms	Key ON Inlet Air Heater commanded ON	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects a short to GND in the Inlet Air Heater (IAH) circuits.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

IAHFI circuit

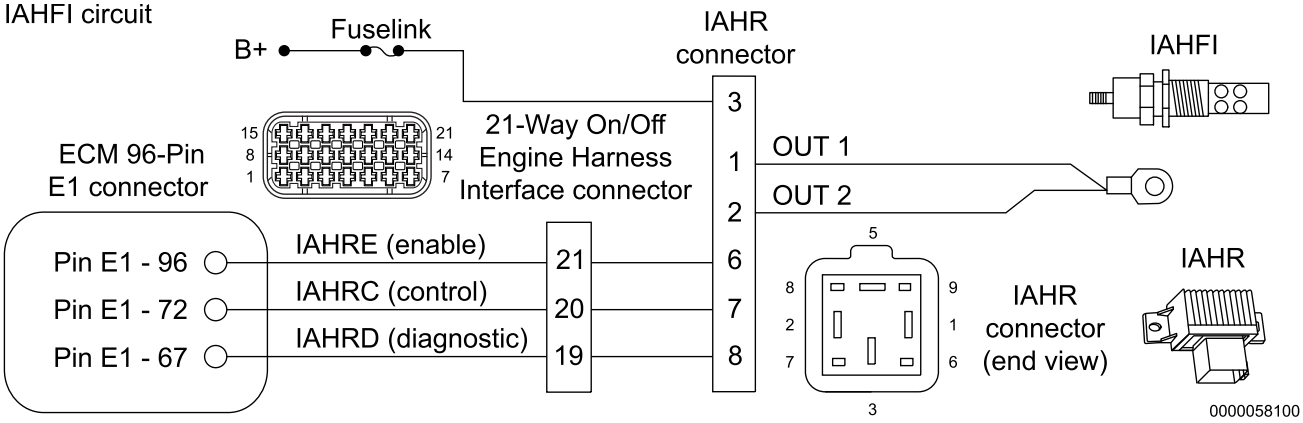


Figure 196 IAHFI circuit diagram

Possible Causes

- OUT1 short to GND
- OUT2 short to GND
- IAHRE short to GND
- IAHRD / IAHRE shorted together
- Failed IAHFI

Step	Action	Decision
1	Inspect connections at Inlet Air Heater Fuel Igniter (IAHFI). Check IAHFI connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IAHFI harness and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5548 FMI 4.

Step	Action	Decision
2	Inspect connections at Inlet Air Heater Relay (IAHR). Key-Off, disconnect IAHR connector. Check IAHR connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the IAHR connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 5548 FMI 4.

Step	Action	Decision
3	Check IAHRE circuit for short to GND. Connect Breakout Harness ZTSE4885 to vehicle harness and leave IAHR disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness ZTSE4885 pin-6 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 4. No: Repair short to GND in IAHRE circuit between IAHR pin-6 and ECM pin E1-96. After repairs are complete, retest for SPN 5548 FMI 4.

Step	Action	Decision
4	Check IAHRE circuit for short to IAHRD. Key OFF with Breakout Harness ZTSE4885 connected to vehicle harness and IAHR disconnected. Use a DMM to measure resistance between Breakout Harness pin-6 and pin-8. Is resistance greater than 1000 ohms?	Yes: Go to step 5. No: Repair short between IAHR pin-6 and IAHR pin-8. After repairs are complete, retest for SPN 5548 FMI 4.

Step	Action	Decision
5	Check OUT1 circuit for short to GND. With Breakout Harness ZTSE4885 connected to vehicle harness and IAHR disconnected. Disconnect IAHFI and leave terminals disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-1 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 6. No: Repair short to GND in OUT1 circuit between IAH relay pin-1 and IAHFI terminal. After repairs are complete, retest for SPN 5548 FMI 4.

Step	Action	Decision
6	Check OUT2 circuit for short to GND. With Breakout Harness ZTSE4885 connected to vehicle harness and IAHR disconnected. Key OFF with IAHFI disconnected, use a DMM to measure resistance between Breakout Harness pin-2 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Replace IAHFI. After repairs are complete, retest for SPN 5548 FMI 4.
		No: Repair short to GND in OUT2 circuit between IAH relay pin-2 and IAHFI terminal. After repairs are complete, retest for SPN 5548 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 5548 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

SPN 626 FMI 18 – Inlet Air Heater fault: Lack of heat in the Intake Manifold

During cold start DTC sets when Intake Manifold Temperature (IMT) signal does not raise 50°F (10°C).

NOTE: Temperature values need to be measured after 8 hours of cold soak.

1. Inspect for aftermarket engine block heater. Is engine free of an aftermarket engine block heater?
   - Yes: Go to step 2.
   - No: Disconnect aftermarket engine block heater and retest for SPN 626 FMI 18.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine Off, load the Default session. Compare IMT, Ambient Air Temperature (AAT), and Inlet Air Temperature (IAT).

   Are IMT, Ambient Air Temperature (AAT), and Inlet Air Temperature (IAT) sensor temperatures within 10°F (5°C) of each other.
   - Yes: IMT circuit is in specification, see Inlet Air Heater System Test in “HARD START AND NO START DIAGNOSTICS."
   - No: Go to IMT sensor Circuit Checks (page 727).

Voltage Check on IAHFI - Actuator Test

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Inlet Air Heater Fuel Igniter from the drop-down menu.
2. Command Inlet Air Heater Fuel Igniter to 95%.
3. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
IAHFI to GND	B+	If > 0 V to B+, do Amperage Draw Check - Actuator Test. If 0 V, do Voltage Checks on Relay Connector (page 417).

Amperage Draw Check - Actuator Test

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Amp Clamp ZTSE4575 to DMM. Set the DMM to DCmV and Zero the Amp clamp.
2. Connect Amp Clamp ZTSE4575 around the IAHFI wires.
3. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Inlet Air Heater Fuel Igniter from the drop-down menu.
4. Command Inlet Air Heater Fuel Igniter to 95%.
5. Use DMM to measure voltage from the Amp Clamp, representing amperage through the IAHFI.

Test Point	Specifications	Comment
DMM - Measure amperage to IAHFI		
IAHFI	30 Amps (within 2 seconds)	If within specification, IAHR and IAHFI are working correctly. If not within specification, do Voltage Checks on Relay - Actuator Test (page 418).
If Amps are within specification, do Harness Resistance Check (page 420) for IAHRD circuit.		

Voltage Checks on Relay Connector

Connect Breakout Harness ZTSE4885 to IAHR engine harness, and leave IAHR disconnected. Turn ignition ON. Use DMM to measure voltage after 60 seconds.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to GND	0 V	If > 0 V, check for short to PWR.
2 to GND	0 V	If > 0 V, check for short to PWR.
3 to GND	B+	If < B+, check for OPEN or short to GND.
6 to GND	1.5 V ± 0.5 V	If < 8 V, check for OPEN or short to GND.
7 to GND	0.5 V ± 0.5 V	If < 3 V, check for OPEN or short to GND. If > 5.5 V, check for short to PWR.
8 to GND	6 V ± 1 V	If < 4 V, check for OPEN or short to GND. If > 6 V, check for short to PWR.
If voltages are within specification, do Voltage Checks on Relay - Actuator Test (page 418).		

Voltage Checks on Relay - Actuator Test

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE4885 between IAHR and engine harness.
2. Use DMM to measure voltage.
3. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Inlet Air Heater Fuel Igniter from the drop-down menu.
4. Command Inlet Air Heater Fuel Igniter to 5%.
5. Use DMM to measure voltage.
6. Command Inlet Air Heater Fuel Igniter to 95%.
7. Use DMM to measure voltage.

Connect Breakout Harness ZTSE4885 between IAHR and engine harness. Turn the ignition switch to ON. Use DMM to measure voltage. Batteries must be fully charged before performing this test.

Test Point	Specifications	Comment – < Less than, > Greater than
6 to GND, Run Actuator Test		
Normal state	> 1 V	If < 1 V, check IAHRE circuit for OPEN or short to GND. Do Harness Resistance Check (page 420).
Actuator state LOW (5%)	> 10 V	If < 10 V, check IAHRE circuit for OPEN or short to GND. Do Harness Resistance Check (page 420).
Actuator state HIGH (95%)	> 10 V	If < 10 V, check IAHRE circuit for OPEN or short to GND. Do Harness Resistance Check (page 420).
7 to GND, Run Actuator Test.		
Normal state	< 1 V	If > 1 V, check IAHRC circuit for short to PWR. Do Harness Resistance Check (page 420).
Actuator state LOW (5%)	> 8 V	If < 8 V, check IAHRC circuit for OPEN or short to GND. Do Harness Resistance Check (page 420).
Actuator state HIGH (95%)	<1 V	If > 1 V, check IAHRD circuit for short to PWR. Do Harness Resistance Check (page 420).
8 to GND, Run Actuator Test.		
Normal state	6 V ± 1.5 V	If < 4.5 V, check IAHRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 420).
Actuator state LOW (5%)	6 V ± 1.5 V	If < 4.5 V, check IAHRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 420).
Actuator state HIGH (95%)	1 V ± 0.5 V	If < 0.5 V, check IAHRD circuit for OPEN or short to GND. Do Harness Resistance Check (page 420).
1 to GND, Run Actuator Test.		

Voltage Checks on Relay - Actuator Test (cont.)

Normal state	0 V	If > 0 V, replace IAHR.
Actuator state LOW	0 V	If > 0 V, replace IAHR.
Actuator state HIGH	B+	If < B+, replace IAHR.
2 to GND, Run Actuator Test.		
Normal state	0 V	If > 0 V, replace IAHR.
Actuator state LOW	0 V	If > 0 V, replace IAHR.
Actuator state HIGH	B+	If < B+, replace IAHR.
If measurements are not within specifications, do Harness Resistance Check (page 420).		

IAHFI Resistance Check

Turn ignition switch to OFF. Use DMM to measure resistance between IAHFI and engine GND.

Test Point	Specifications	Comment – < Less than, > Greater than
IAHFI to GND	< 5 Ω	If > 5 Ω, replace failed IAHFI.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4885 to IAHR engine harness, and leave IAHR disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to IAHFI	< 5 Ω	If > 5 Ω, check for OPEN circuit.
1 to GND	< 5 Ω	If > 5 Ω, check for OPEN IAHFI.
2 to IAHFI	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	< 5 Ω	If > 5 Ω, check for OPEN IAHFI.
3 to B+	< 5 Ω	If > 5 Ω, check for OPEN circuit.
6 to E1-96	< 5 Ω	If > 5 Ω, check for OPEN circuit.
6 to GND	> 1k Ω	If < 1k Ω check for short to GND.
7 to E1-72	< 5 Ω	If > 5 Ω, check for OPEN circuit.
7 to GND	> 1k Ω	If < 1k Ω check for short to GND.
8 to E1-67	< 5 Ω	If > 5 Ω, check for OPEN circuit.
8 to GND	> 1k Ω	If < 1k Ω check for short to GND.
If all checks are within specification, but DTCs are still active, replace the IAHR.		

IAHFS (Inlet Air Heater Fuel Solenoid)

SPN	FMI	Condition	Possible Causes
626	3	IAHFS short to PWR	• IAHFS circuit short to PWR
626	4	IAHFS short to GND	• IAHFS circuit short to GND
626	5	IAHFS open load/circuit	• IAHFS circuit OPEN • IAHFS failure
626	18	Inlet Air Heater fault: Lack of heat in the Intake Manifold	• Biased IMT sensor or circuit • Inlet Air Heater System failure • Failed Inlet Air Heater Fuel Solenoid • Failed Inlet Air Heater Fuel Igniter • Failed Inlet Air Heater Relay • Inlet Air Heater circuit faults • Aftermarket engine block heater • Restricted Fuel Igniter supply line

Figure 197 IAHFS circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4827 (IAHFS)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Connector Voltage Check – IAHFS Disconnected

Connect Breakout Harness ZTSE4827 to engine harness. Leave IAHFS disconnected. Use DMM to measure voltage.

Test Point	Specifications	Comment – < Less than, > Greater than
2 to GND	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check (page 423).
1 to GND	3.5 V ± 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check (page 423).
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE4827 between IAHFS and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Inlet Air Heater Fuel Solenoid from the drop-down menu.
3. Command Inlet Air Heater Fuel Solenoid to 5%.
4. Use DMM to measure voltage.
5. Command Inlet Air Heater Fuel Solenoid to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5% = 12 V ± 2.0 V	If < 10 V, check for OPEN circuit.
1 to GND	95% = 0.5 V ± 0.5 V	If > 1 V, check for OPEN circuit or failed IAHFS.

Actuator Resistance Check

Turn ignition switch OFF. Connect Breakout Harness ZTSE4827 to IAHFS and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to 2	8 Ω	If not within specification, replace IAHFS.
If measurements are within specifications, do Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4827 to IAHFS engine harness, and leave IAHFS disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-03	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-29	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, replace the IAHFS valve.		

Cylinder Balance

SPN	FMI	Condition	Possible Causes	Actions
651	13	Injector 1 programmable parameter error	• Incorrect Programmed IQA	Step-Based Diagnostics (page 429)
651	16	Injector 1 Fuel quantity/timing high error	• Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 431)
651	18	Injector 1 Fuel quantity/timing low error	• Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 433)
652	13	Injector 1 programmable parameter error	• Incorrect Programmed IQA	Step-Based Diagnostics (page 435)
652	16	Injector 2 Fuel quantity/timing high error	• Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 437)
652	18	Injector 2 Fuel quantity/timing low error	• Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 439)
653	13	Injector 1 programmable parameter error	• Incorrect Programmed IQA	Step-Based Diagnostics (page 441)
653	16	Injector 3 Fuel quantity/timing high error	• Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 443)

653	18	Injector 3 Fuel quantity/timing low error	•	Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 445)
654	13	Injector 1 programmable parameter error	•	Incorrect Programmed IQA	Step-Based Diagnostics (page 447)
654	16	Injector 4 Fuel quantity/timing high error	•	Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 449)
654	18	Injector 4 Fuel quantity/timing low error	•	Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 451)
655	13	Injector 1 programmable parameter error	•	Incorrect Programmed IQA	Step-Based Diagnostics (page 453)
655	16	Injector 5 Fuel quantity/timing high error	•	Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 455)
655	18	Injector 5 Fuel quantity/timing low error	•	Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 457)
656	13	Injector 1 programmable parameter error	•	Incorrect Programmed IQA	Step-Based Diagnostics (page 459)

656	16	Injector 6 Fuel quantity/timing high error	•	Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 461)
656	18	Injector 6 Fuel quantity/timing low error	•	Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 463)
1322	31	Misfire – Multiple cylinders	•	Low Fuel Delivery Pressure (FDP) • Low Fuel Rail Pressure (FRP) • Crankshaft Position (CKP) sensor out of calibration • Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 465)
1323	31	Misfire – Cylinder 1	•	Low Fuel Delivery Pressure (FDP) • Low Fuel Rail Pressure (FRP) • Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 469)

1324	31	Misfire – Cylinder 2	• Low Fuel Delivery Pressure (FDP) • Low Fuel Rail Pressure (FRP) • Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 472)
1325	31	Misfire – Cylinder 3	• Low Fuel Delivery Pressure (FDP) • Low Fuel Rail Pressure (FRP) • Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 475)
1326	31	Misfire – Cylinder 4	• Low Fuel Delivery Pressure (FDP) • Low Fuel Rail Pressure (FRP) • Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 478)

1327	31	Misfire – Cylinder 5	• Low Fuel Delivery Pressure (FDP) • Low Fuel Rail Pressure (FRP) • Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 481)
1328	31	Misfire – Cylinder 6	• Low Fuel Delivery Pressure (FDP) • Low Fuel Rail Pressure (FRP) • Contaminated fuel • Failed injector (Mechanical) • Base engine compression imbalance	Step-Based Diagnostics (page 484)

Overview

Many factors influence the combustion process in a power cylinder. This can affect the production of torque or horsepower from that cylinder. Some of the factors include piston and cylinder geometry, injector performance, and fuel rail pressure. Variations in these factors can cause unevenness in torque and horsepower from one cylinder to the next. Power cylinder unevenness also causes increased engine noise and vibration, especially at low idle. This is also referred to as rough idle.

The Engine Control Module (ECM) uses a Cylinder Balance control strategy to even the power contribution of the cylinders, particularly at low idle. This strategy incorporates information from the Crankshaft Position (CKP) sensor. The ECM uses the instantaneous engine speed near Top Dead Center (TDC) for each cylinder as an indication of that cylinder's power contribution. The ECM computes a nominal instantaneous engine speed value based on all cylinders. The nominal value would be the expected value from all cylinders if the engine is balanced.

By knowing the error quantities, the ECM can add or subtract fuel from a particular cylinder. The control strategy attempts to correct the cylinder unbalance by using fuel quantity compensation through adjustments of the pulse width values for each fuel injector. This method of compensation is repeated until all error quantities are close to zero causing all cylinders to contribute the same amount.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

SPN 651 FMI 13- Injector 1 programmable parameter error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Incorrect Injector Quantity Adjustment (IQA) programed to Engine Control Module (ECM).	IQA checksum or range error	Key ON (runs once per key cycle)	Immediate

Fault Overview

Fault code sets when Engine Control Module (ECM) detects an incorrect Injector Quantity Adjustment (IQA) has been programmed into the ECM.

Malfunction Indicator Lamp (MIL) Reaction

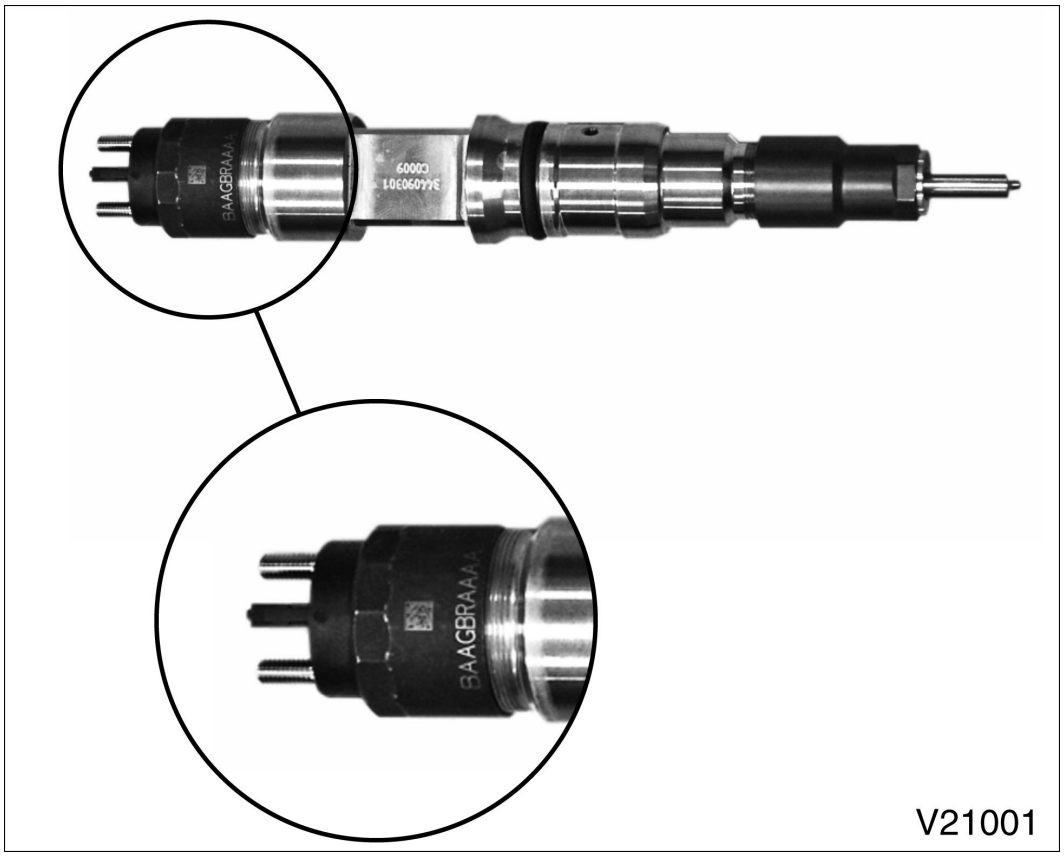
MIL will illuminate when this fault is detected during one drive cycle.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Incorrect Programmed IQA



Step	Action	Decision
1	Check that the proper Injector Quantity Adjustment (IQA) is programed into the Engine Control Module (ECM). 1. Remove valve cover (see Engine Service Manual) and engine brake housing. Document the IQA code for all six injectors. 2. Using Electronic Service Tool (EST) with ServiceMaxx, select Procedures > KOEO Procedures > Injection Quantity Adjustment. Do the IQA codes displayed in ServiceMaxx match the injectors in the engine?	Yes: Clear fault code. Recheck IQA codes. After repairs are complete, retest for SPN 651 FMI 13. No: Reprogram ECM with correct IQA codes (follow on screen instructions). After repairs are complete, retest for SPN 651 FMI 13.

NOTE: After performing all diagnostic steps, if SPN 651 FMI 13 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 651 FMI 16- Injector 1 Fuel quantity/timing high error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized for longer than expected.	The sum of actual and learned energizing time > 580 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine Speed Steady: Engine speed variation < 100 rpm, per time > 3 seconds Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized longer than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 651 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Aerated fuel delivery
- Failed injector (Mechanical)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 651 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17. Is EST DTC list free of SPN 94; SPN 157; SPN 651 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15, and 17?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 651 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15 and 17. After repairs are complete, retest for SPN 651 FMI 16.

Step	Action	Decision
2	Check for low Fuel Delivery Pressure (FDP). Using EST, monitor FDP at idle. Is FDP above 85 psi??	Yes: Go to step 3. No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 651 FMI 16.

Step	Action	Decision
3	Check for aeration in low-pressure fuel system. Perform Fuel Aeration Test (page 131). Is low-pressure fuel system free from aeration?	Yes: Go to step 4. No: Repair aeration in low-pressure fuel system. After repairs are complete, retest for SPN 651 FMI 16.

Step	Action	Decision
4	Run the fault monitors to determine source of fault. • Using EST, load the HD-OBD monitors session. Click the refresh button at the bottom to load the values. Save a screen shot documenting the Injector quantity/timing error values. • Clear all faults, Start the engine and run for 5 minutes at high idle. Verify that the engine coolant temperature is above 160°F (71°C). • Return the engine to normal idle for 5 minutes • Using the HD-OBD monitors session monitor the injector timing quantity error values. Refresh the page using the refresh button at the bottom and save a screen shot of the new values. • Compare last screen shot to the previous. Verify all values changed from the previous screen shot indicating the monitors have run properly. Is EST DTC list free from SPN 651 FMI 16?	Yes: Clear fault. No: Replace Injector 1. After repairs are complete, retest for SPN 651 FMI 16.

NOTE: After performing all diagnostic steps, if SPN 651 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 651 FMI 18- Injector 1 Fuel quantity/timing low error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized shorter than expected.	The sum of actual and learned fuel rail pressure energizing times < 320 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine speed steady: Engine speed variation < 100 rpm, per time > 3 seconds] Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized shorter than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); and SPN 651 FMI 4, 5, and 13 (CYL/INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); and SPN 651 FMI 4, 5, and 13 (CYL/INJ). Is EST DTC list free of SPN 94; SPN 157; and SPN 651 FMI 4, 5, and 13?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; and SPN 651 FMI 4, 5, and 13. After repairs are complete, retest for SPN 651 FMI 18.

Step	Action	Decision
2	Check fuel for contamination. Perform Fuel Quality Check (page 154). Is the fuel contaminated?	Yes: Drain fuel tank and fill fuel tank with appropriate diesel fuel. After repairs are complete, retest for SPN 651 FMI 18. No: Go to step 3.

Step	Action	Decision
3	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 651 FMI 18. No: Go to step 4.

Step	Action	Decision
4	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 5. No: Retest for SPN 651 FMI 18.

Step	Action	Decision
5	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 651 FMI 18. No: Repair failed valve train components. After repairs are complete retest for SPN 651 FMI 18.

NOTE: After performing all diagnostic steps, if SPN 651 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 652 FMI 13- Injector 2 programmable parameter error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Incorrect Injector Quantity Adjustment (IQA) programed to Engine Control Module (ECM).	IQA checksum or range error	Key ON (runs once per key cycle)	Immediate

Fault Overview

Fault code sets when Engine Control Module (ECM) detects an incorrect Injector Quantity Adjustment (IQA) has been programmed into the ECM.

Malfunction Indicator Lamp (MIL) Reaction

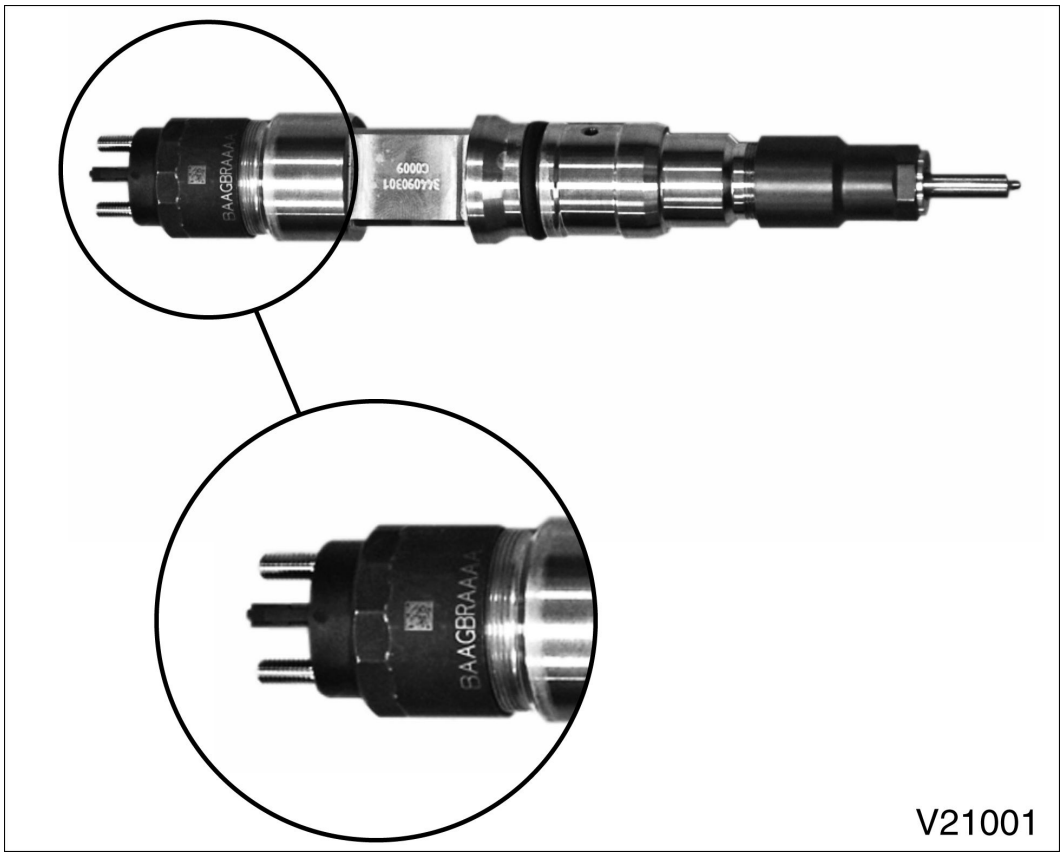
MIL will illuminate when this fault is detected during one drive cycle.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Incorrect Programmed IQA



Step	Action	Decision
1	Check that the proper Injector Quantity Adjustment (IQA) is programed into the Engine Control Module (ECM). 1. Remove valve cover (see Engine Service Manual) and engine brake housing. Document the IQA code for all six injectors. 2. Using Electronic Service Tool (EST) with ServiceMaxx, select Procedures > KOEO Procedures > Injection Quantity Adjustment. Do the IQA codes displayed in ServiceMaxx match the injectors in the engine?	Yes: Clear fault code. Recheck IQA codes. After repairs are complete, retest for SPN 652 FMI 13. No: Reprogram ECM with correct IQA codes (follow on screen instructions). After repairs are complete, retest for SPN 652 FMI 13.

NOTE: After performing all diagnostic steps, if SPN 652 FMI 13 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 652 FMI 16- Injector 2 Fuel quantity/timing high error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized for longer than expected.	The sum of actual and learned energizing time > 580 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine Speed Steady: Engine speed variation < 100 rpm, per time > 3 seconds Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized longer than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 652 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Aerated fuel delivery
- Failed injector (Mechanical)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 652 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17. Is EST DTC list free of SPN 94; SPN 157; SPN 652 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15, and 17?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 652 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15 and 17. After repairs are complete, retest for SPN 652 FMI 16.

Step	Action	Decision
2	Check for low Fuel Delivery Pressure (FDP). Using EST, monitor FDP at idle. Is FDP above 85 psi??	Yes: Go to step 3. No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 652 FMI 16.

Step	Action	Decision
3	Check for aeration in low-pressure fuel system. Perform Fuel Aeration Test (page 131). Is low-pressure fuel system free from aeration?	Yes: Go to step 4. No: Repair aeration in low-pressure fuel system. After repairs are complete, retest for SPN 652 FMI 16.

Step	Action	Decision
4	Run the fault monitors to determine source of fault. • Using EST, load the HD-OBD monitors session. Click the refresh button at the bottom to load the values. Save a screen shot documenting the Injector quantity/timing error values. • Clear all faults, Start the engine and run for 5 minutes at high idle. Verify that the engine coolant temperature is above 160°F (71°C). • Return the engine to normal idle for 5 minutes • Using the HD-OBD monitors session monitor the injector timing quantity error values. Refresh the page using the refresh button at the bottom and save a screen shot of the new values. • Compare last screen shot to the previous. Verify all values changed from the previous screen shot indicating the monitors have run properly. Is EST DTC list free from SPN 652 FMI 16?	Yes: Clear fault. No: Replace Injector 2. After repairs are complete, retest for SPN 652 FMI 16.

NOTE: After performing all diagnostic steps, if SPN 652 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 652 FMI 18- Injector 2 Fuel quantity/timing low error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized shorter than expected.	The sum of actual and learned fuel rail pressure energizing times < 320 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine speed steady: Engine speed variation < 100 rpm, per time > 3 seconds] Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized shorter than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); and SPN 652 FMI 4, 5, and 13 (CYL/INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); and SPN 652 FMI 4, 5, and 13 (CYL/INJ). Is EST DTC list free of SPN 94; SPN 157; and SPN 652 FMI 4, 5, and 13?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; and SPN 652 FMI 4, 5, and 13. After repairs are complete, retest for SPN 652 FMI 18.

Step	Action	Decision
2	Check fuel for contamination. Perform Fuel Quality Check (page 154). Is the fuel contaminated?	Yes: Drain fuel tank and fill fuel tank with appropriate diesel fuel. After repairs are complete, retest for SPN 652 FMI 18. No: Go to step 3.

Step	Action	Decision
3	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 652 FMI 18. No: Go to step 4.

Step	Action	Decision
4	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 5. No: Retest for SPN 652 FMI 18.

Step	Action	Decision
5	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 652 FMI 18. No: Repair failed valve train components. After repairs are complete retest for SPN 652 FMI 18.

NOTE: After performing all diagnostic steps, if SPN 652 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 653 FMI 13- Injector 3 programmable parameter error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Incorrect Injector Quantity Adjustment (IQA) programed to Engine Control Module (ECM).	IQA checksum or range error	Key ON (runs once per key cycle)	Immediate

Fault Overview

Fault code sets when Engine Control Module (ECM) detects an incorrect Injector Quantity Adjustment (IQA) has been programmed into the ECM.

Malfunction Indicator Lamp (MIL) Reaction

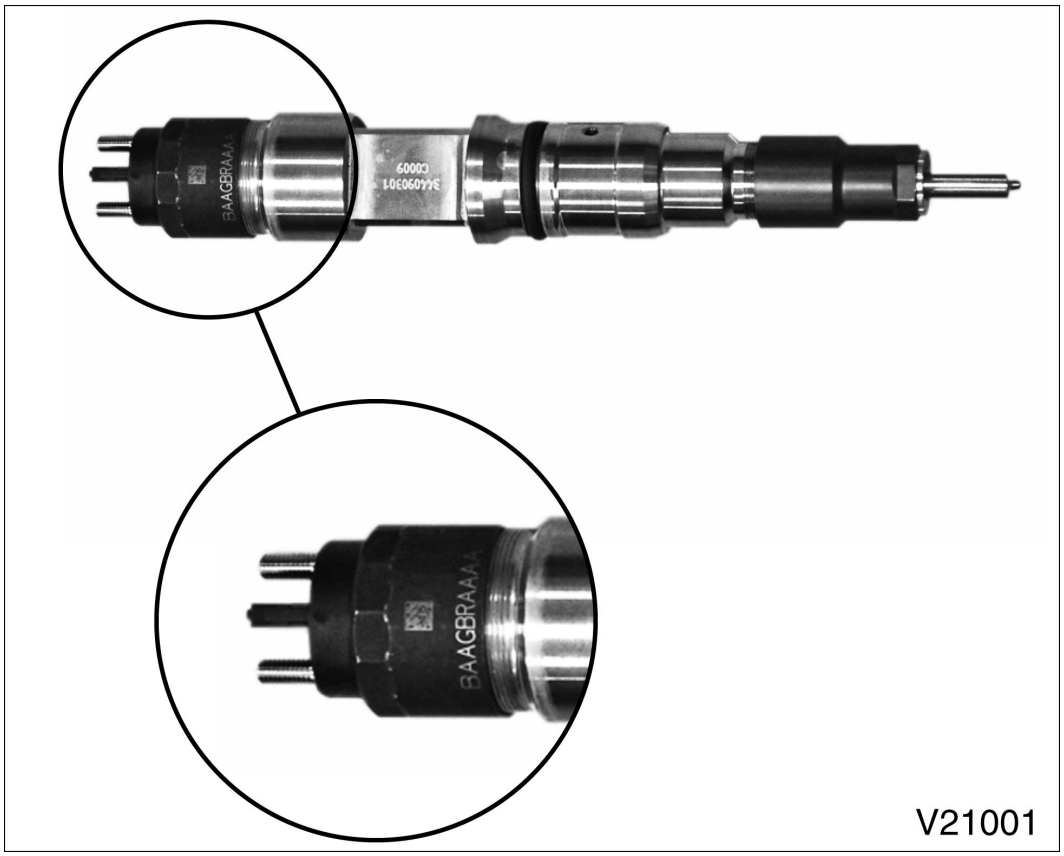
MIL will illuminate when this fault is detected during one drive cycle.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Incorrect Programmed IQA



Step	Action	Decision
1	Check that the proper Injector Quantity Adjustment (IQA) is programed into the Engine Control Module (ECM). 1. Remove valve cover (see Engine Service Manual) and engine brake housing. Document the IQA code for all six injectors. 2. Using Electronic Service Tool (EST) with ServiceMaxx, select Procedures > KOEO Procedures > Injection Quantity Adjustment. Do the IQA codes displayed in ServiceMaxx match the injectors in the engine?	Yes: Clear fault code. Recheck IQA codes. After repairs are complete, retest for SPN 653 FMI 13. No: Reprogram ECM with correct IQA codes (follow on screen instructions). After repairs are complete, retest for SPN 653 FMI 13.

NOTE: After performing all diagnostic steps, if SPN 653 FMI 13 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 653 FMI 16- Injector 3 Fuel quantity/timing high error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized for longer than expected.	The sum of actual and learned energizing time > 580 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine Speed Steady: Engine speed variation < 100 rpm, per time > 3 seconds Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized longer than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 653 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Aerated fuel delivery
- Failed injector (Mechanical)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 653 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17. Is EST DTC list free of SPN 94; SPN 157; SPN 653 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15, and 17?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 653 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15 and 17. After repairs are complete, retest for SPN 653 FMI 16.

Step	Action	Decision
2	Check for low Fuel Delivery Pressure (FDP). Using EST, monitor FDP at idle. Is FDP above 85 psi??	Yes: Go to step 3. No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 653 FMI 16.

Step	Action	Decision
3	Check for aeration in low-pressure fuel system. Perform Fuel Aeration Test (page 131). Is low-pressure fuel system free from aeration?	Yes: Go to step 4. No: Repair aeration in low-pressure fuel system. After repairs are complete, retest for SPN 653 FMI 16.

Step	Action	Decision
4	Run the fault monitors to determine source of fault. • Using EST, load the HD-OBD monitors session. Click the refresh button at the bottom to load the values. Save a screen shot documenting the Injector quantity/timing error values. • Clear all faults, Start the engine and run for 5 minutes at high idle. Verify that the engine coolant temperature is above 160°F (71°C). • Return the engine to normal idle for 5 minutes • Using the HD-OBD monitors session monitor the injector timing quantity error values. Refresh the page using the refresh button at the bottom and save a screen shot of the new values. • Compare last screen shot to the previous. Verify all values changed from the previous screen shot indicating the monitors have run properly. Is EST DTC list free from SPN 653 FMI 16?	Yes: Clear fault. No: Replace Injector 3. After repairs are complete, retest for SPN 653 FMI 16.

NOTE: After performing all diagnostic steps, if SPN 653 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 653 FMI 18- Injector 3 Fuel quantity/timing low error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized shorter than expected.	The sum of actual and learned fuel rail pressure energizing times < 320 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine speed steady: Engine speed variation < 100 rpm, per time > 3 seconds] Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized shorter than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); and SPN 653 FMI 4, 5, and 13 (CYL/INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); and SPN 653 FMI 4, 5, and 13 (CYL/INJ). Is EST DTC list free of SPN 94; SPN 157; and SPN 653 FMI 4, 5, and 13?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; and SPN 653 FMI 4, 5, and 13. After repairs are complete, retest for SPN 653 FMI 18.

Step	Action	Decision
2	Check fuel for contamination. Perform Fuel Quality Check (page 154). Is the fuel contaminated?	Yes: Drain fuel tank and fill fuel tank with appropriate diesel fuel. After repairs are complete, retest for SPN 653 FMI 18. No: Go to step 3.

Step	Action	Decision
3	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 653 FMI 18. No: Go to step 4.

Step	Action	Decision
4	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 5. No: Retest for SPN 653 FMI 18.

Step	Action	Decision
5	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 653 FMI 18. No: Repair failed valve train components. After repairs are complete retest for SPN 653 FMI 18.

NOTE: After performing all diagnostic steps, if SPN 653 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 654 FMI 13- Injector 4 programmable parameter error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Incorrect Injector Quantity Adjustment (IQA) programed to Engine Control Module (ECM).	IQA checksum or range error	Key ON (runs once per key cycle)	Immediate

Fault Overview

Fault code sets when Engine Control Module (ECM) detects an incorrect Injector Quantity Adjustment (IQA) has been programmed into the ECM.

Malfunction Indicator Lamp (MIL) Reaction

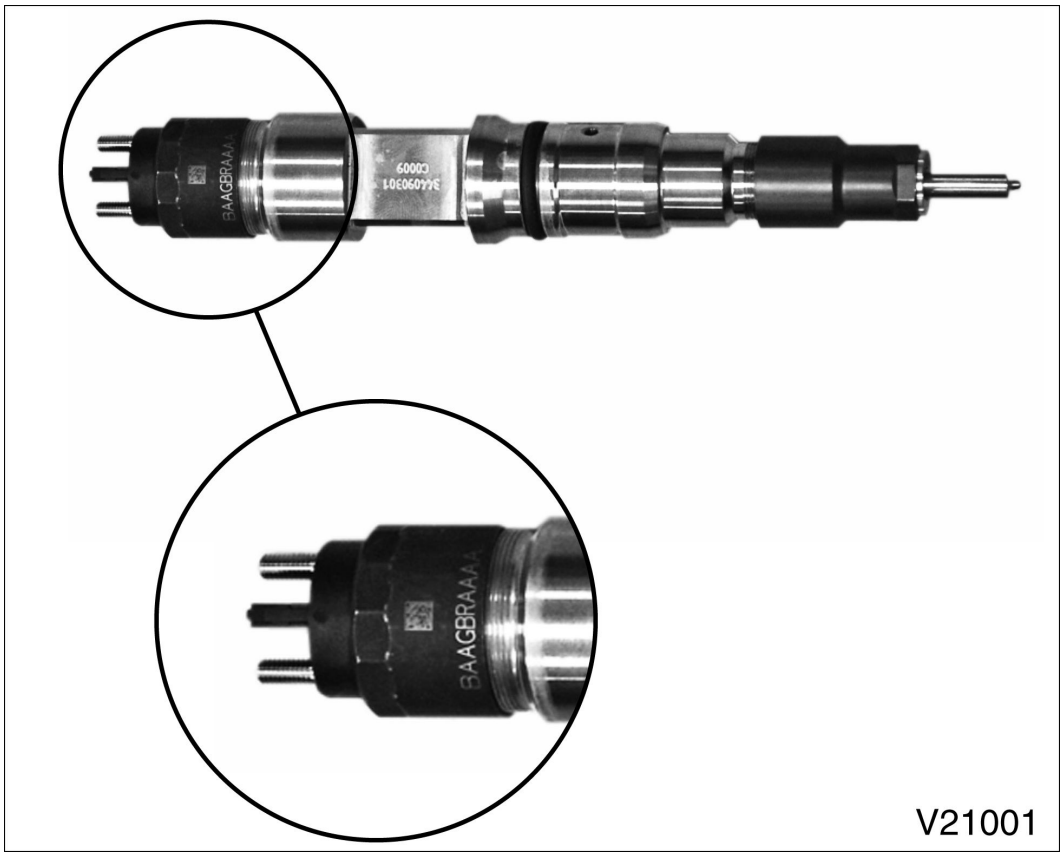
MIL will illuminate when this fault is detected during one drive cycle.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Incorrect Programmed IQA



Step	Action	Decision
1	Check that the proper Injector Quantity Adjustment (IQA) is programed into the Engine Control Module (ECM). 1. Remove upper valve cover (see Engine Service Manual) and engine brake housing. Document the IQA code for all six injectors. 2. Using Electronic Service Tool (EST) with ServiceMaxx, select Procedures > KOEO Procedures > Injection Quantity Adjustment. Do the IQA codes displayed in ServiceMaxx match the injectors in the engine?	Yes: Clear fault code. Recheck IQA codes. After repairs are complete, retest for SPN 654 FMI 13. No: Reprogram ECM with correct IQA codes (follow on screen instructions). After repairs are complete, retest for SPN 654 FMI 13.

NOTE: After performing all diagnostic steps, if SPN 654 FMI 13 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 654 FMI 16- Injector 1 Fuel quantity/timing high error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized for longer than expected.	The sum of actual and learned energizing time > 580 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine Speed Steady: Engine speed variation < 100 rpm, per time > 3 seconds Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized longer than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 654 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Aerated fuel delivery
- Failed injector (Mechanical)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 652 FMI 4, 5, 13, 20 and 21(CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17. Is EST DTC list free of SPN 94; SPN 157; SPN 654 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15, and 17?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 654 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15 and 17. After repairs are complete, retest for SPN 654 FMI 16.

Step	Action	Decision
2	Check for low Fuel Delivery Pressure (FDP). Using EST, monitor FDP at idle. Is FDP above 85 psi??	Yes: Go to step 3. No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 654 FMI 16.

Step	Action	Decision
3	Check for aeration in low-pressure fuel system. Perform Fuel Aeration Test (page 131). Is low-pressure fuel system free from aeration?	Yes: Go to step 4. No: Repair aeration in low-pressure fuel system. After repairs are complete, retest for SPN 654 FMI 16.

Step	Action	Decision
4	Run the fault monitors to determine source of fault. • Using EST, load the HD-OBD monitors session. Click the refresh button at the bottom to load the values. Save a screen shot documenting the Injector quantity/timing error values. • Clear all faults, Start the engine and run for 5 minutes at high idle. Verify that the engine coolant temperature is above 160°F (71°C). • Return the engine to normal idle for 5 minutes • Using the HD-OBD monitors session monitor the injector timing quantity error values. Refresh the page using the refresh button at the bottom and save a screen shot of the new values. • Compare last screen shot to the previous. Verify all values changed from the previous screen shot indicating the monitors have run properly. Is EST DTC list free from SPN 654 FMI 16?	Yes: Clear fault. No: Replace Injector 4. After repairs are complete, retest for SPN 654 FMI 16.

NOTE: After performing all diagnostic steps, if SPN 654 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 654 FMI 18- Injector 4 Fuel quantity/timing low error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized shorter than expected.	The sum of actual and learned fuel rail pressure energizing times < 320 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine speed steady: Engine speed variation < 100 rpm, per time > 3 seconds] Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized shorter than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); and SPN 654 FMI 4, 5, and 13 (CYL/INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); and SPN 654 FMI 4, 5, and 13 (CYL/INJ). Is EST DTC list free of SPN 94; SPN 157; and SPN 654 FMI 4, 5, and 13?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; and SPN 654 FMI 4, 5, and 13. After repairs are complete, retest for SPN 654 FMI 18.

Step	Action	Decision
2	Check fuel for contamination. Perform Fuel Quality Check (page 154). Is the fuel contaminated?	Yes: Drain fuel tank and fill fuel tank with appropriate diesel fuel. After repairs are complete, retest for SPN 654 FMI 18. No: Go to step 3.

Step	Action	Decision
3	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 654 FMI 18. No: Go to step 4.

Step	Action	Decision
4	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 5. No: Retest for SPN 654 FMI 18.

Step	Action	Decision
5	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 654 FMI 18. No: Repair failed valve train components. After repairs are complete retest for SPN 654 FMI 18.

NOTE: After performing all diagnostic steps, if SPN 654 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 655 FMI 13- Injector 5 programmable parameter error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Incorrect Injector Quantity Adjustment (IQA) programed to Engine Control Module (ECM).	IQA checksum or range error	Key ON (runs once per key cycle)	Immediate

Fault Overview

Fault code sets when Engine Control Module (ECM) detects an incorrect Injector Quantity Adjustment (IQA) has been programmed into the ECM.

Malfunction Indicator Lamp (MIL) Reaction

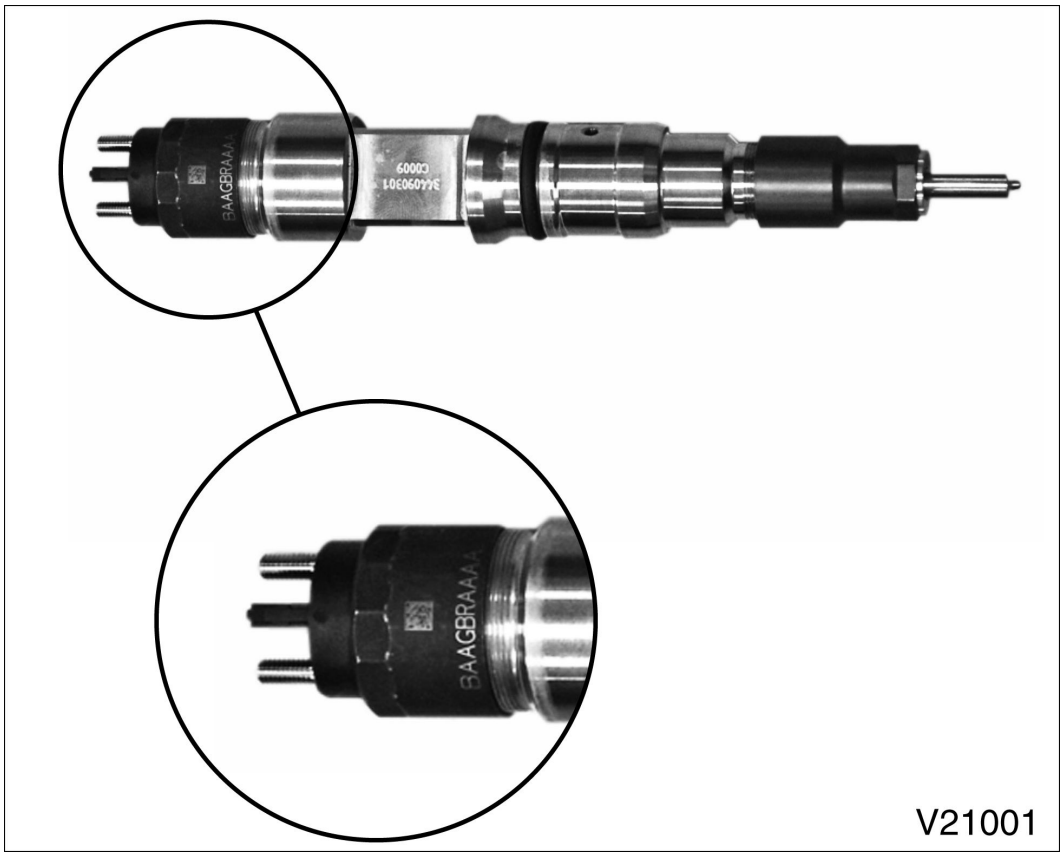
MIL will illuminate when this fault is detected during one drive cycle.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Incorrect Programmed IQA



Step	Action	Decision
1	Check that the proper Injector Quantity Adjustment (IQA) is programed into the Engine Control Module (ECM). 1. Remove upper valve cover (see Engine Service Manual) and engine brake housing. Document the IQA code for all six injectors. 2. Using Electronic Service Tool (EST) with ServiceMaxx, select Procedures > KOEO Procedures > Injection Quantity Adjustment. Do the IQA codes displayed in ServiceMaxx match the injectors in the engine?	Yes: Clear fault code. Recheck IQA codes. After repairs are complete, retest for SPN 655 FMI 13. No: Reprogram ECM with correct IQA codes (follow on screen instructions). After repairs are complete, retest for SPN 655 FMI 13.

NOTE: After performing all diagnostic steps, if SPN 655 FMI 13 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 655 FMI 16- Injector 5 Fuel quantity/timing high error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized for longer than expected.	The sum of actual and learned energizing time > 580 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine Speed Steady: Engine speed variation < 100 rpm, per time > 3 seconds Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized longer than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 655 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Aerated fuel delivery
- Failed injector (Mechanical)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 655 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17. Is EST DTC list free of SPN 94; SPN 157; SPN 655 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15, and 17?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 655 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15 and 17. After repairs are complete, retest for SPN 655 FMI 16.

Step	Action	Decision
2	Check for low Fuel Delivery Pressure (FDP). Using EST, monitor FDP at idle. Is FDP above 85 psi??	Yes: Go to step 3. No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 655 FMI 16.

Step	Action	Decision
3	Check for aeration in low-pressure fuel system. Perform Fuel Aeration Test (page 131). Is low-pressure fuel system free from aeration?	Yes: Go to step 4. No: Repair aeration in low-pressure fuel system. After repairs are complete, retest for SPN 655 FMI 16.

Step	Action	Decision
4	Run the fault monitors to determine source of fault. • Using EST, load the HD-OBD monitors session. Click the refresh button at the bottom to load the values. Save a screen shot documenting the Injector quantity/timing error values. • Clear all faults, Start the engine and run for 5 minutes at high idle. Verify that the engine coolant temperature is above 160°F (71°C). • Return the engine to normal idle for 5 minutes • Using the HD-OBD monitors session monitor the injector timing quantity error values. Refresh the page using the refresh button at the bottom and save a screen shot of the new values. • Compare last screen shot to the previous. Verify all values changed from the previous screen shot indicating the monitors have run properly. Is EST DTC list free from SPN 655 FMI 16?	Yes: Clear fault. No: Replace Injector 5. After repairs are complete, retest for SPN 655 FMI 16.

NOTE: After performing all diagnostic steps, if SPN 655 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 655 FMI 18- Injector 5 Fuel quantity/timing low error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized shorter than expected.	The sum of actual and learned fuel rail pressure energizing times < 320 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine speed steady: Engine speed variation < 100 rpm, per time > 3 seconds] Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized shorter than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); and SPN 655 FMI 4, 5, and 13 (CYL/INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); and SPN 655 FMI 4, 5, and 13 (CYL/INJ). Is EST DTC list free of SPN 94; SPN 157; and SPN 655 FMI 4, 5, and 13?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; and SPN 655 FMI 4, 5, and 13. After repairs are complete, retest for SPN 655 FMI 18.

Step	Action	Decision
2	Check fuel for contamination. Perform Fuel Quality Check (page 154). Is the fuel contaminated?	Yes: Drain fuel tank and fill fuel tank with appropriate diesel fuel. After repairs are complete, retest for SPN 655 FMI 18. No: Go to step 3.

Step	Action	Decision
3	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 655 FMI 18. No: Go to step 4.

Step	Action	Decision
4	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 5. No: Retest for SPN 655 FMI 18.

Step	Action	Decision
5	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 655 FMI 18. No: Repair failed valve train components. After repairs are complete retest for SPN 655 FMI 18.

NOTE: After performing all diagnostic steps, if SPN 655 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 656 FMI 13- Injector 6 programmable parameter error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Incorrect Injector Quantity Adjustment (IQA) programed to Engine Control Module (ECM).	IQA checksum or range error	Key ON (runs once per key cycle)	Immediate

Fault Overview

Fault code sets when Engine Control Module (ECM) detects an incorrect Injector Quantity Adjustment (IQA) has been programmed into the ECM.

Malfunction Indicator Lamp (MIL) Reaction

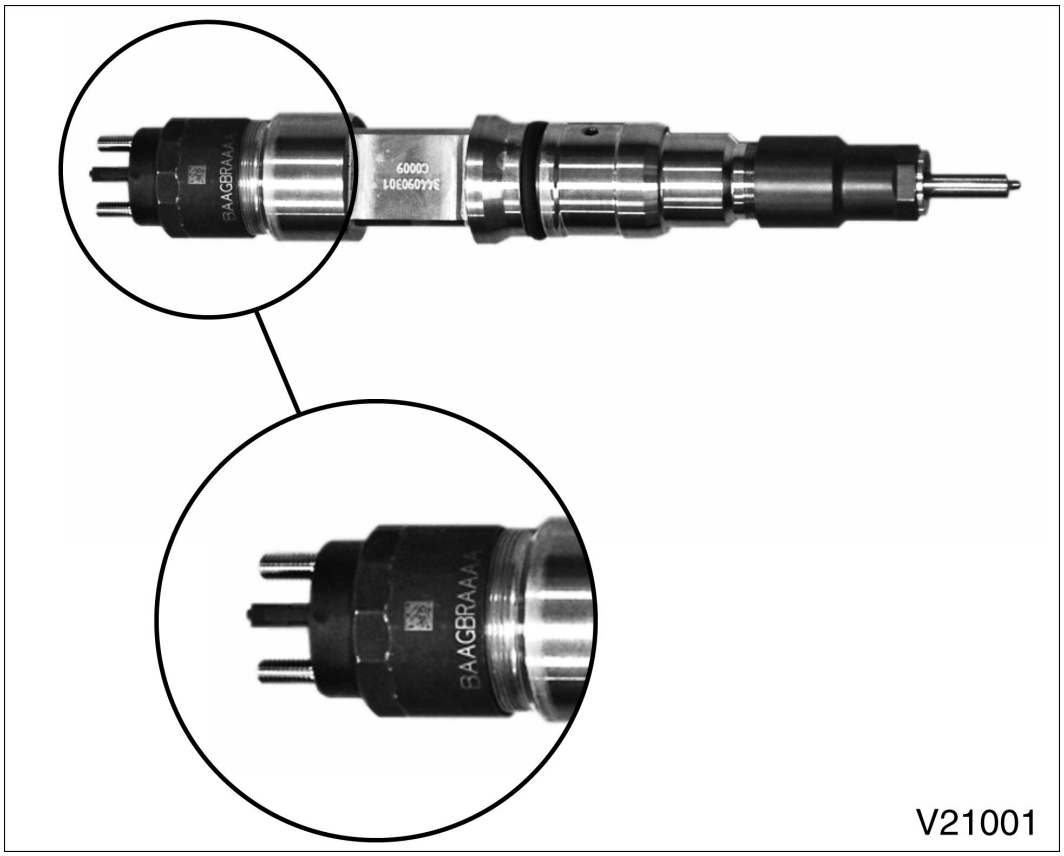
MIL will illuminate when this fault is detected during one drive cycle.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Incorrect Programmed IQA



Step	Action	Decision
1	Check that the proper Injector Quantity Adjustment (IQA) is programed into the Engine Control Module (ECM). 1. Remove upper valve cover (see Engine Service Manual) and engine brake housing. Document the IQA code for all six injectors. 2. Using Electronic Service Tool (EST) with ServiceMaxx, select Procedures > KOEO Procedures > Injection Quantity Adjustment. Do the IQA codes displayed in ServiceMaxx match the injectors in the engine?	Yes: Clear fault code. Recheck IQA codes. After repairs are complete, retest for SPN 656 FMI 13. No: Reprogram ECM with correct IQA codes (follow on screen instructions). After repairs are complete, retest for SPN 656 FMI 13.

NOTE: After performing all diagnostic steps, if SPN 656 FMI 13 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 656 FMI 16- Injector 6 Fuel quantity/timing high error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized for longer than expected.	The sum of actual and learned energizing time > 580 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine Speed Steady: Engine speed variation < 100 rpm, per time > 3 seconds Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized longer than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 656 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Aerated fuel delivery
- Failed injector (Mechanical)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 656 FMI 4, 5, and 13 (CYL/INJ); and SPN 3055 FMI 0, 1, 15, and 17. Is EST DTC list free of SPN 94; SPN 157; SPN 656 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15, and 17?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 656 FMI 4, 5, and 13; and SPN 3055 FMI 0, 1, 15 and 17. After repairs are complete, retest for SPN 656 FMI 16.

Step	Action	Decision
2	Check for low Fuel Delivery Pressure (FDP). Using EST, monitor FDP at idle. Is FDP above 85 psi??	Yes: Go to step 3. No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 656 FMI 16.

Step	Action	Decision
3	Check for aeration in low-pressure fuel system. Perform Fuel Aeration Test (page 131). Is low-pressure fuel system free from aeration?	Yes: Go to step 4. No: Repair aeration in low-pressure fuel system. After repairs are complete, retest for SPN 656 FMI 16.

Step	Action	Decision
4	Run the fault monitors to determine source of fault. • Using EST, load the HD-OBD monitors session. Click the refresh button at the bottom to load the values. Save a screen shot documenting the Injector quantity/timing error values. • Clear all faults, Start the engine and run for 5 minutes at high idle. Verify that the engine coolant temperature is above 160°F (71°C). • Return the engine to normal idle for 5 minutes • Using the HD-OBD monitors session monitor the injector timing quantity error values. Refresh the page using the refresh button at the bottom and save a screen shot of the new values. • Compare last screen shot to the previous. Verify all values changed from the previous screen shot indicating the monitors have run properly. Is EST DTC list free from SPN 656 FMI 16?	Yes: Clear fault. No: Replace Injector 6. After repairs are complete, retest for SPN 656 FMI 16.

NOTE: After performing all diagnostic steps, if SPN 656 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 656 FMI 18- Injector 6 Fuel quantity/timing low error

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel injector is energized shorter than expected.	The sum of actual and learned fuel rail pressure energizing times < 320 microseconds	Charge Air Cooler Outlet Temperature (CACOT) > 14°F (-10°C) Engine Coolant Temperature 1 (ECT1) > 158°F (70°C) and < 239°F (115°C) Engine speed steady: Engine speed variation < 100 rpm, per time > 3 seconds] Ambient air pressure (BARO) > 11.6 psi (80 kpa) and < 16 psi (110 kpa) Idle speed error < 50 rpm Engine speed < 800 rpm Fuel command > 6 mg/stroke and < 66 mg / stroke Vehicle stationary Time in entry conditions > 2 seconds Fuel rail pressure deviation < 725 psi (5000 kpa)	1 second

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel injector is energized shorter than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); and SPN 656 FMI 4, 5, and 13 (CYL/INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); and SPN 656 FMI 4, 5, and 13 (CYL/INJ). Is EST DTC list free of SPN 94; SPN 157; and SPN 655 FMI 4, 5, and 13?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; and SPN 656 FMI 4, 5, and 13. After repairs are complete, retest for SPN 656 FMI 18.

Step	Action	Decision
2	Check fuel for contamination. Perform Fuel Quality Check (page 154). Is the fuel contaminated?	Yes: Drain fuel tank and fill fuel tank with appropriate diesel fuel. After repairs are complete, retest for SPN 656 FMI 18. No: Go to step 3.

Step	Action	Decision
3	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 656 FMI 18. No: Go to step 4.

Step	Action	Decision
4	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 5. No: Retest for SPN 656 FMI 18.

Step	Action	Decision
5	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 656 FMI 18. No: Repair failed valve train components. After repairs are complete retest for SPN 656 FMI 18.

NOTE: After performing all diagnostic steps, if SPN 656 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1322 FMI 31- Misfire- Multiple Cylinders

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on multiple cylinders.	Misfire Count > 180	Engine Running Engine speed > 500 rpm and < 950 rpm Idle speed error < 200 rpm Fuel command > 2 mg / stroke and < 60mg / stroke Engine Coolant Temperature 1 (ECT1) > 86°F (30°C) Vehicle speed < 2 mph (3 km/h) Diesel Particulate Filter (DPF) Not regenerating	440 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects multiple cylinder misfires from the Crankshaft Position (CKP) sensor signal.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP)

SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL)

SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Low Fuel Rail Pressure (FRP)
- Crankshaft Position (CKP) sensor out of calibration
- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP). Is EST DTC list free of SPN 94; SPN 157; SPN 633; and SPN 3055?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 633; and SPN 3055. After repairs are complete, retest for SPN 1322 FMI 31.

Step	Action	Decision
2	Using EST with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL). Is EST DTC list free of SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1323; SPN 1324; SPN 1325; SPN 1326; SPN 1327; and SPN 1328?	Yes: Go to step 3. No: Repair SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1323; SPN 1324; SPN 1325; SPN 1326; SPN 1327; and SPN 1328. After repairs are complete, retest for SPN 1322 FMI 31.

Step	Action	Decision
3	Using EST with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 (CYL/INJ); SPN 652 (CYL/INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ). Is EST DTC list free of SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798?	Yes: Go to step 4. No: Repair SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798. After repairs are complete, retest for SPN 1322 FMI 31.

Step	Action	Decision
4	Check for poor fuel quality or contaminants. Perform Fuel Quality Check (page 154). Is fuel sample clean and free of sediments, traces of gasoline or kerosene, and waxing or icing?	Yes: Go to step 5. No: Drain fuel and fill with new or known good diesel fuel. After repairs are complete, retest for SPN 1322 FMI 31.

Step	Action	Decision
5	Using EST with ServiceMaxx software, check Fuel Rail Pressure (FRP). Select Sessions > Performance. Start engine and monitor FRP. Is Fuel Rail Pressure 10,500 psi (72,395 kPa) or greater?	Yes: Go to step 7. No: Go to step 6.

Step	Action	Decision
6	Using EST with ServiceMaxx software, check Fuel Delivery Pressure (FDP). Select Sessions > Performance. Start engine and monitor FDP. Is Fuel Delivery Pressure 60 psi (414 kpa) or greater?	Yes: Perform High-pressure Fuel System tests (page 174). After repairs are complete, retest for SPN 1322 FMI 31.
		No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 1322 FMI 31.

Step	Action	Decision
7	Using EST with ServiceMaxx software, perform crank sensor relearn procedure. 1. Select Sessions > Programming > Service Interval (tab) > Crankshaft Position Learning Reset Request (ID 95232). 2. In Value field select Yes from the drop-down menu. 3. Select Program Engine button (when finished programming Value field will switch back to No). 4. Clear Fault Code and perform drive cycle 2. Did SPN 1322 FMI 31 become active?	Yes: Go to step 8.

Step	Action	Decision
8	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 1322 FMI 31.
		No: Go to step 9.

Step	Action	Decision
9	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 10.
		No: Retest for SPN 1322 FMI 31.

Step	Action	Decision
10	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 1322 FMI 31.
		No: Repair failed valve train components. After repairs are complete retest for SPN 1322 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 1322 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1323 FMI 31- Misfire- Cylinder 1

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on cylinder 1.	Misfire Count > 180	Engine Running Engine speed > 500 rpm and < 950 rpm Idle speed error < 200 rpm Fuel command > 2 mg / stroke and < 60mg / stroke Engine Coolant Temperature 1 (ECT1) > 86°F (30°C) Vehicle speed < 2 mph (3 km/h) Diesel Particulate Filter (DPF) Not regenerating	440 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects a cylinder 1 misfire from the Crankshaft Position (CKP) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP)

SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL)

SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Low Fuel Rail Pressure (FRP)
- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP). Is EST DTC list free of SPN 94; SPN 157; SPN 633; and SPN 3055?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 633; and SPN 3055. After repairs are complete, retest for SPN 1323 FMI 31.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL). Is EST DTC list free of SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1324; SPN 1325; SPN 1326; SPN 1327; and SPN 1328?	Yes: Go to step 3. No: Repair SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1324; SPN 1325; SPN 1326; SPN 1327; and SPN 1328. After repairs are complete, retest for SPN 1323 FMI 31.

Step	Action	Decision
3	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ). Is EST DTC list free of SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798?	Yes: Go to step 4. No: Repair SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798. After repairs are complete, retest for SPN 1323 FMI 31.

Step	Action	Decision
4	Check for poor fuel quality or contaminants. Perform Fuel Quality Check (page 154). Is fuel sample clean and free of sediments, traces of gasoline or kerosene, and waxing or icing?	Yes: Go to step 5. No: Drain fuel and fill with new or known good diesel fuel. After repairs are complete, retest for SPN 1323 FMI 31.

Step	Action	Decision
5	Using EST with ServiceMaxx software, check Fuel Rail Pressure (FRP). Select Sessions > Performance. Start engine and monitor FRP. Is Fuel Rail Pressure 10,500 psi (72,395 kPa) or greater?	Yes: Go to step 7. No: Go to step 6.

Step	Action	Decision
6	Using EST with ServiceMaxx software, check Fuel Delivery Pressure (FDP). Select Sessions > Performance. Start engine and monitor FDP. Is Fuel Delivery Pressure 60 psi (414 kpa) or greater?	Yes: Perform High-pressure Fuel System tests (page 174). After repairs are complete, retest for SPN 1323 FMI 31.
		No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 1323 FMI 31.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 1323 FMI 31.
		No: Go to step 8.

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9.
		No: Retest for SPN 1323 FMI 31.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 1323 FMI 31.
		No: Repair failed valve train components. After repairs are complete retest for SPN 1323 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 1323 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1324 FMI 31- Misfire- Cylinder 2

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on cylinder 2.	Misfire Count > 180	Engine Running Engine speed > 500 rpm and < 950 rpm Idle speed error < 200 rpm Fuel command > 2 mg / stroke and < 60mg / stroke Engine Coolant Temperature 1 (ECT1) > 86°F (30°C) Vehicle speed < 2 mph (3 km/h) Diesel Particulate Filter (DPF) Not regenerating	440 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects a cylinder 2 misfire from the Crankshaft Position (CKP) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP)

SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL)

SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Low Fuel Rail Pressure (FRP)
- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP). Is EST DTC list free of SPN 94; SPN 157; SPN 633; and SPN 3055?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 633; and SPN 3055. After repairs are complete, retest for SPN 1324 FMI 31.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL). Is EST DTC list free of SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1324; SPN 1325; SPN 1326; SPN 1327; and SPN 1328?	Yes: Go to step 3. No: Repair SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1325; SPN 1326; SPN 1327; and SPN 1328. After repairs are complete, retest for SPN 1324 FMI 31.

Step	Action	Decision
3	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ). Is EST DTC list free of SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798?	Yes: Go to step 4. No: Repair SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798. After repairs are complete, retest for SPN 1324 FMI 31.

Step	Action	Decision
4	Check for poor fuel quality or contaminants. Perform Fuel Quality Check (page 154). Is fuel sample clean and free of sediments, traces of gasoline or kerosene, and waxing or icing?	Yes: Go to step 5. No: Drain fuel and fill with new or known good diesel fuel. After repairs are complete, retest for SPN 1324 FMI 31.

Step	Action	Decision
5	Using EST with ServiceMaxx software, check Fuel Rail Pressure (FRP). Select Sessions > Performance. Start engine and monitor FRP. Is Fuel Rail Pressure 10,500 psi (72,395 kPa) or greater?	Yes: Go to step 7. No: Go to step 6.

Step	Action	Decision
6	Using EST with ServiceMaxx software, check Fuel Delivery Pressure (FDP). Select Sessions > Performance. Start engine and monitor FDP. Is Fuel Delivery Pressure 60 psi (414 kpa) or greater?	Yes: Perform High-pressure Fuel System tests (page 174). After repairs are complete, retest for SPN 1324 FMI 31.
		No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 1324 FMI 31.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 1324 FMI 31.
		No: Go to step 8.

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9.
		No: Retest for SPN 1324 FMI 31.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 1324 FMI 31.
		No: Repair failed valve train components. After repairs are complete retest for SPN 1324 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 1324 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1325 FMI 31- Misfire- Cylinder 3

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on cylinder 3.	Misfire Count > 180	Engine Running Engine speed > 500 rpm and < 950 rpm Idle speed error < 200 rpm Fuel command > 2 mg / stroke and < 60mg / stroke Engine Coolant Temperature 1 (ECT1) > 86°F (30°C) Vehicle speed < 2 mph (3 km/h) Diesel Particulate Filter (DPF) Not regenerating	440 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects a cylinder 3 misfire from the Crankshaft Position (CKP) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP)

SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL)

SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Low Fuel Rail Pressure (FRP)
- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP). Is EST DTC list free of SPN 94; SPN 157; SPN 633; and SPN 3055?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 633; and SPN 3055. After repairs are complete, retest for SPN 1325 FMI 31.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL). Is EST DTC list free of SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1324; SPN 1325 ; SPN 1326; SPN 1327; and SPN 1328?	Yes: Go to step 3. No: Repair SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1324; SPN 1326; SPN 1327; and SPN 1328. After repairs are complete, retest for SPN 1325 FMI 31.

Step	Action	Decision
3	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ). Is EST DTC list free of SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798?	Yes: Go to step 4. No: Repair SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798. After repairs are complete, retest for SPN 1325 FMI 31.

Step	Action	Decision
4	Check for poor fuel quality or contaminants. Perform Fuel Quality Check (page 154). Is fuel sample clean and free of sediments, traces of gasoline or kerosene, and waxing or icing?	Yes: Go to step 5. No: Drain fuel and fill with new or known good diesel fuel. After repairs are complete, retest for SPN 1325 FMI 31.

Step	Action	Decision
5	Using EST with ServiceMaxx software, check Fuel Rail Pressure (FRP). Select Sessions > Performance. Start engine and monitor FRP. Is Fuel Rail Pressure 10,500 psi (72,395 kPa) or greater?	Yes: Go to step 7. No: Go to step 6.

Step	Action	Decision
6	Using EST with ServiceMaxx software, check Fuel Delivery Pressure (FDP). Select Sessions > Performance. Start engine and monitor FDP. Is Fuel Delivery Pressure 60 psi (414 kpa) or greater?	Yes: Perform High-pressure Fuel System tests (page 174). After repairs are complete, retest for SPN 1325 FMI 31.
		No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 1325 FMI 31.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 1325 FMI 31.
		No: Go to step 8.

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9.
		No: Retest for SPN 1325 FMI 31.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 1325 FMI 31.
		No: Repair failed valve train components. After repairs are complete retest for SPN 1325 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 1325 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1326 FMI 31- Misfire- Cylinder 4

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on cylinder 4.	Misfire Count > 180	Engine Running Engine speed > 500 rpm and < 950 rpm Idle speed error < 200 rpm Fuel command > 2 mg / stroke and < 60mg / stroke Engine Coolant Temperature 1 (ECT1) > 86°F (30°C) Vehicle speed < 2 mph (3 km/h) Diesel Particulate Filter (DPF) Not regenerating	440 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects a cylinder 4 misfire from the Crankshaft Position (CKP) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP)

SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL)

SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Low Fuel Rail Pressure (FRP)
- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP). Is EST DTC list free of SPN 94; SPN 157; SPN 633; and SPN 3055?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 633; and SPN 3055. After repairs are complete, retest for SPN 1326 FMI 31.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL). Is EST DTC list free of SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1324; SPN 1325; SPN 1327; and SPN 1328?	Yes: Go to step 3. No: Repair SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1324; SPN 1325; SPN 1327; and SPN 1328. After repairs are complete, retest for SPN 1326 FMI 31.

Step	Action	Decision
3	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ). Is EST DTC list free of SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798?	Yes: Go to step 4. No: Repair SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798. After repairs are complete, retest for SPN 1326 FMI 31.

Step	Action	Decision
4	Check for poor fuel quality or contaminants. Perform Fuel Quality Check (page 154). Is fuel sample clean and free of sediments, traces of gasoline or kerosene, and waxing or icing?	Yes: Go to step 5. No: Drain fuel and fill with new or known good diesel fuel. After repairs are complete, retest for SPN 1326 FMI 31.

Step	Action	Decision
5	Using EST with ServiceMaxx software, check Fuel Rail Pressure (FRP). Select Sessions > Performance. Start engine and monitor FRP. Is Fuel Rail Pressure 10,500 psi (72,395 kPa) or greater?	Yes: Go to step 7. No: Go to step 6.

Step	Action	Decision
6	Using EST with ServiceMaxx software, check Fuel Delivery Pressure (FDP). Select Sessions > Performance. Start engine and monitor FDP. Is Fuel Delivery Pressure 60 psi (414 kpa) or greater?	Yes: Perform High-pressure Fuel System tests (page 174). After repairs are complete, retest for SPN 1326 FMI 31.
		No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 1326 FMI 31.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 1326 FMI 31.
		No: Go to step 8.

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9.
		No: Retest for SPN 1326 FMI 31.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 1326 FMI 31.
		No: Repair failed valve train components. After repairs are complete retest for SPN 1326 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 1326 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1327 FMI 31- Misfire- Cylinder 5

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on cylinder 5.	Misfire Count > 180	Engine Running Engine speed > 500 rpm and < 950 rpm Idle speed error < 200 rpm Fuel command > 2 mg / stroke and < 60mg / stroke Engine Coolant Temperature 1 (ECT1) > 86°F (30°C) Vehicle speed < 2 mph (3 km/h) Diesel Particulate Filter (DPF) Not regenerating	440 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects a cylinder 5 misfire from the Crankshaft Position (CKP) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP)

SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); and SPN 1328 (CYL)

SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Low Fuel Rail Pressure (FRP)
- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP). Is EST DTC list free of SPN 94; SPN 157; SPN 633; and SPN 3055?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 633; and SPN 3055. After repairs are complete, retest for SPN 1327 FMI 31.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); and SPN 1328 (CYL). Is EST DTC list free of SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1324; SPN 1325; SPN 1326; and SPN 1328?	Yes: Go to step 3. No: Repair SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1324; SPN 1325 ; SPN 1326; SPN 1327; and SPN 1328. After repairs are complete, retest for SPN 1327 FMI 31.

Step	Action	Decision
3	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ). Is EST DTC list free of SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798?	Yes: Go to step 4. No: Repair SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798. After repairs are complete, retest for SPN 1327 FMI 31.

Step	Action	Decision
4	Check for poor fuel quality or contaminants. Perform Fuel Quality Check (page 154). Is fuel sample clean and free of sediments, traces of gasoline or kerosene, and waxing or icing?	Yes: Go to step 5. No: Drain fuel and fill with new or known good diesel fuel. After repairs are complete, retest for SPN 1327 FMI 31.

Step	Action	Decision
5	Using EST with ServiceMaxx software, check Fuel Rail Pressure (FRP). Select Sessions > Performance. Start engine and monitor FRP. Is Fuel Rail Pressure 10,500 psi (72,395 kPa) or greater?	Yes: Go to step 7. No: Go to step 6.

Step	Action	Decision
6	Using EST with ServiceMaxx software, check Fuel Delivery Pressure (FDP). Select Sessions > Performance. Start engine and monitor FDP. Is Fuel Delivery Pressure 60 psi (414 kpa) or greater?	Yes: Perform High-pressure Fuel System tests (page 174). After repairs are complete, retest for SPN 1327 FMI 31.
		No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 1327 FMI 31.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 1327 FMI 31.
		No: Go to step 8.

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9.
		No: Retest for SPN 1327 FMI 31.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 1327 FMI 31.
		No: Repair failed valve train components. After repairs are complete retest for SPN 1327 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 1327 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1328 FMI 31- Misfire- Cylinder 6

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Crankshaft acceleration indicates misfire on cylinder 6.	Misfire Count > 180	Engine Running Engine speed > 500 rpm and < 950 rpm Idle speed error < 200 rpm Fuel command > 2 mg / stroke and < 60mg / stroke Engine Coolant Temperature 1 (ECT1) > 86°F (30°C) Vehicle speed < 2 mph (3 km/h) Diesel Particulate Filter (DPF) Not regenerating	440 engine revolutions

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects a cylinder 6 misfire from the Crankshaft Position (CKP) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP)

SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); SPN 1327 (CYL); and SPN 1328 (CYL)

SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Delivery Pressure (FDP)
- Low Fuel Rail Pressure (FRP)
- Contaminated fuel
- Failed injector (Mechanical)
- Base engine compression imbalance

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 (FDP); SPN 157 (FRP); SPN 633 (FPCV); and SPN 3055 (FRP). Is EST DTC list free of SPN 94; SPN 157; SPN 633; and SPN 3055?	Yes: Go to step 2. No: Repair SPN 94; SPN 157; SPN 633; and SPN 3055. After repairs are complete, retest for SPN 1328 FMI 31.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 111 (EWPS); SPN 636 FMI 2, 8, and 10 (CMP); SPN 637 FMI 8 and 10 (CKP); SPN 731 (CYL); SPN 1322 (CYL); SPN 1323 (CYL); SPN 1324 (CYL); SPN 1325 (CYL); SPN 1326 (CYL); and SPN 1327 (CYL). Is EST DTC list free of SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1324; SPN 1325 ; SPN 1326; and SPN 1327?	Yes: Go to step 3. No: Repair SPN 111; SPN 636 FMI 2, 8, and 10; SPN 637 FMI 8 and 10; SPN 731; SPN 1322; SPN 1323; SPN 1324; SPN 1325 ; SPN 1326; and SPN 1327. After repairs are complete, retest for SPN 1328 FMI 31.

Step	Action	Decision
3	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 (CYL/INJ); SPN 652 (CYL/ INJ); SPN 653 (CYL / INJ); SPN 654 (CYL / INJ); SPN 655 (CYL / INJ); SPN 656 (CYL / INJ); SPN 2797 (INJ); and SPN 2798 (INJ). Is EST DTC list free of SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798?	Yes: Go to step 4. No: Repair SPN 651; SPN 652; SPN 653; SPN 654; SPN 655; SPN 656; SPN 2797; and SPN 2798. After repairs are complete, retest for SPN 1328 FMI 31.

Step	Action	Decision
4	Check for poor fuel quality or contaminants. Perform Fuel Quality Check (page 154). Is fuel sample clean and free of sediments, traces of gasoline or kerosene, and waxing or icing?	Yes: Go to step 5. No: Drain fuel and fill with new or known good diesel fuel. After repairs are complete, retest for SPN 1328 FMI 31.

Step	Action	Decision
5	Using EST with ServiceMaxx software, check Fuel Rail Pressure (FRP). Select Sessions > Performance. Start engine and monitor FRP. Is Fuel Rail Pressure 10,500 psi (72,395 kPa) or greater?	Yes: Go to step 7. No: Go to step 6.

Step	Action	Decision
6	Using EST with ServiceMaxx software, check Fuel Delivery Pressure (FDP). Select Sessions > Performance. Start engine and monitor FDP. Is Fuel Delivery Pressure 60 psi (414 kpa) or greater?	Yes: Perform High-pressure Fuel System tests (page 174). After repairs are complete, retest for SPN 1328 FMI 31.
		No: Perform Low-pressure Fuel System tests (page 166). After repairs are complete, retest for SPN 1328 FMI 31.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 1328 FMI 31.
		No: Go to step 8.

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9.
		No: Retest for SPN 1328 FMI 31.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 1328 FMI 31.
		No: Repair failed valve train components. After repairs are complete retest for SPN 1328 FMI 31.

NOTE: After performing all diagnostic steps, if SPN 1328 FMI 31 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DOCIT Sensor (Diesel Oxidation Catalyst Inlet Temperature)

SPN	FMI	Condition	Possible Causes	Actions
4765	2	DOCIT signal erratic, intermittent, or incorrect	• Failed DOCIT sensor • High resistance in DOCIT circuit • High resistance in SIG GND circuit	Step-Based Diagnostics (page 490)
4765	3	DOCIT signal Out-of-Range HIGH	• High resistance or open in SIG GND circuit • High resistance or open in DOCIT circuit • Short to PWR in DOCIT circuit • Failed DOCIT sensor	Step-Based Diagnostics (page 493)
4765	4	DOCIT signal Out-of-Range LOW	• Short to GND in DOCIT circuit • SIG GND circuit shorted to DOCIT circuit • Failed DOCIT sensor	Step-Based Diagnostics (page 496)

4765	20	DOCIT signal drifted HIGH	• DOCIT signal short to PWR • SIG GND circuit high resistance • Failing DOCIT sensor	Step-Based Diagnostics (page 498)
4765	21	DOCIT signal drifted LOW	• Failing DOCIT sensor • Exhaust system leak • DOCIT signal circuit short to GND • DOCIT signal circuit high resistance	Step-Based Diagnostics (page 500)

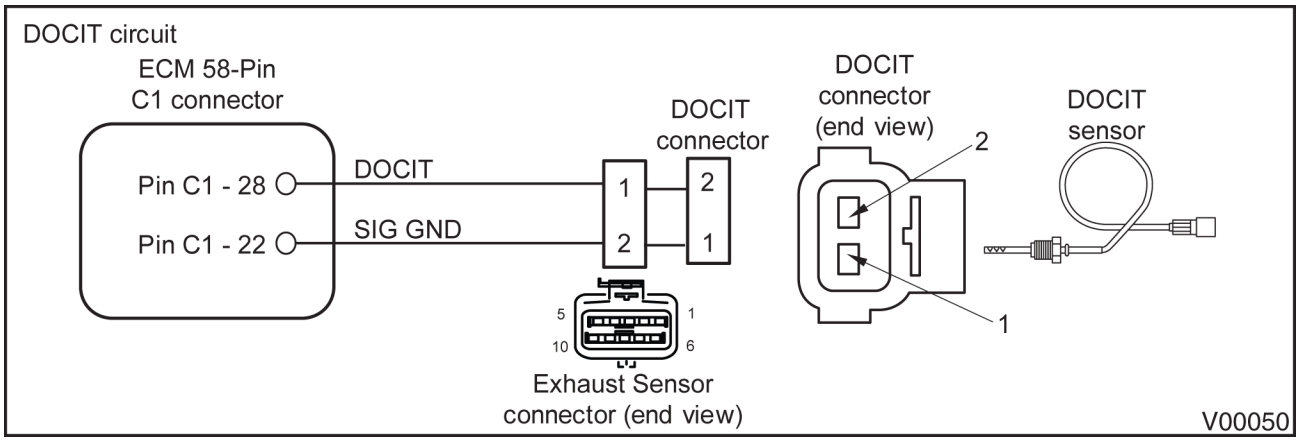


Figure 204 DOCIT circuit diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor is a thermistor-style sensor that measures temperature between the Pre-Diesel Oxidation Catalyst (Pre-DOC) and the Diesel Oxidation Catalyst (DOC). As temperature increases, resistance values drop. This change of resistance varies the voltage that is sent to the Engine Control Module (ECM). The DOCIT sensor works with the Diesel Oxidation Catalyst Outlet Temperature (DOCOT), Diesel Particulate Filter Outlet Temperature (DPFOT), and Diesel Particulate Filter Differential Pressure (DPFDP) sensors to indicate operation and control the regeneration cycles of the Aftertreatment (AFT) system via the ECM.

Tools Required

- 00-00956-08 - 180-Pin Breakout Box
- ZTSE4498 - 3-Banana Plug Harness
- ZTSE4497 - 500 Ohm Resistor Harness
- ZTSE4899 - Big Bore Terminal Test Probe Kit

- Breakout Harness ZTSE4760A (DOCIT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

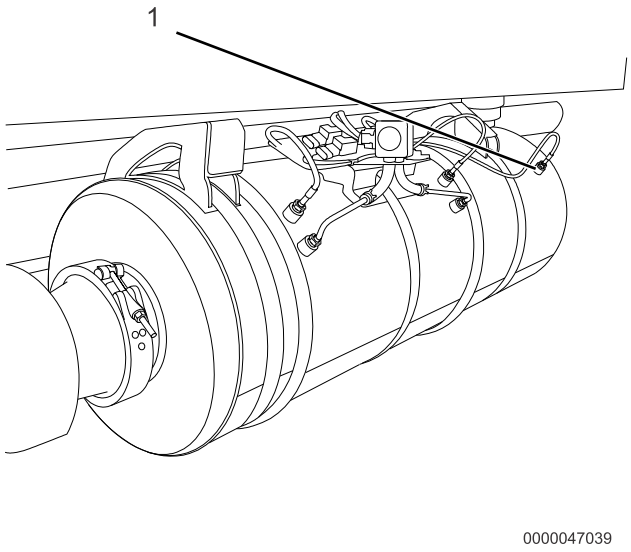


Figure 205 DOCIT Sensor Location (Typical)

1. Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor

SPN 4765 FMI 2 DOCIT signal does not agree with other exhaust sensors

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The Diesel Oxidation Catalyst Inlet Temperature (DOCIT) is not changing with engine operating conditions (in-range but not rational).	Difference between DOCIT, Diesel Oxidation Catalyst Outlet Temperature (DOCOT), and Diesel Particulate Filter Outlet Temperature (DPFOT) > 27°F (15°C). DOCIT < 212°F (100°C).	Key-On Engine-Running (KOER) > 120 seconds Engine is cold soaked Engine speed > 1300 RPM Injection Quantity > 150 mg / stroke Intake Manifold Pressure (IMP) > 200 kpa Enable Condition met > 45 seconds	5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the difference between the Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Oxidation Catalyst Outlet Temperature (DOCOT), and Diesel Particulate Filter Outlet Temperature (DPFOT) readings do not match expected values for engine operating conditions. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3246 FMI 3 and 4 (DPFOT); SPN 4766 FMI 3 and 4 (DOCOT)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

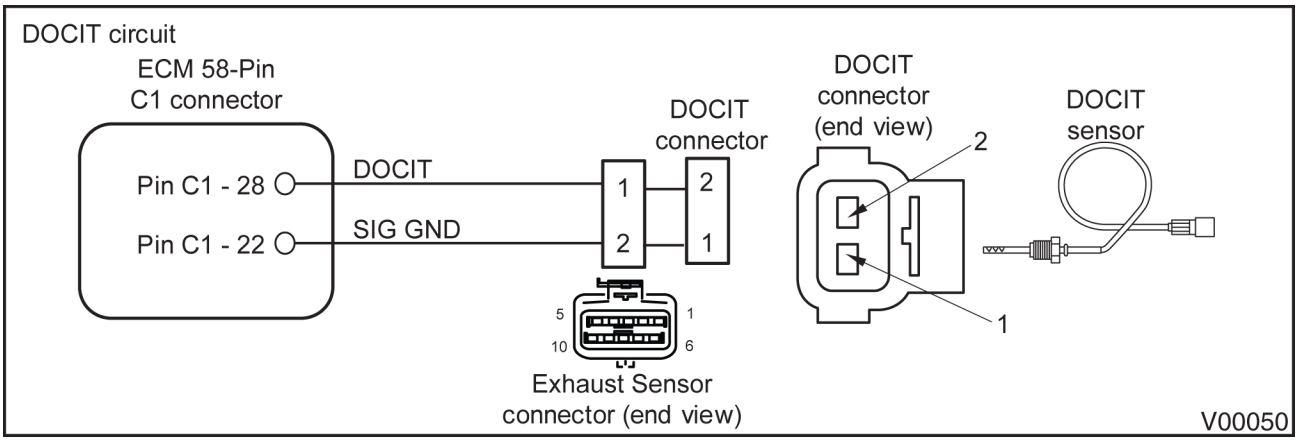


Figure 206 DOCIT circuit diagram

Possible Causes

- Failed Diesel Oxidation Catalyst Inlet (DOCIT) sensor
- High resistance in DOCIT circuit
- High resistance in SIG GND circuit

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3246 FMI 3 and 4 (DPFOT); SPN 4766 FMI 3 and 4 (DOCOT). Is EST DTC list free of SPN 3246 FMI 3 and 4; SPN 4766 FMI 3 and 4?	Yes: Go to step 2. No: Repair SPN 3246 FMI 3 and 4; SPN 4766 FMI 3 and 4. After repairs are complete, retest for SPN 4765 FMI 2.

Step	Action	Decision
2	Inspect connections at Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor. Key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCIT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 2.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 2.

Step	Action	Decision
4	Check DOCIT circuit for high resistance. Connect Breakout Harness ZTSE4760A to DOCIT harness and leave DOCIT disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01467-00 to ECM C1 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness pin-2 and Breakout Box pin C1-28. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair high resistance between DOCIT connector pin-2 and ECM connector pin C1-28. After repairs are complete, retest for SPN 4765 FMI 2.

Step	Action	Decision
5	Check SIG GND circuit for high resistance. Connect Breakout Harness ZTSE4760A to DOCIT harness and leave DOCIT disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01467-00 to Chassis C1 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness pin-1 and Breakout Box pin C1-22. Is resistance less than 5 ohms?	Yes: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 2. No: Repair high resistance between DOCIT connector pin-1 and ECM connector pin C1-22. After repairs are complete, retest for SPN 4765 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 4765 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4765 FMI 3 DOCIT signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Inlet Temperature (DOCIT) circuit short to PWR.	DOCIT sensor input voltage ≥ 5 volts	Key ON	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that the Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor signal voltage is greater than expected. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

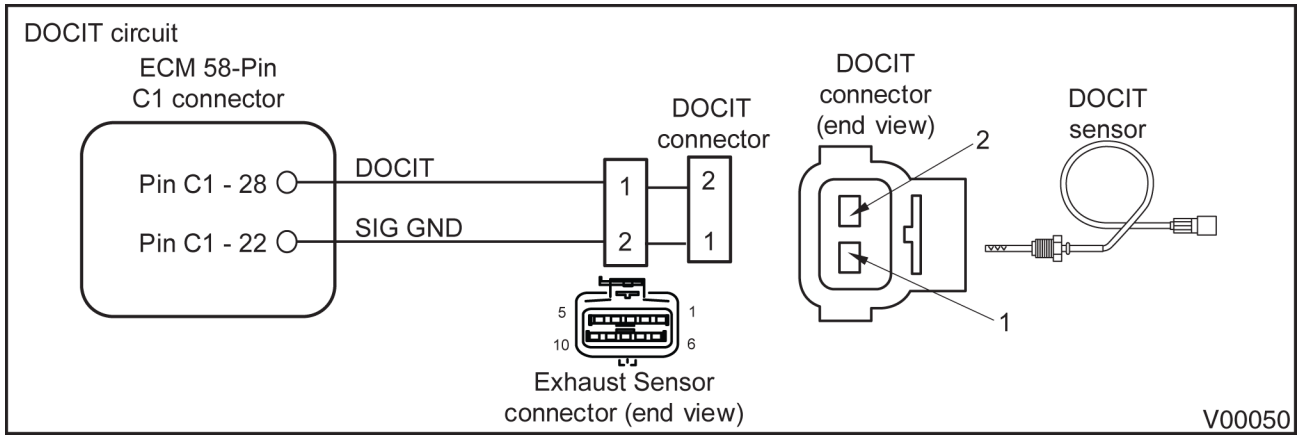


Figure 207 DOCIT circuit diagram

Possible Causes

- High resistance or open in SIG GND circuit
- High resistance or open in DOCIT circuit
- Short to PWR in DOCIT circuit
- Failed DOCIT sensor

Step	Action	Decision
1	Inspect connections at Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor. Key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCIT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 3.

Step	Action	Decision
2	Check DOCIT circuit for short to PWR. Connect Breakout Harness ZTSE4760A to vehicle harness and leave DOCIT sensor disconnected. Key-On Engine-Off (KOEO) measure voltage between Breakout Harness pin-2 and a known good ground. Is voltage within 0.5 volts of 5 volts?	Yes: Go to step 3. No: Repair short to power in DOCIT circuit between ECM pin C1-28 and DOCIT sensor pin-2. After repairs are complete, retest for SPN 4765 FMI 3.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 3.

Step	Action	Decision
4	Check DOCIT circuit for high resistance or Open. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness, and leave ECM disconnected. With Breakout Harness ZTSE4760A connected to vehicle harness and with DOCIT sensor disconnected. Use a DMM to measure resistance from Breakout Box pin C1-28 and Breakout Harness pin-2. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance in DOCIT circuit between ECM pin C1-28 and DOCIT sensor pin-2. After repairs are complete, retest for SPN 4765 FMI 3.

Step	Action	Decision
5	Check SIG GND circuit for high resistance or Open. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness, and leave ECM disconnected. With Breakout Harness ZTSE4760A connected to vehicle harness and with DOCIT sensor disconnected. Use a DMM to measure resistance from Breakout Box pin C1-22 and Breakout Harness pin-1. Is resistance less than 5 ohms?	Yes: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 3. No: Repair Open or high resistance in SIG GND circuit between ECM pin C1-22 and DOCIT sensor pin-1. After repairs are complete, retest for SPN 4765 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 4765 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4765 FMI 4 DOCIT signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Inlet Temperature (DOCIT) circuit short to ground.	DOCIT signal ≤ 0.05 volt	Key-On Engine-Running (KOER)	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor signal voltage is less than 0.05 volts for more than 0.5 seconds. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

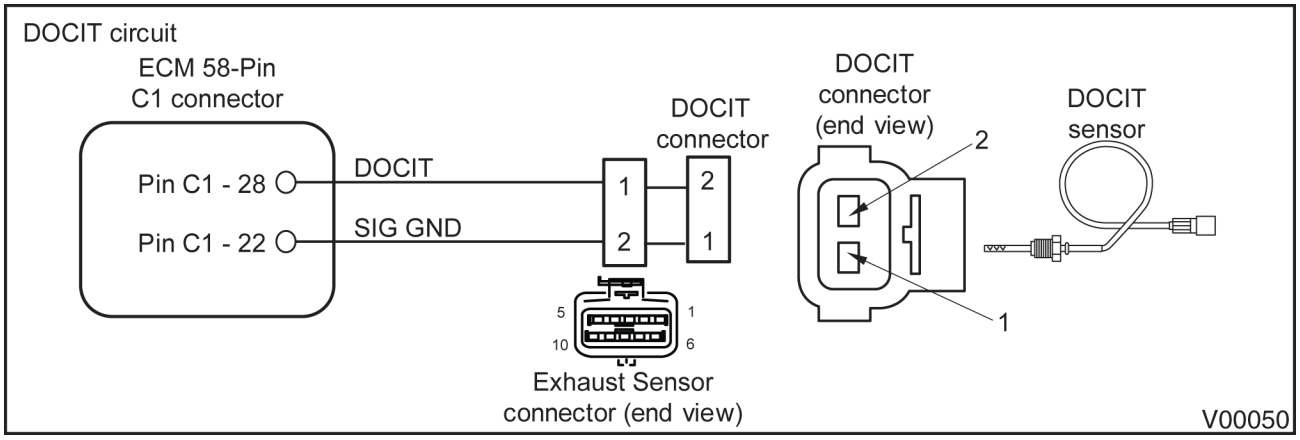


Figure 208 DOCIT circuit diagram

Possible Causes

- Short to GND in DOCIT circuit
- SIG GND circuit shorted to DOCIT circuit
- Failed DOCIT sensor

Step	Action	Decision
1	Inspect connections at Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor. Key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCIT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 4.

Step	Action	Decision
2	Check DOCIT circuit for short to GND. Connect Breakout Harness ZTSE4760A to vehicle harness and leave DOCIT sensor disconnected. Key-On Engine-Off (KOEO) measure voltage between Breakout Harness pin-2 and a known good ground. Is voltage within 0.5 volts of 5 volts?	Yes: Go to step 3. No: Repair short to GND in DOCIT circuit between ECM pin C1-28 and DOCIT sensor pin-2. After repairs are complete, retest for SPN 4765 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 4.

Step	Action	Decision
4	Check for short between DOCIT and SIG GND circuits. Connect Breakout Harness ZTSE4760A and leave DOCIT sensor disconnected. Key OFF, disconnect ECM and measure resistance between Breakout Harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Replace DOCIT sensor. After repairs are complete, retest for SPN 4765 FMI 4. No: Repair short between DOCIT and SIG GND circuits. After repairs are complete, retest for SPN 4765 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 4765 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4765 FMI 20 - DOCIT signal drifted HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor rationality offset high.	Oxidation Catalyser Upstream temperature > 842°F (450°C)	Time after successful regen Complete > 10 minutes Time after Key On > 0 seconds Battery voltage > 10.7 Volts Battery voltage <15 Volts	10 Seconds

Fault Overview

Fault sets when the Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor is reading above 842°F (450°C) for approximately 300–600 seconds after aftertreatment regeneration is completed.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN 2659

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

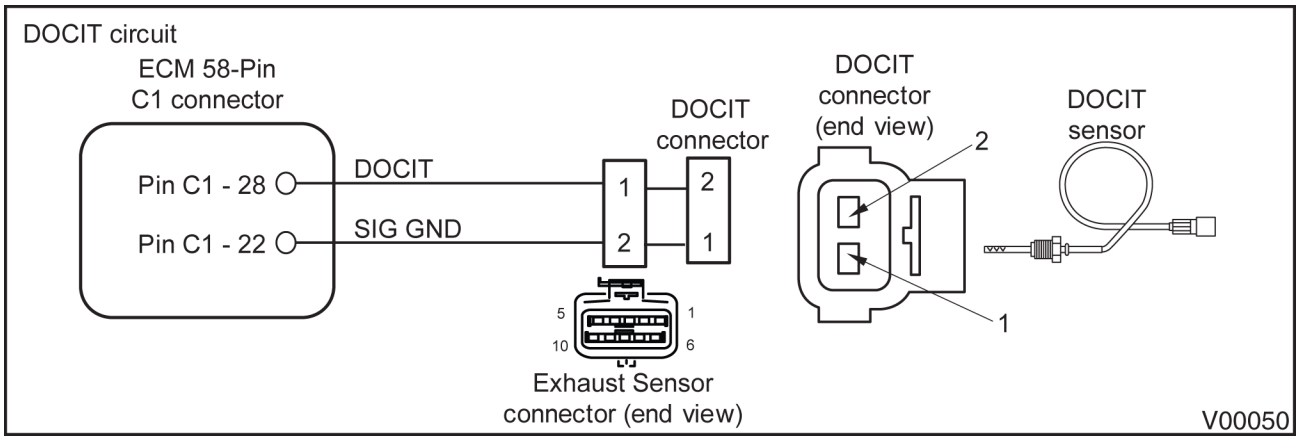


Figure 209 DOCIT circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4765 FMI 20 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 4765 FMI 20.

Step	Action	Decision
2	Inspect connections at Diesel Oxidation Catalyst Inlet (DOCIT) sensor. Key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DOCIT sensor connector, harness, and terminal clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 20.

Step	Action	Decision
3	Check DOCIT circuit for short to power. In ServiceMaxx start Continuous Monitor test. Key-On Engine-Off, with DOCIT sensor connected. Does ServiceMaxx™ software show DOCIT voltage less than 5.5 volts?	Yes: Go to step 4. No: Repair short to power between DOCIT connector pin 2 to ECM 58-pin connector C1 pin 28 . After repairs are complete, retest for SPN 4765 FMI 20.

Step	Action	Decision
4	Check SIG GND circuit for high resistance. With DOCIT sensor disconnected, connect Breakout Harness ZTSE4760A. Measure resistance between DOCIT connector pin 1 and a known good ground. Is resistance less then 5 ohms?	Yes: Replace DOCIT sensor. No: Repair high resistance between DOCIT connector pin 1 and ECM 58-pin connector C1 pin 22 . After repairs are complete, retest for SPN 4765 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 4765 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4765 FMI 21 - DOCIT signal drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor rationality offset low.	Oxidation Catalyser Upstream temperature > 392°F (200°C)	Engine speed > 1400 rpm Injection quantity > 115 mg / stroke Intake Manifold Pressure (IMP) > 120 kPa In above conditions > 45 seconds Time after Key On > 0 seconds Battery voltage > 10.7 Volts Battery voltage <15 Volts	10 Seconds

Fault Overview

Fault sets when the Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor is reading below 392°F (200°C) for approximately 45 seconds with enable conditions met.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN 2659

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

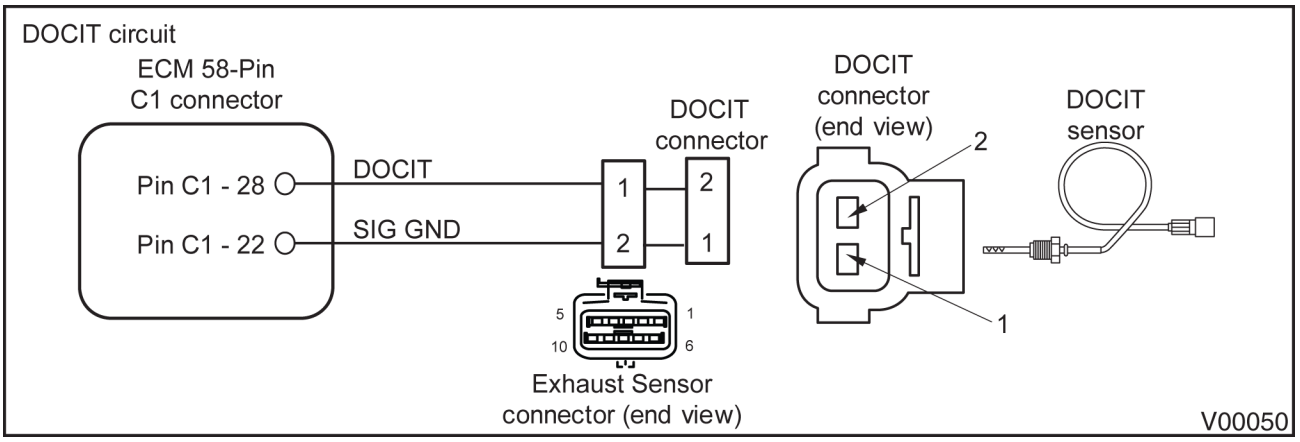


Figure 210 DOCIT circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 4765 FMI 21 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Also, inspect the fuel system from fuel tank to AFI valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
3	Inspect connections at Diesel Oxidation Catalyst Inlet (DOCIT) sensor. Key OFF, disconnect DOCIT sensor connector. Check DOCIT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Is the DOCIT sensor connector, harness, and terminal clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
4	Check DOCIT circuit for short to ground. Connect Breakout Harness ZTSE4760A to DOCIT sensor connector and leave DOCIT sensor disconnected. Use a DMM to measure resistance between Breakout harness ZTSE4760A test point 2 and a known, good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 4. No: Repair short to ground between DOCIT connector pin 2 and ECM 58-pin connector C1 pin 28. After repairs are complete, retest for SPN 4765 FMI 21.

Step	Action	Decision
5	Check DOCIT circuit for high resistance or Open. In ServiceMaxx start Continuous Monitor test. Key-On Engine-Off, with Breakout Harness ZTSE4760A connected, short DOCIT connector pin 1 to pin 2. Does ServiceMaxx software show DOCIT voltage of 4.5 volts or more?	Yes: Replace DOCIT sensor. No: Repair high resistance between DOCIT connector pin 2 and ECM 58-pin connector C1 pin 28. After repairs are complete, retest for SPN 4765 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 4765 FMI 21 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DOCOT Sensor (Diesel Oxidation Catalyst Outlet Temperature)

SPN	FMI	Condition	Possible Causes	Actions
4766	2	DOCOT signal does not agree with other exhaust sensors	• Failed DOCOT sensor • High resistance in DOCOT circuit • High resistance in SIG GND circuit	Step-Based Diagnostics (page 505)
4766	3	DOCOT signal Out of Range HIGH	• High resistance or open in SIG GND circuit • High resistance or open in DOCOT circuit • Short to PWR in DOCOT circuit • Failed DOCOT sensor	Step-Based Diagnostics (page 509)
4766	4	DOCOT signal Out of Range LOW	• Short to GND in DOCOT circuit • SIG GND circuit shorted to DOCOT circuit • Failed DOCOT sensor	Step-Based Diagnostics (page 512)

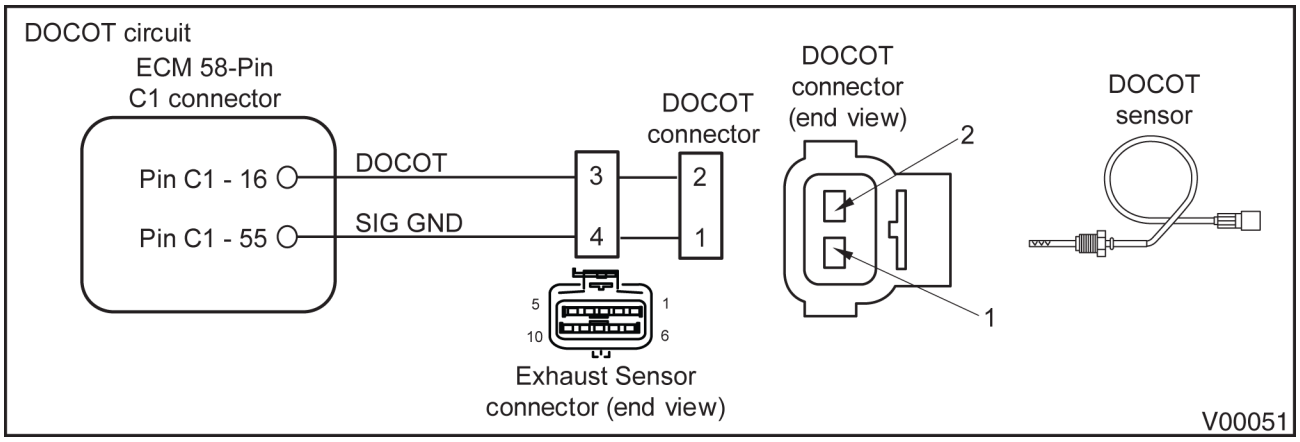


Figure 211 DOCOT sensor circuit diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor is a thermistor-style sensor that measures temperature between the Diesel Oxidation Catalyst (DOC) and the Diesel Particulate Filter (DPF). As temperature increases, resistance values drop. This change of resistance varies the voltage that is sent to the Engine Control Module (ECM). The DOCOT sensor works with the Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Particulate Filter Outlet Temperature (DPFOT), and Diesel Particulate Filter Differential Pressure (DPFDP) sensors to indicate operation and control the regeneration cycles of the Aftertreatment (AFT) system via the ECM.

Tools Required

- 00-00956-08 - 180-Pin Breakout Box
- ZTSE4498 - 3-Banana Plug Harness
- ZTSE4497 - 500 Ohm Resistor Harness
- ZTSE4899 - Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4760A (DOCOT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN 4766 FMI 2 - DOCOT signal does not agree with other exhaust sensors

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The Diesel Oxidation Catalyst Outlet Temperature (DOCOT) is not changing with engine operating conditions (in-range but not rational).	Difference between Diesel Oxidation Catalyst Inlet Temperature (DOCIT), DOCOT, and Diesel Particulate Filter Outlet Temperature (DPFOT) > 27°F (15°C).	Engine is cold soaked	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the difference between the Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Oxidation Catalyst Outlet Temperature (DOCOT), and Diesel Particulate Filter Outlet Temperature (DPFOT) readings do not match expected values for engine operating conditions. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3246 FMI 3 and 4 (DPFOT); SPN 4765 FMI 3 and 4 (DOCIT)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

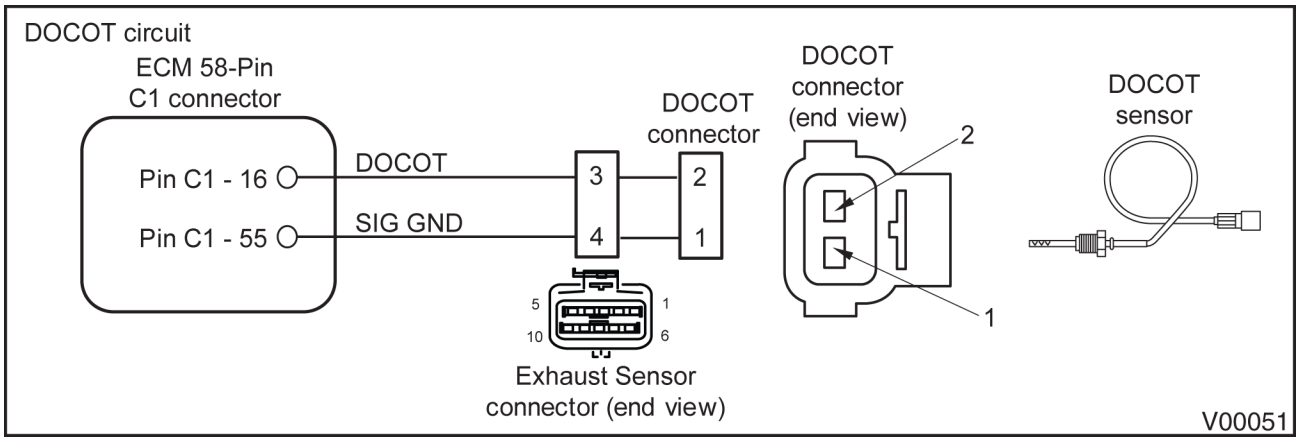


Figure 212 DOCOT sensor circuit diagram

Possible Causes

- Failed Diesel Oxidation Catalyst Inlet (DOCOT) sensor
- High resistance in DOCOT circuit
- High resistance in SIG GND circuit

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3246 FMI 3 and 4 (DPFOT); SPN 4765 FMI 3 and 4 (DOCIT). Is EST DTC list free of SPN 3246 FMI 3 and 4; SPN 4765 FMI 3 and 4?	Yes: Go to step 2. No: Repair SPN 3246 FMI 3 and 4; SPN 4765 FMI 3 and 4. After repairs are complete, retest for SPN 4766 FMI 2.

Step	Action	Decision
2	Inspect connections at Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor. Key OFF, disconnect DOCOT sensor connector. Check DOCOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCOT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4766 FMI 2.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4766 FMI 2.

Step	Action	Decision
4	Check DOCOT circuit for high resistance. Connect Breakout Harness ZTSE4760A to DOCOT harness and leave DOCOT disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01467-00 to ECM C1 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness ZTSE4760A pin-2 and 180-pin Breakout Box pin C1-16. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair high resistance between DOCOT connector pin-2 and ECM connector pin C1-16. After repairs are complete, retest for SPN 4766 FMI 2.

Step	Action	Decision
5	Check SIG GND circuit for high resistance. Connect Breakout Harness ZTSE4760A to DOCOT harness and leave DOCOT disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01467-00 to Chassis C1 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness ZTSE4760A pin-1 and 180-pin Breakout Box pin C1-55. Is resistance less than 5 ohms?	Yes: Replace DOCOT sensor. After repairs are complete, retest for SPN 4766 FMI 2. No: Repair high resistance between DOCOT connector pin-1 and ECM connector pin C1-55. After repairs are complete, retest for SPN 4766 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 4766 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4766 FMI 3 - DOCOT signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Outlet Temperature (DOCOT) circuit short to PWR.	DOCOT sensor input voltage ≥ 5 volts	Key ON	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that the Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor signal voltage is greater than expected. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

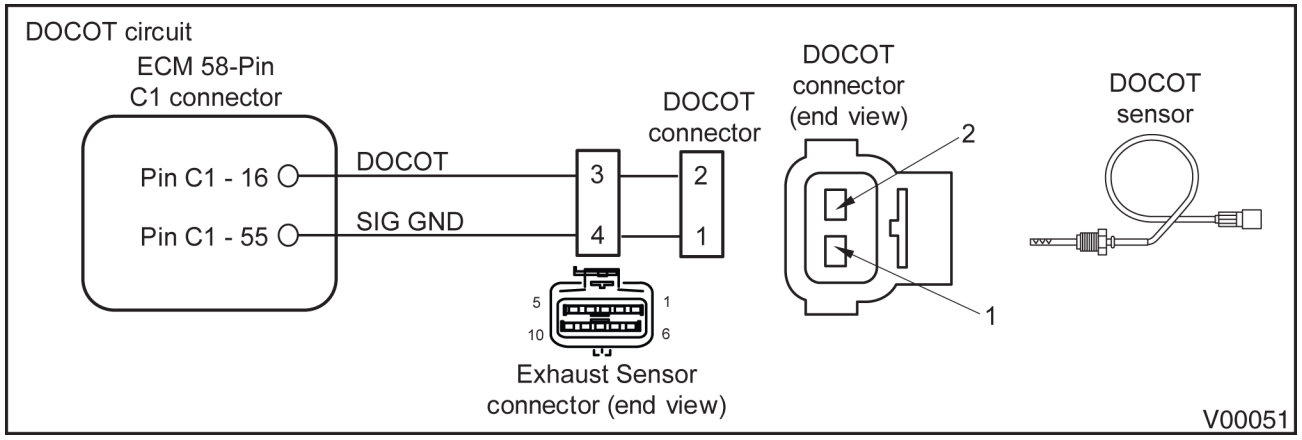


Figure 213 DOCOT sensor circuit diagram

Possible Causes

- High resistance or open in SIG GND circuit
- High resistance or open in DOCOT circuit
- Short to PWR in DOCOT circuit
- Failed DOCOT sensor

Step	Action	Decision
1	Inspect connections at Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor. Key OFF, disconnect DOCOT sensor connector. Check DOCOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCOT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4766 FMI 3.

Step	Action	Decision
2	Check DOCOT circuit for short to PWR. Connect Breakout Harness ZTSE4760A to vehicle harness and leave DOCOT sensor disconnected. Key-On Engine-Off (KOEO) measure voltage between Breakout Harness pin-2 and a known good ground. Is voltage within 0.5 volts of 5 volts?	Yes: Go to step 3. No: Repair short to power in DOCOT circuit between ECM pin C1-16 and DOCOT sensor pin-2. After repairs are complete, retest for SPN 4766 FMI 3.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4766 FMI 3.

Step	Action	Decision
4	Check DOCOT circuit for high resistance or Open. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness, and leave ECM disconnected. With Breakout Harness ZTSE4760A connected to vehicle harness and with DOCOT sensor disconnected. Use a DMM to measure resistance from Breakout Box pin C1-16 and Breakout Harness pin-2. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance in DOCOT circuit between ECM pin C1-16 and DOCOT sensor pin-2. After repairs are complete, retest for SPN 4766 FMI 3.

Step	Action	Decision
5	Check SIG GND circuit for high resistance or Open. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness, and leave ECM disconnected. With Breakout Harness ZTSE4760A connected to vehicle harness and with DOCOT sensor disconnected. Use a DMM to measure resistance from Breakout Box pin C1-55 and Breakout Harness pin-1. Is resistance less than 5 ohms?	Yes: Replace DOCOT sensor. After repairs are complete, retest for SPN 4766 FMI 3. No: Repair Open or high resistance in SIG GND circuit between ECM pin C1-55 and DOCOT sensor pin-1. After repairs are complete, retest for SPN 4766 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 4766 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 4766 FMI 4 - DOCOT signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Oxidation Catalyst Outlet Temperature (DOCOT) circuit short to ground.	DOCOT signal ≤ 0.5 volts	Key-On Engine-Running (KOER)	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor signal voltage is less than 0.5 volts for more than 0.5 seconds. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

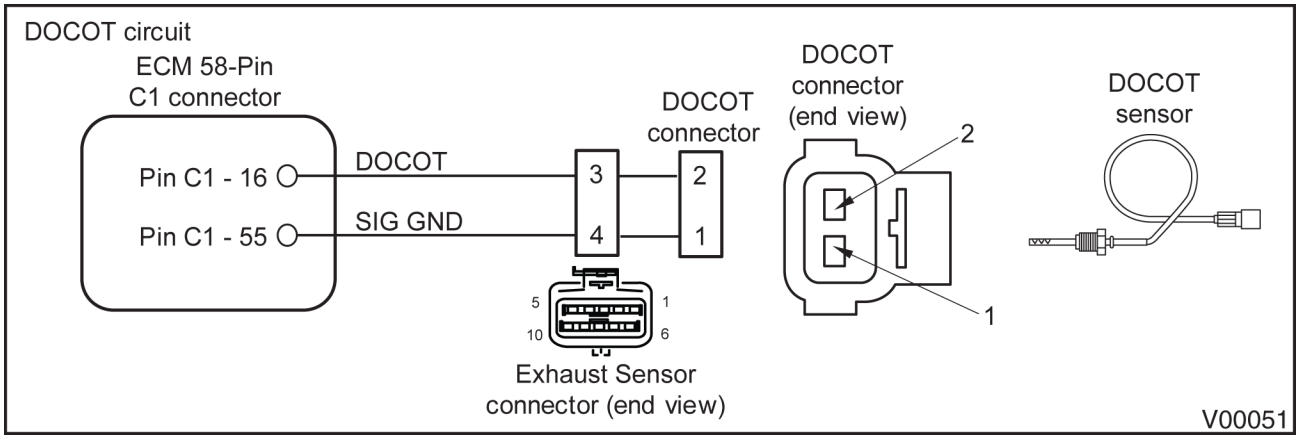


Figure 214 DOCOT sensor circuit diagram

Possible Causes

- Short to GND in DOCOT circuit
- SIG GND circuit shorted to DOCOT circuit
- Failed DOCOT sensor

Step	Action	Decision
1	Inspect connections at Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor. Key OFF, disconnect DOCOT sensor connector. Check DOCOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCOT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4766 FMI 4.

Step	Action	Decision
2	Check DOCOT circuit for short to GND. Connect Breakout Harness ZTSE4760A to vehicle harness and leave DOCOT sensor disconnected. Key-On Engine-Off (KOEO) measure voltage between Breakout Harness pin-2 and a known good ground. Is voltage within 0.5 volts of 5 volts?	Yes: Go to step 3. No: Repair short to GND in DOCOT circuit between ECM pin C1-16 and DOCOT sensor pin-2. After repairs are complete, retest for SPN 4766 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 4766 FMI 4.

Step	Action	Decision
4	Check for short between DOCOT and SIG GND circuits. Connect Breakout Harness ZTSE4760A and leave DOCOT sensor disconnected. Key OFF, disconnect ECM and measure resistance between Breakout Harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Replace DOCOT sensor. After repairs are complete, retest for SPN 4766 FMI 4. No: Repair short between DOCOT and SIG GND circuits. After repairs are complete, retest for SPN 4766 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 4766 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFDP Sensor (Diesel Particulate Filter Differential Pressure)

SPN	FMI	Condition	Possible Causes	Actions
3251	2	DPFDP signal erratic, intermittent, or incorrect	• DPFDP circuit high resistance • Leaking or Restricted DPFDP hoses • Failed DPFDP sensor	Step-Based Diagnostics (page 517)
3251	3	DPFDP signal Out of Range HIGH	• SIG GND Open or high resistance • DPFDP shorted to PWR • Failed DPFDP Sensor	Step-Based Diagnostics (page 521)
3251	4	DPFDP signal Out of Range LOW	• VREF-4 circuit Open or high resistance • DPFDP circuit shorted to GND • DPFDP circuit Open or high resistance • Failed DPFDP Sensor	Step-Based Diagnostics (page 523)

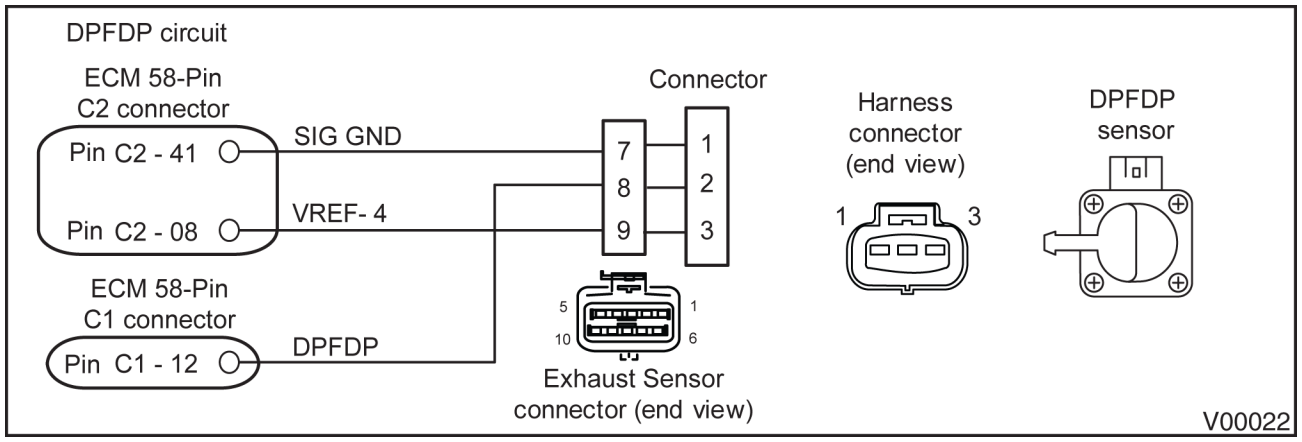


Figure 215 DPFDP sensor circuit diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Diesel Particulate Filter Differential Pressure (DPFDP) sensor measures the pressure difference between the inlet pressure and outlet pressure of the DPF. Aftertreatment regeneration will not run with DPFDP sensor module fault codes present.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- Breakout Harness 00-01467-00
- Breakout Harness ZTSE4761
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

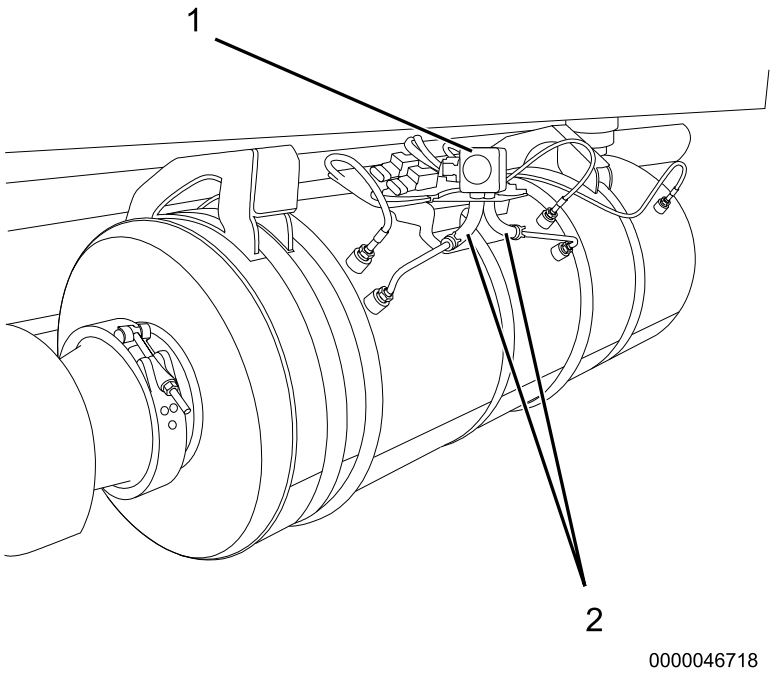


Figure 216 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

SPN 3251 FMI 2 - DPFDP signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Differential Pressure (DPFDP) sensor Key ON check indicates signal in-range but not rational or stuck in range.	Absolute value of DPFDP > 0.25 psi (1.5 kPa) Range of DPFDP since last monitor decision when Enable Conditions are met < 0.15 psi (1 kpa)	Inactive: SPN 3251 FMI 3, 4 Engine Speed ≤ 200 RPM Elapsed time since key ON > 1 sec Range of exhaust volumetric flow since last monitor > 0.4 m3/sec DPFDP sensor signal not saturated at high exhaust flow: (DPFDP <= 5.1 psi (35 kpa) OR (Exhaust flow <= 1 m3/sec) Key-On Engine-Running (KOER)	Immediate

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the aftertreatment Diesel Particulate Filter Differential Pressure (DPFDP) is greater than 0.25 psi (1.5 kpa), is not changing with engine conditions, or range since last monitor < 0.15 psi (1 kpa).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3251 FMI 3, 4 (DPFDP); SPN 3512 FMI 14 (VREF-4)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

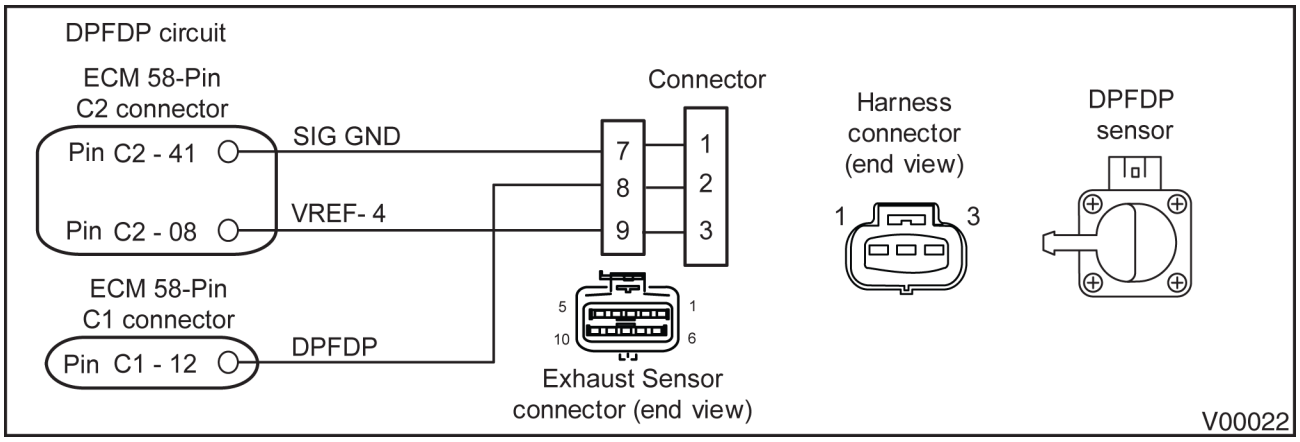


Figure 217 DPFDP sensor circuit diagram

Possible Causes

- DPFDP circuit high resistance
- Leaking or Restricted DPFDP sensor hoses
- Failed DPFDP sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3251 FMI 3 and 4 (DPFDP); SPN 3512 FMI 14 (VREF-4). Is EST DTC list free of SPN 3251 FMI 3 and 4; SPN 3512 FMI 14?	Yes: Go to step 2. No: Repair SPN 3251 FMI 3 and 4; SPN 3512 FMI 14. After repairs are complete, retest for SPN 3251 FMI 2.

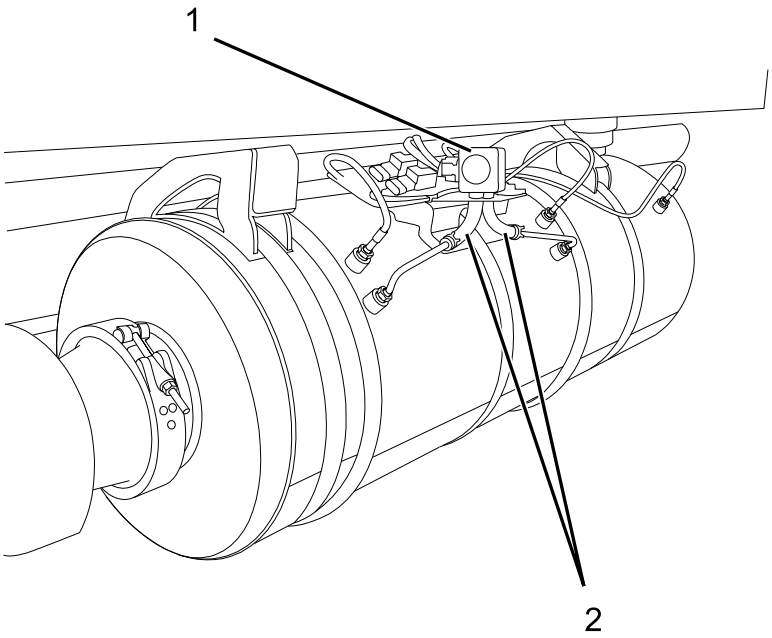


Figure 218 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

Step	Action	Decision
2	Inspect hoses and tube connections at the Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Check sensor, tubes, and passages for leaks, restrictions, and damage. Are the DPFDP sensor module connections free of leaks, restrictions, and damage?	Yes: Go to step 3. No: Repair leaking, restricted or damaged hoses and connections. After repairs are complete, retest for SPN 3251 FMI 2.

Step	Action	Decision
3	Inspect connections at DPFDP sensor. Key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 2.

Step	Action	Decision
4	Inspect connections at Engine Control Module (ECM) sensor. Key OFF, disconnect ECM sensor. Check ECM sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 2.

Step	Action	Decision
5	Check DPFDP circuit for high resistance. Connect Breakout Harness ZTSE4761 to vehicle harness and leave DPFDP sensor disconnected. Connect 180-Pin Breakout Box and Breakout Harness 00-01467-00 to vehicle harness and leave ECM disconnected. Key OFF, use a DMM to measure resistance between Breakout Harness pin-2 and Breakout Box pin C1-12. Is resistance less than 5 ohms?	Yes: Replace the DPFDP sensor. After repairs are complete retest for SPN 3251 FMI 2. No: Repair high resistance between the DPFDP sensor module connector pin-2 and ECM connector pin C1-12. After repairs are complete retest for SPN 3251 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 3251 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3251 FMI 3 - DPFDP signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Differential Pressure (DPFDP) sensor reading greater than specified operating range for a specified amount of time.	Aftertreatment DPFDP sensor value > 4.25 volts	Key ON	2 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that the aftertreatment Diesel Particulate Filter Differential Pressure (DPFDP) signal voltage is greater than 4.75 volts for more than 2 seconds.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Fault

SPN 3512 FMI 14 (VREF-4)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

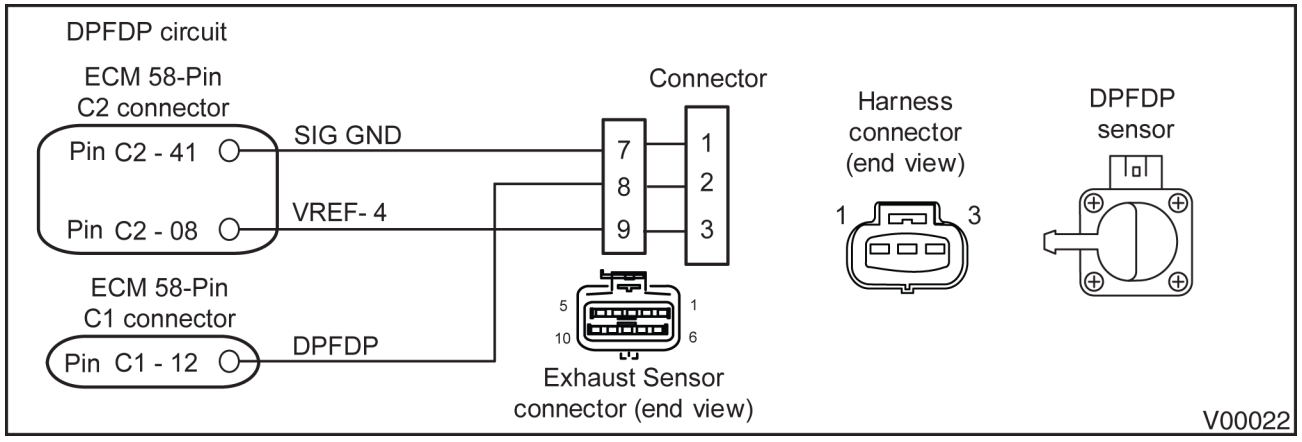


Figure 219 DPFDP sensor circuit diagram

Possible Causes

- SIG GND Open or high resistance
- DPFDP shorted to PWR
- Failed DPFDP sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3512 FMI 14 (VREF-4). Is EST DTC list free of SPN 3512 FMI 14?	Yes: Go to step 2. No: Repair SPN 3512 FMI 14. After repairs are complete, retest for SPN 3251 FMI 3.

Step	Action	Decision
2	Inspect connections at DPFDP sensor. Key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 3.

Step	Action	Decision
3	Check DPFDP circuit for Short to power. Key-On Engine-Off (KOEO), with Breakout Harness ZTSE4761 connected between DPFDP sensor and vehicle harness. Use a DMM to measure voltage between DPFDP sensor module pin-2 and a known good ground. Is voltage at pin-2 less than 4.7 volts?	Yes: Go to step 4. No: Repair short to power between DPFDP sensor connector pin-2 and ECM connector pin C1-12. After repairs are complete retest for SPN 3251 FMI 3.

Step	Action	Decision
4	Check SIG GND circuit for Open or high resistance. Key OFF, Connect Breakout Harness ZTSE4761 to vehicle harness and leave DPFDP disconnected. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness and leave Engine Control Module (ECM) disconnected. Use a DMM to measure resistance from Breakout Harness pin-1 to Breakout Box pin C2-41. Is resistance less than 5 ohms?	Yes: Replace the DPFDP sensor. After repairs are complete retest for SPN 3251 FMI 3. No: Repair Open or high resistance between DPFDP sensor connector pin-1 and ECM connector pin C2-41. After repairs are complete, retest for SPN 3251 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 3251 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3251 FMI 4- DPFDP signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Differential Pressure (DPFDP) signal voltage is less than 0.25 V for more than 2 seconds.	DPFDP < 0.25 volts	Key ON	2 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the aftertreatment Diesel Particulate Filter Differential Pressure (DPFDP) signal voltage is greater than 0.25 volts for more than 2 seconds.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3512 FMI 14 (VREF-4)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

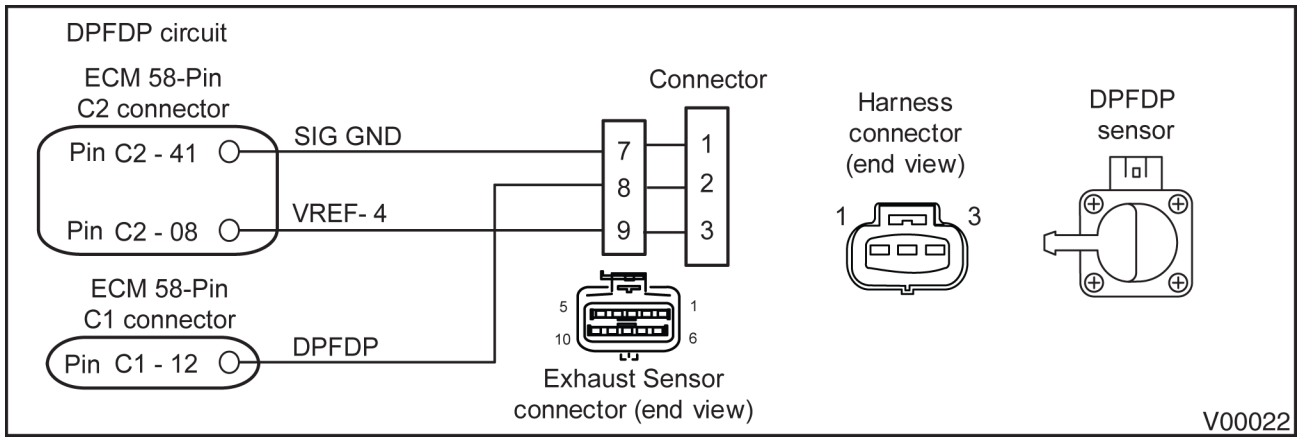


Figure 220 DPFDP sensor circuit diagram

Possible Causes

- VREF-4 circuit Open or high resistance
- DPFDP circuit shorted to GND
- DPFDP circuit Open or high resistance
- Failed DPFDP sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3512 FMI 14 (VREF-4). Is EST DTC list free of SPN 3512 FMI 14?	Yes: Go to step 2. No: Repair SPN 3512 FMI 14. After repairs are complete, retest for SPN 3480 FMI 4.

Step	Action	Decision
2	Inspect connections at DPFDP sensor. Key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3251 FMI 4.

Step	Action	Decision
3	Check DPFDP circuit for Short to ground. Key OFF, with Breakout Harness ZTSE4761 connected to vehicle harness and leave DPFDP sensor disconnected. Use a DMM to measure resistance between DPFDP sensor connector pin-2 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 4. No: Repair short to GND between DPFDP sensor connector pin-2 and ECM connector pin C1-12. After repairs are complete retest for SPN 3251 FMI 4.

Step	Action	Decision
4	Check VREF-4 circuit for Open or high resistance. Connect Breakout Harness ZTSE4761 to vehicle harness and leave DPFDP sensor disconnected. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness and leave Engine Control Module (ECM) disconnected. Use a DMM to measure resistance between Breakout Harness pin-3 and Breakout Box pin C2-08. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance between DPFDP sensor connector pin-3 and ECM connector pin C2-08. After repairs are complete, retest for SPN 3251 FMI 4.

Step	Action	Decision
5	Check DPFDP signal circuit for Open or high resistance. Connect Breakout Harness ZTSE4761 to vehicle harness and leave DPFDP sensor disconnected. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness and leave ECM disconnected. Use a DMM to measure resistance between Breakout Harness pin-2 and Breakout Box pin C1-12. Is resistance less than 5 ohms?	Yes: Replace DPFDP sensor. After repairs are complete, retest for SPN 3251 FMI 4. No: Repair Open or high resistance between DPFDP sensor module pin-2 and ECM connector pin C1-12. After repairs are complete, retest for SPN 3251 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 3251 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPFOT Sensor (Diesel Particulate Filter Outlet Temperature)

SPN	FMI	Condition	Possible Causes	Actions
3246	2	DPFOT signal does not agree with other exhaust sensors	• Failed DPFOT sensor • High resistance in DPFOT circuit • High resistance in SIG GND circuit	Step-Based Diagnostics (page 530)
3246	3	DPFOT signal Out of Range HIGH	• High resistance or open in SIG GND circuit • High resistance or open in DPFOT circuit • Short to PWR in DPFOT circuit • Failed DPFOT sensor	Step-Based Diagnostics (page 533)
3246	4	DPFOT signal Out of Range LOW	• Short to GND in DPFOT circuit • SIG GND circuit shorted to DPFOT circuit • Failed DPFOT sensor	Step-Based Diagnostics (page 536)
3246	20	DPFOT signal drifted HIGH	• Restricted air filter • Fuel leaks • Biased DPFOT sensor or circuit • Engine over fueling • Failed Down Stream Injection (DSI) unit • Oil contamination of exhaust system	Step-based Diagnostics (page 538)

SPN	FMI	Condition	Possible Causes	Actions
3246	21	DPFOT signal drifted LOW	• Exhaust leaks • Restricted air filter • Biased DPFOT sensor or circuit • Low FDP • Failed DSI unit • Leaking or restricted DSI fuel supply line • AFTFD valve and AFTFSV connectors swapped • Leaking or damaged AFI supply line • Restricted exhaust system	Step-based Diagnostics (page 544)

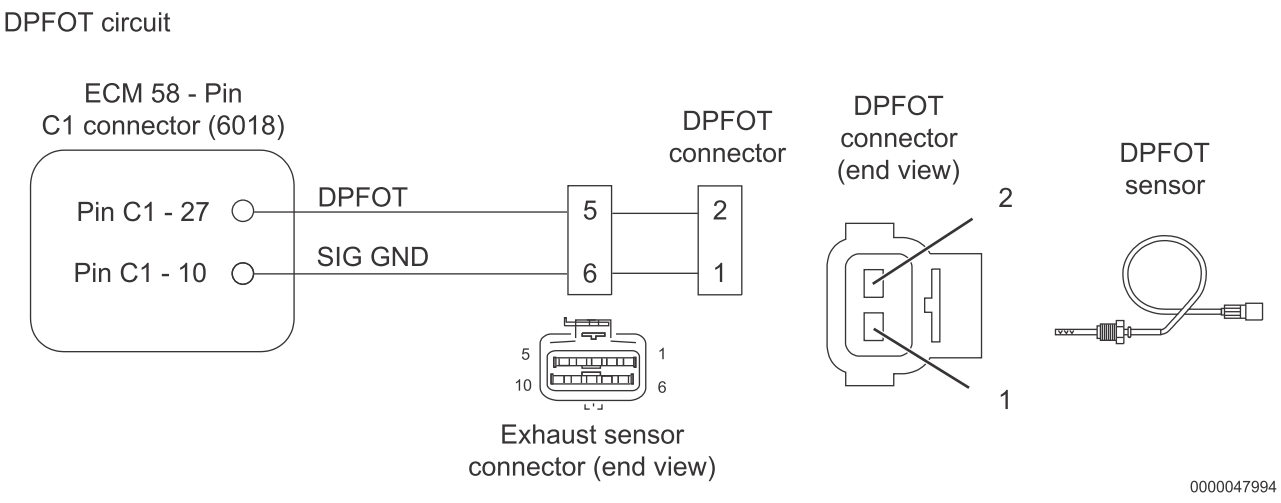


Figure 221 DPFOT sensor circuit diagram

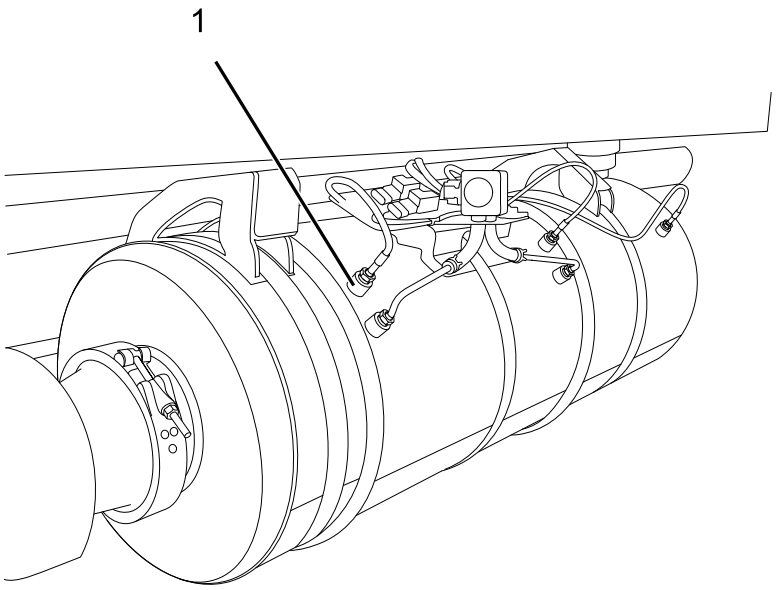
NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Diesel Particulate Filter Outlet Temperature (DPFOT) is a thermistor-style sensor that measures Diesel Particulate Filter (DPF) outlet temperature. As temperature increases, resistance decreases, causing the voltage signal sent to the Engine Control Module (ECM) to vary. The Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor works with the Diesel Oxidation Catalyst Outlet Temperature (DOCOT), DPFOT, and Diesel Particulate Filter Differential Pressure (DPFDP) sensors for operation and control the regeneration cycles of the Aftertreatment (AFT) system via the ECM.

Tools Required

- 00-00956-08 - 180-Pin Breakout Box
- ZTSE4498 - 3-Banana Plug Harness
- ZTSE4497 - 500 Ohm Resistor Harness
- ZTSE4899 - Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4760A (DPFOT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device



0000047843

Figure 222 DPFOT Sensor Location (Typical)

1. Diesel Particulate Filter Outlet Temperature (DPFOT) sensor

SPN 3246 FMI 2 - DPFOT signal does not agree with other exhaust sensors

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The Diesel Particulate Filter Outlet Temperature (DPFOT) is not changing with engine operating conditions (in-range but not rational).	Difference between Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Oxidation Catalyst Outlet Temperature (DOCOT), and DPFOT > 27°F (15°C).	Engine is cold soaked	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the difference between the Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Oxidation Catalyst Outlet Temperature (DOCOT), and Diesel Particulate Filter Outlet Temperature (DPFOT) readings do not match expected values for engine operating conditions. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 3246 FMI 3 and 4 (DPFOT); SPN 4765 FMI 3 and 4 (DOCIT); SPN 4766 FMI 3 and 4 (DOCOT)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

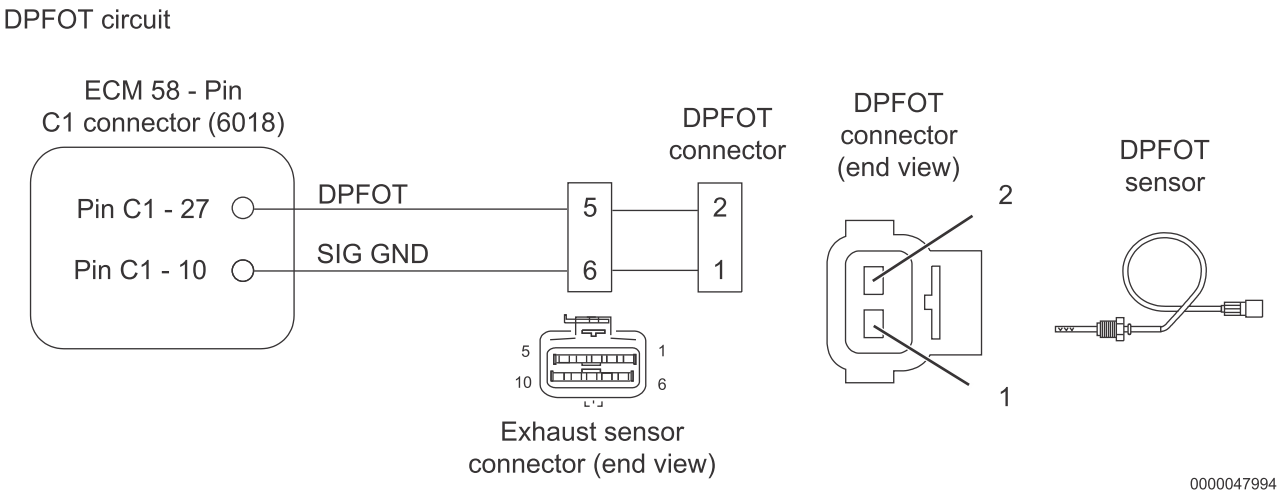


Figure 223 DPFOT sensor circuit diagram

Possible Causes

- Failed Diesel Particulate Filter Outlet Temperature (DPFOT) sensor
- High resistance in DPFOT circuit
- High resistance in SIG GND circuit

Step	Action	Decision
1	Using Engine Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3246 FMI 3 and 4 (DPFOT); SPN 4765 FMI 3 and 4 (DOCIT); SPN 4766 FMI 3 and 4 (DOCOT). Is EST DTC list free of SPN 3246 FMI 3 and 4; SPN 4765 FMI 3 and 4; SPN 4766 FMI 3 and 4?	Yes: Go to step 2. No: Repair SPN 3246 FMI 3 and 4; SPN 4765 FMI 3 and 4; SPN 4766 FMI 3 and 4. After repairs are complete, retest for SPN 3246 FMI 2.

Step	Action	Decision
2	Inspect connections at Diesel Particulate Outlet Temperature (DPFOT) sensor. Key OFF, disconnect DPFOT sensor connector. Check DPFOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFOT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 2.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 2.

Step	Action	Decision
4	Check DPFOT circuit for high resistance. Connect Breakout Harness ZTSE4760A to DPFOT harness and leave DPFOT disconnected. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to ECM C1 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness pin-2 and Breakout Box pin C1-27. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair high resistance between DPFOT connector pin-2 and ECM connector pin C1-27. After repairs are complete, retest for SPN 3246 FMI 2.

Step	Action	Decision
5	Check SIG GND circuit for high resistance. Connect Breakout Harness ZTSE4760A to DPFOT harness and leave DPFOT disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01467-00 to Chassis C1 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness pin-1 and Breakout Box pin C1-10. Is resistance less than 5 ohms?	Yes: Replace DPFOT sensor. After repairs are complete, retest for SPN 3246 FMI 2. No: Repair high resistance between DPFOT connector pin-1 and ECM connector pin C1-10. After repairs are complete, retest for SPN 3246 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 3246 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3246 FMI 3 - DPFOT signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Outlet Temperature (DPFOT) circuit short to PWR.	DPFOT sensor input voltage ≥ 5 volts	Key ON	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that the Diesel Particulate Filter Outlet Temperature (DPFOT) sensor signal voltage is greater than expected. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

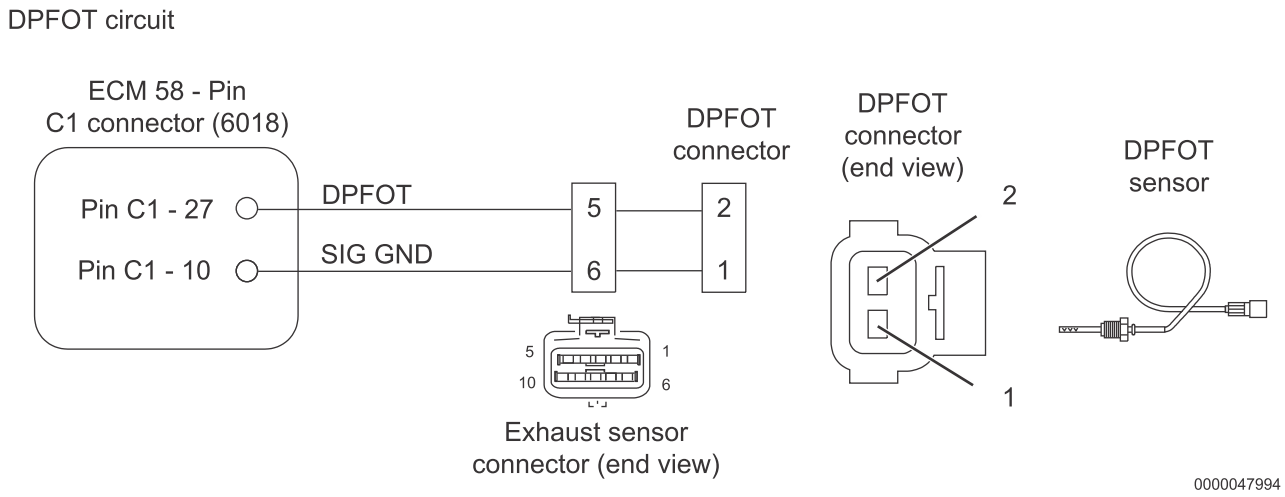


Figure 224 DPFOT sensor circuit diagram

Possible Causes

- High resistance or open in SIG GND circuit
- High resistance or open in DPFOT circuit
- Short to PWR in DPFOT circuit
- Failed DPFOT sensor

Step	Action	Decision
1	Inspect connections at Diesel Particulate Filter Outlet Temperature (DPFOT) sensor. Key OFF, disconnect DPFOT sensor connector. Check DPFOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFOT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 3.

Step	Action	Decision
2	Check DPFOT circuit for short to PWR. Connect Breakout Harness ZTSE4760A to vehicle harness and leave DPFOT sensor disconnected. Key-On Engine-Off (KOEO) measure voltage between Breakout Harness pin-2 and a known good ground. Is voltage within 0.5 volts of 5 volts?	Yes: Go to step 3. No: Repair short to power in DPFOT circuit between ECM pin C1-27 and DPFOT sensor pin-2. After repairs are complete, retest for SPN 3246 FMI 3.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 3.

Step	Action	Decision
4	Check DPFOT circuit for high resistance or Open. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness, and leave ECM disconnected. With Breakout Harness ZTSE4760A connected to vehicle harness and with DPFOT sensor disconnected. Use a DMM to measure resistance from Breakout Box pin C1-27 and Breakout Harness pin-2. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance in DPFOT circuit between ECM pin C1-27 and DPFOT sensor pin-2. After repairs are complete, retest for SPN 3246 FMI 3.

Step	Action	Decision
5	Check SIG GND circuit for high resistance or Open. Connect 180-pin Breakout Box with Breakout Harness 00-01467-00 to vehicle harness, and leave ECM disconnected. With Breakout Harness ZTSE4760A connected to vehicle harness and with DPFOT sensor disconnected. Use a DMM to measure resistance from Breakout Box pin C1-10 and Breakout Harness pin-1. Is resistance less than 5 ohms?	Yes: Replace DPFOT sensor. After repairs are complete, retest for SPN 3246 FMI 3. No: Repair Open or high resistance in SIG GND circuit between ECM pin C1-10 and DPFOT sensor pin-1. After repairs are complete, retest for SPN 3246 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 3246 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3246 FMI 4 - DPFOT signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Outlet Temperature (DPFOT) circuit short to ground.	DPFOT signal ≤ 0.05 volt	Key-On Engine-Running (KOER)	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the Diesel Particulate Filter Outlet Temperature (DPFOT) sensor signal voltage is less than 0.05 volts for more than 0.5 seconds. Active and parked regeneration of the DPF will be disabled. Engine torque will be reduced if the engine is operated for an extended period of time with this fault active.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

DPFOT circuit

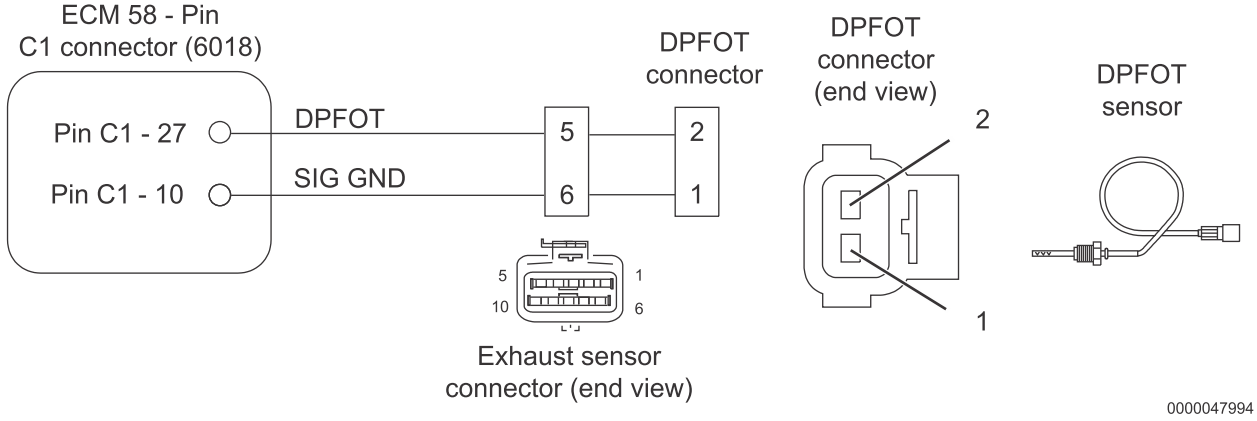


Figure 225 DPFOT sensor circuit diagram

Possible Causes

- Short to GND in DPFOT circuit
- SIG GND circuit shorted to DPFOT circuit
- Failed DPFOT sensor

Step	Action	Decision
1	Inspect connections at Diesel Particulate Filter Outlet Temperature (DPFOT) sensor. Key OFF, disconnect DPFOT sensor connector. Check DPFOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DOCOT sensor, connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 4.

Step	Action	Decision
2	Check DPFOT circuit for short to GND. Connect Breakout Harness ZTSE4760A to vehicle harness and leave DPFOT sensor disconnected. Key-On Engine-Off (KOEO) measure voltage between Breakout Harness pin-2 and a known good ground. Is voltage within 0.5 volts of 5 volts?	Yes: Go to step 3. No: Repair short to GND in DPFOT circuit between ECM pin C1-27 and DPFOT sensor pin-2. After repairs are complete, retest for SPN 3246 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM). Key OFF, disconnect ECM connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 4.

Step	Action	Decision
4	Check for short between DPFOT and SIG GND circuits. Connect Breakout Harness ZTSE4760A and leave DPFOT sensor disconnected. Key OFF, disconnect ECM and measure resistance between Breakout Harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Replace DPFOT sensor. After repairs are complete, retest for SPN 3246 FMI 4. No: Repair short between DPFOT and SIG GND circuits. After repairs are complete, retest for SPN 3246 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 3246 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3246 FMI 20 - DPFOT signal drifted HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Output Temperature (DPFOT) is above 932°F (500°C) ten to twenty minutes after Regeneration completes.	DPFOT > 932°F (500°C) 10 to 20 minutes after regen	Time after successful regen complete > 20 minutes Timer after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	10 seconds

Fault Overview

Fault code sets when the Diesel Particulate Filter Outlet Temperature (DPFOT) reaches above 932°F (500°C) within a predetermined time frame by the Engine Control Module (ECM).

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN's 94, 157, 3055, 3246, 3251, 3480, 4077, 4765, 5456, and 5541.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

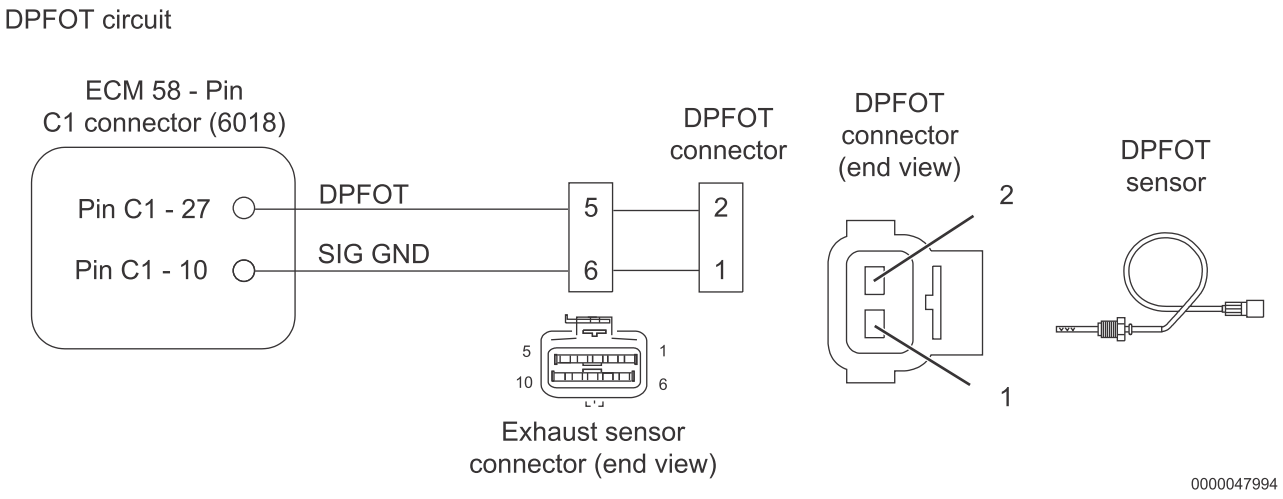


Figure 226 DPFOT sensor circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3246 FMI 20 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3246 FMI 20.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect the fuel system from fuel tank to Aftertreatment Fuel Injector (AFI) valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 3246 FMI 20.

Step	Action	Decision
3	Inspect connections at Diesel Particulate Filter Outlet Temperature (DPFOT) sensor. Key OFF, disconnect DPFOT. Check DPFOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 20.

Step	Action	Decision
4	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 5. No: Do Fuel Delivery Pressure (FDP) Test (page 167). After repairs are complete, retest for SPN 3246 FMI 20.

Step	Action	Decision
5	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 3246 FMI 20. No: Go to step 6.

Step	Action	Decision
6	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 7. No: Go to step 8.

Step	Action	Decision
7	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 3246 FMI 20.
		No: Repair failed valve train components. After repairs are complete retest for SPN 3246 FMI 20.

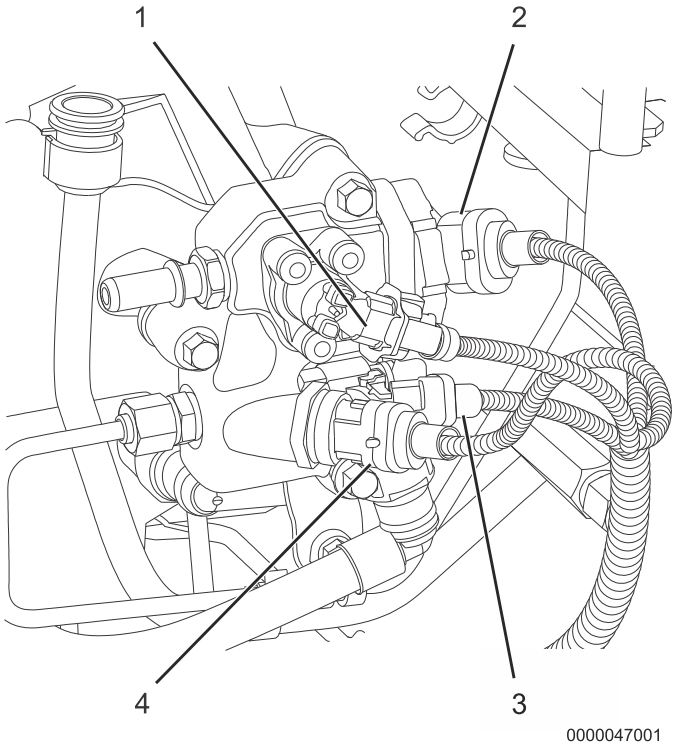


Figure 227 Down Stream Injection (DSI) Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
8	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location? (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Go to step 9.
		No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 3246 FMI 20.

Step	Action	Decision
9	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 3246 FMI 20.
		AFTFP2 signal value does not rise properly then drop when AFI opens: Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. After repairs are complete, retest for SPN 3246 FMI 20.
		AFTFP2 signal value rises but does not drop. Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. Inspect for kinked AFI supply line. After repairs are complete, retest for SPN 3246 FMI 20.
		AFTFP1 signal value drops and AFTFP2 signal value rises, then drops when AFI is opened (correct operation): Go to step 10.

Step	Action	Decision
10	Using EST with ServiceMaxx software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 11.
		No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

Step	Action			Decision
11	While running OBFCT, inspect for exhaust leaks and monitor following signals during test: Are Parked Regen Checks within specification during OBFCT?			If Parked Regen Checks are within specification: Go to step 12.
	Parked Regen Checks	**Specifications**	**Pass / Fail**	
	Engine condition	Smooth, not stumbling		If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 3246 FMI 20.
	Engine Coolant Temp (ECT)	Above 122°F (50°C) per ServiceMaxx		
	DOCIT	After 5 - 10 minutes above 500°F (260°C)		If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3246 FMI 20.
	DOCOT	After 5 – 10 minutes above 986°F (530°C)		
	DPFOT	Below 1292°F (700°C)		If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 3246 FMI 20.
	Aftertreatment Fuel Pressure 1 (AFTFP1)	> 110 psi during test		
	Aftertreatment Fuel Pressure 2 (AFTFP2)	Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.		

Step	Action	Decision
12	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Inspect for oil contamination of exhaust system. See Lube Oil to Exhaust (page 96). After repairs are complete, retest for SPN 3246 FMI 20.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3246 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 3246 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3246 FMI 21 - DPFOT signal drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Output Temperature (DPFOT) is below 392°F (200°C) with enable conditions met.	DPFOT < 392°F (200°C)	Injection Quantity > 115 mg / stroke IMP > 120 kPa Engine speed > 1400 rpm In above conditions > 45 seconds Timer after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	10 seconds

Fault Overview

Fault code sets when the Diesel Particulate Filter Outlet Temperature (DPFOT) is below 392°F (200°C) within a predetermined time frame by the Engine Control Module (ECM).

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN's 94, 157, 3055, 3251, 3480, 4077, 4765, 5456, and 5541.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

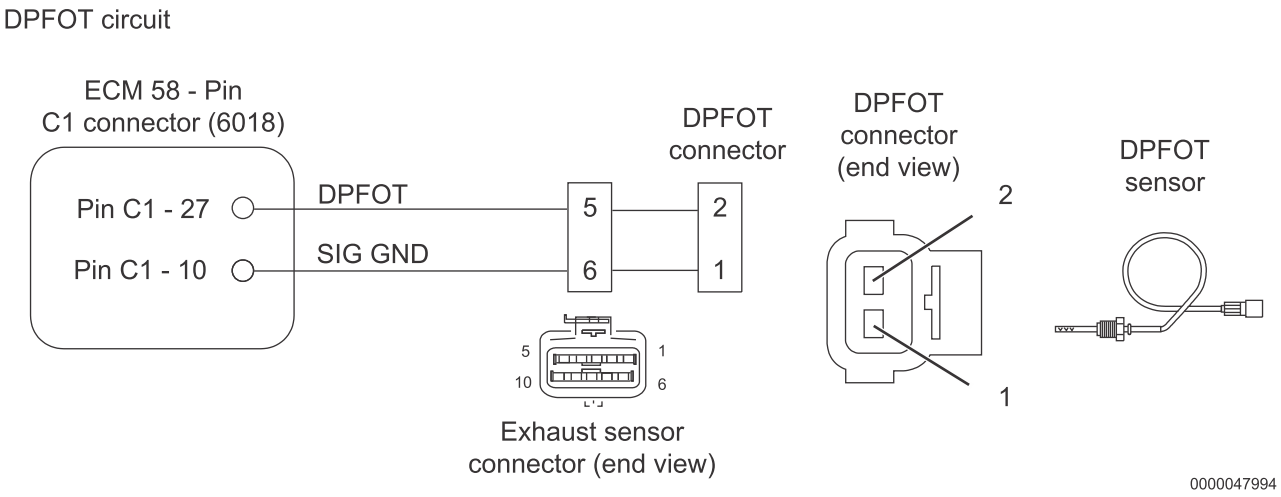


Figure 228 DPFOT sensor circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3246 FMI 21 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Inspect the fuel system from fuel tank to Aftertreatment Fuel Injector (AFI) valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
3	Inspect connections at Diesel Particulate Filter Outlet Temperature (DPFOT) sensor. Key OFF, disconnect DPFOT. Check DPFOT sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFOT sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
4	Determine if Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. FDP should be at a steady pressure of 90 psi or more. Is FDP between 85 – 120 psi?	Yes: Go to step 5. No: Do Fuel Delivery Pressure (FDP) Test (page 167). After repairs are complete, retest for SPN 3246 FMI 21.

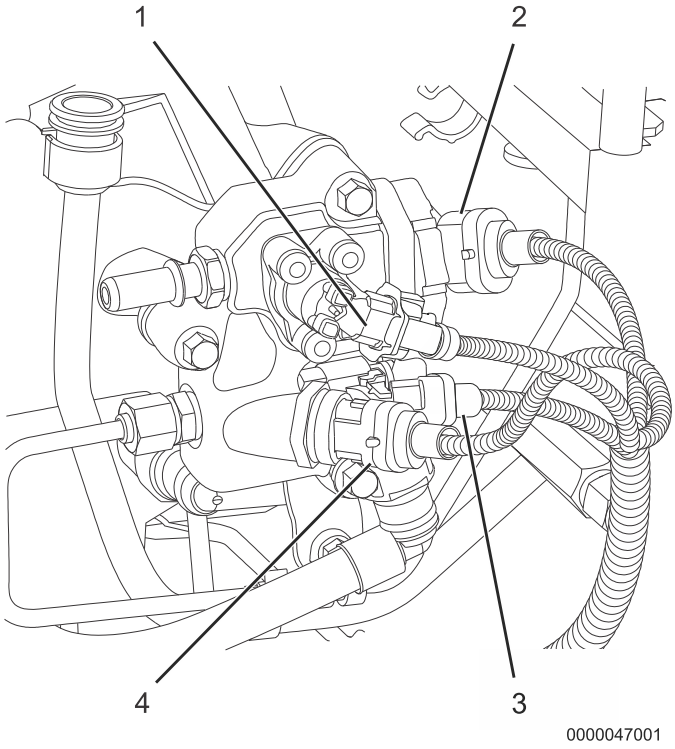


Figure 229 Down Stream Injection (DSI) Unit

1. Aftertreatment Fuel Shutoff Valve (AFTFSV) (WHITE)
2. Aftertreatment Fuel Inlet Sensor (AFTFIS)
3. Aftertreatment Fuel Doser (AFTFD) (BLACK)
4. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor

Step	Action	Decision
5	Check AFTFSV and Aftertreatment Fuel Doser (AFTFD) harness connectors are connected to the correct location? (AFTFSV and AFTFD harness connectors can be swapped.) Are AFTFSV and AFTFD harness connectors connected to the correct sensors?	Yes: Go to step 6. No: Connect harness connectors to correct location. After repairs are complete, retest for SPN 3246 FMI 21.

Step	Action	Decision
6	Verify correct Down Stream Injection (DSI) unit and Aftertreatment Fuel Injector (AFI) operation. Using Electronic Service Tool (EST) with ServiceMaxx™ software, KOER, run DSI De-Aeration test. Actuate AFTFSV and AFTFD. Monitor AFTFP1 and AFTFP2 signal values during activation. • Does AFTFP1 signal value drop when AFTFD is actuated? • Does AFTFP2 signal value rise then drop when AFI opens?	AFTFP1 signal value does not drop: Replace DSI unit. After repairs are complete, retest for SPN 3246 FMI 21.
		AFTFP2 signal value does not rise properly then drop when AFI opens: Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. After repairs are complete, retest for SPN 3246 FMI 21.
		AFTFP2 signal value rises but does not drop. Clean Aftertreatment Fuel Injector (AFI), AFI housing, and bore. Inspect for kinked AFI supply line. After repairs are complete, retest for SPN 3246 FMI 21.
		AFTFP1 signal value drops and AFTFP2 signal value rises, then drops when AFI is opened (correct operation): Go to step 7.

Step	Action	Decision
7	Using EST with ServiceMaxx software, start an On Board Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 8.
		No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

Step	Action			Decision
8	While running OBFCT, inspect for exhaust leaks and monitor following signals during test: Are Parked Regen Checks within specification during OBFCT?			If Parked Regen Checks are within specification: Go to step 9.
	Parked Regen Checks	**Specifications**	**Pass / Fail**	
	Engine condition	Smooth, not stumbling		If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 3246 FMI 21.
	Engine Coolant Temp (ECT)	Above 122°F (50°C) per ServiceMaxx		
	DOCIT	After 5 - 10 minutes above 500°F (260°C)		If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3246 FMI 21.
	DOCOT	After 5 – 10 minutes above 986°F (530°C)		
	DPFOT	Below 1292°F (700°C)		If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 3246 FMI 21.
	Aftertreatment Fuel Pressure 1 (AFTFP1)	> 110 psi during test		
	Aftertreatment Fuel Pressure 2 (AFTFP2)	Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.		

Step	Action	Decision
9	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3246 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 3246 FMI 21 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

DPF System (Diesel Particulate Filter)

SPN	FMI	Condition	Possible Causes	Actions
3719	0	DPF Soot Load - Highest (level 3/3)	• Engine performance problem • Engine mechanical • Regen inhibited • Failed DPFDP sensor module • Restricted DPFDP sensor hose(s)	Step-Based Diagnostics (page 552)
3719	15	DPF Soot Load - Lowest (level 1/3)	• Engine performance problem • Engine mechanical • Regen inhibited • Failed DPFDP sensor module • Restricted DPFDP sensor hose(s)	Step-Based Diagnostics (page 556)
3719	16	DPF Soot Load - Moderate (level 2/3)	• Engine performance problem • Engine mechanical • Regen inhibited • Failed DPFDP sensor module • Restricted DPFDP sensor hose(s)	Step-Based Diagnostics (page 560)
3720	0	DPF Ash load at maximum limit	• High DPF ash level • Low Fuel Delivery Pressure • Restricted AFI unit • Parked Regen Inhibited • Exhaust leak(s) • Biased DPFDP sensor • Biased IMP sensor • Low boost pressure	Step-Based Diagnostics (page 564)

3936	10	DPF Thermal management mode failed to raise DOC-In Temp as expected	• Engine Throttle Valve (ETV) or circuit fault • Exhaust Gas Recirculation Valve (EGRV) or circuit fault • Exhaust Back Pressure Valve (EBPV) or circuit fault • Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor or circuit fault • Ambient Air Temperature (AAT) sensor or circuit fault • Exhaust leaks • Restricted air filter	Step-based Diagnostics (page 569)
3936	20	High Regen Frequency	• Biased Intake Manifold Pressure (IMP) sensor or circuit • Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor or circuit • Diesel Particulate Filter Differential Pressure (DPFDP) sensor or circuit. DPFDP hoses restricted or leaking. • Diesel Oxidation Catalyst Inlet Temperature (DOCIT), DOC Outlet Temperature (DOCOT), or DPF Outlet Temperature (DPFOT) sensor or circuit • Oxygen (O_2) sensor or circuit • Restricted Aftertreatment Fuel Injector (AFI) or AFI housing • Down Stream Injection (DSI) failure or system leak • Failed DOC • Restricted air filter • Exhaust or boost leaks • Exhaust Gas Recirculation Valve (EGRV) or circuit failure • Turbocharger 2 Wastegate Control failure • Excessive forced parked regenerations (with Electronic Service Tool [EST]) in a short amount of time	Step-based Diagnostics (page 572)

Overview

The Diesel Particulate Filter (DPF) system is used to reduce soot released into the exhaust aftertreatment system. The DPF is used in conjunction with the Diesel Oxidation Catalyst (DOC) to reduce soot. The process of reducing soot to ash is called regeneration (regen). Regen can be active, stationary, or passive. Passive regen needs no input from the ECM to work. Active happens when the ECM commands the truck to regen, and the truck goes into a regen strategy. Stationary regen is used when an operator manually tells the ECM to begin the regen process. This can be accomplished by either manually pushing an override button inside the cab, or through the use of ServiceMaxx. The DOC and DPF can be serviced separately.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

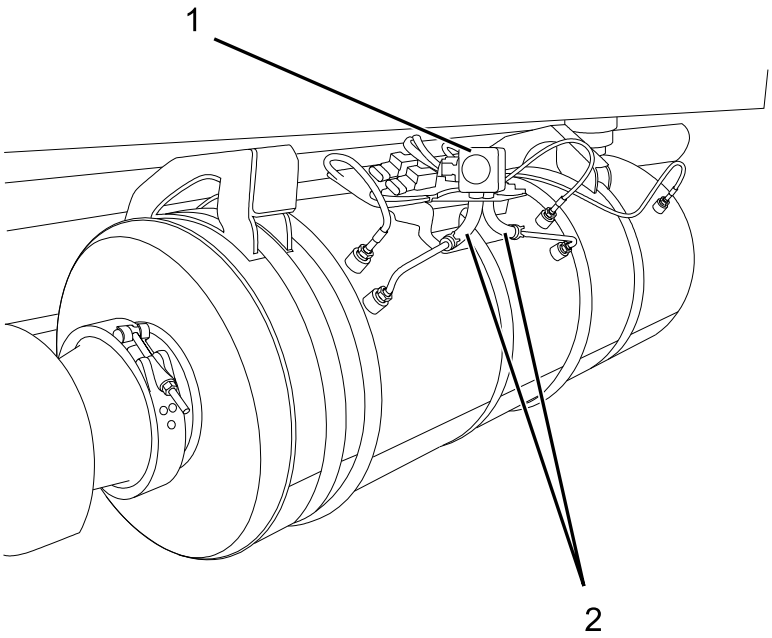


Figure 230 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

SPN 3719 FMI 0- DPF Soot Load - Highest (level 3/3)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Diesel Particulate Filter Differential Pressure (DPFDP) sensor data valid, but above normal operating range (most severe level).	DPFDP sensor has exceeded the recommended pressure limits.	Key-ON Engine-Running (KOER) Engine Speed > 500 rpm	1 event

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the soot load of the Diesel Particulate Filter (DPF) has exceeded the maximum operating limits. Torque output of the engine will be reduced as soot load increases. Active and parked regeneration of the aftertreatment system will be disabled. See AFT System Overview for additional information.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN 94 (FDP); SPN 102 (IMP); SPN 157 (FRP); SPN 651-656 (INJ/CYL); SPN 3246 FMI 2, 3, and 4 (DPFOT); SPN 3480 (AFTFP1); SPN 3482 (AFTFSV); SPN 3556 (AFT); SPN 4765 FMI 2, 3, and 4 (DOCIT); SPN 4766 (DOCOT); SPN 5541 (TC1TOP)

Drive Cycle to Determine Fault Status

Drive Cycle 25 then 1 in 2013 HD-OBD Diagnostic Reference Manual.

Fault Facts

This fault code may indicate exhaust temperature exiting the turbocharger are not high enough to actively regenerate the aftertreatment system. Driving the vehicle with long-term increased load may increase exhaust temperatures and decrease aftertreatment regeneration frequency.

Possible Causes

- Engine performance problem
- Engine mechanical
- Regen inhibited
- Failed DPFDP sensor
- Restricted DPFDP sensor hose(s)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3246 FMI 2, 3, and 4 (DPFOT); SPN 3480 (AFTFP1); SPN 3482 (AFTFSV); SPN 3556 (AFT); SPN 4765 FMI 2, 3, and 4 (DOCIT); and SPN 4766 FMI 2, 3, and 4 (DOCOT). Is EST DTC list free of SPN 3246 FMI 2, 3, and 4; SPN 3480; SPN 3482; SPN 3556; SPN 4765 FMI 2, 3, and 4; and SPN 4766 FMI 2, 3, and 4?	Yes: Go to step 2. No: Repair SPN 3246 FMI 2, 3, and 4; SPN 3480; SPN 3482; SPN 3556; SPN 4765 FMI 2, 3, and 4; and SPN 4766 FMI 2, 3, and 4. After repairs are complete, retest for SPN 3719 FMI 0.

Step	Action	Decision
2	Check for engine performance problems. Using EST with ServiceMaxx™ software, check DTC list for SPN 94 (FDP), SPN 102 (IMP), SPN 157 (FRP), SPN 651-656 (INJ / CYL), and SPN 5541 (TC1TOP). Is EST DTC list free of SPN 94, SPN 102, SPN 157, SPN 651-656, and SPN 5541?	Yes: Go to step 3. No: Repair SPN 94, SPN 102, SPN 157, SPN 651-656, and SPN 5541. After repairs are complete, retest for SPN 3719 FMI 0.

Step	Action	Decision
3	Determine if a regen inhibitor is inhibiting regeneration of the aftertreatment system. Using EST with ServiceMaxx software, go to Procedures > KOER Aftertreatment Procedures > DPF Filter Regeneration > Inhibitors > and click Begin Test. Does DPF Filter Regeneration procedure run without any active Inhibitors?	Yes: Retest for SPN 3719 FMI 0. Go to step 4. No: Correct active regen inhibitors ((page 319) and ServiceMaxx Aftertreatment DPF Filter Regeneration Inhibitors tab). After repairs are complete, retest for SPN 3719 FMI 0.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3719 FMI 0.

Step	Action	Decision
5	Monitor DPFDP sensor signal. Key-On Engine-Running (KOER), using EST with ServiceMaxx software, load the Signals session and monitor DPFDP. Is DPFDP below 0.5 psi (normal operation)?	Yes: Go to step 7. No: Go to step 6.

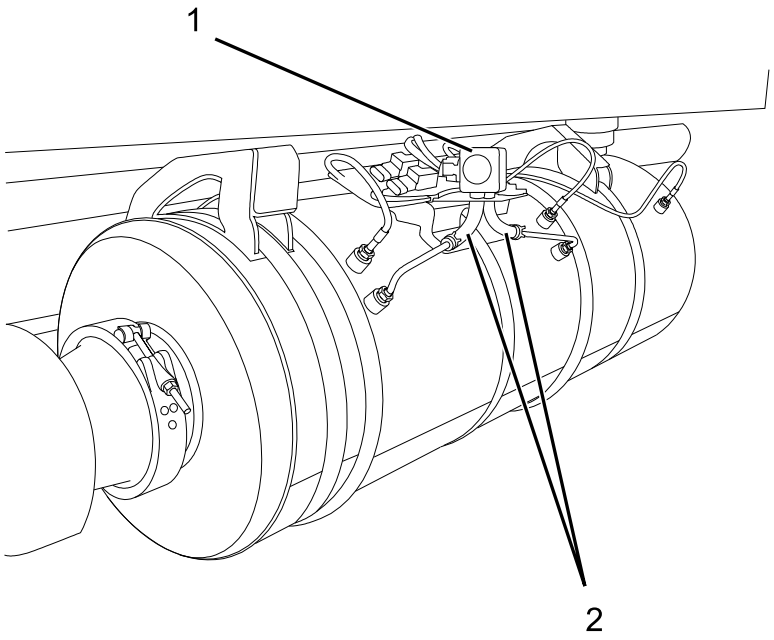


Figure 231 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

Step	Action	Decision
6	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP sensor hoses for improper routing, restrictions, or damage. Are the DPFDP sensor hoses routed correctly, free of damage, and unrestricted?	Yes: Replace DPFDP sensor. After repairs are complete, retest for SPN 3719 FMI 0. No: Repair or replace DPFDP sensor hose(s). After repairs are complete, retest for SPN 3719 FMI 0.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 3719 FMI 0. No: Go to step 8

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9. No: Go to step 10.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 3719 FMI 0. No: Repair failed valve train components. After repairs are complete retest for SPN 3719 FMI 0.

Step	Action	Decision
10	Determine if vehicle has an engine performance related driveability problem. Test drive the vehicle. Does engine have a performance problem.	Yes: Perform Engine Performance Diagnostics. After repairs are complete, retest for SPN 3719 FMI 0.

NOTE: After performing all diagnostic steps, if SPN 3719 FMI 0 remains, verify each step was completed correctly, and the proper decision was made. Notify supervisor for further action.

SPN 3719 FMI 15- DPF Soot Load - Lowest (level 1/3)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DPF Differential Pressure (DPFDP) sensor data valid, but above normal operating range (least severe level).	DPFDP sensor has exceeded the recommended limits.	Key-On Engine-Running (KOER) Engine Speed > 500 rpm	1 event

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the soot load of the Diesel Particulate Filter (DPF) has exceeded operating limits. Torque output of the engine will be reduced as soot load increases. See AFT System Overview for additional information.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN 94 (FDP); SPN 102 (IMP); SPN 157 (FRP); SPN 651-656 (INJ/CYL); SPN 3246 FMI 2, 3, and 4 (DPFOT); SPN 3480 (AFTFP1); SPN 3482 (AFTFSV); SPN 3556 (AFT); SPN 4765 FMI 2, 3, and 4 (DOCIT); SPN 4766 (DOCOT); SPN 5541 (TC1TOP)

Drive Cycle to Determine Fault Status

Drive Cycle 1 in 2013 HD-OBD Diagnostic Reference Manual.

Fault Facts

This fault code may indicate exhaust temperature exiting the turbocharger are not high enough to actively regenerate the aftertreatment system. Driving the vehicle with long-term increased load may increase exhaust temperatures and decrease aftertreatment regeneration frequency.

Possible Causes

- Engine performance problem
- Engine mechanical
- Regen inhibited
- Failed DPFDP sensor
- Restricted DPFDP sensor hose(s)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3246 FMI 2, 3, and 4 (DPFOT); SPN 3480 (AFTFP1); SPN 3482 (AFTFSV); SPN 3556 (AFT); SPN 4765 FMI 2, 3, and 4 (DOCIT); and SPN 4766 FMI 2, 3, and 4 (DOCOT). Is EST DTC list free of SPN 3246 FMI 2, 3, and 4; SPN 3480; SPN 3482; SPN 3556; SPN 4765 FMI 2, 3, and 4; and SPN 4766 FMI 2, 3, and 4?	Yes: Go to step 2. No: Repair SPN 3246 FMI 2, 3, and 4; SPN 3480; SPN 3482; SPN 3556; SPN 4765 FMI 2, 3, and 4; and SPN 4766 FMI 2, 3, and 4. After repairs are complete, retest for SPN 3719 FMI 15.

Step	Action	Decision
2	Check for engine performance problems. Using EST with ServiceMaxx™ software, check DTC list for SPN 94 (FDP), SPN 102 (IMP), SPN 157 (FRP), SPN 651-656 (INJ / CYL), and SPN 5541 (TC1TOP). Is EST DTC list free of SPN 94, SPN 102, SPN 157, SPN 651-656, and SPN 5541?	Yes: Go to step 3. No: Repair SPN 94, SPN 102, SPN 157, SPN 651-656, and SPN 5541. After repairs are complete, retest for SPN 3719 FMI 15.

Step	Action	Decision
3	Determine if a regen inhibitor is inhibiting regeneration of the aftertreatment system. Using EST with ServiceMaxx software, go to Procedures > KOER Aftertreatment Procedures > DPF Filter Regeneration > Inhibitors > and click Begin Test. Does DPF Filter Regeneration procedure run without any active Inhibitors?	Yes: Retest for SPN 3719 FMI 15. Go to step 4. No: Correct active regen inhibitors ((page 319) and ServiceMaxx Aftertreatment DPF Filter Regeneration Inhibitors tab). After repairs are complete, retest for SPN 3719 FMI 15.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3719 FMI 15.

Step	Action	Decision
5	Monitor DPFDP sensor signal. Key-On Engine-Running, using EST with ServiceMaxx software, load the Signals session and monitor DPFDP. Is DPFDP below 0.5 psi (normal operation)?	Yes: Go to step 7. No: Go to step 6.

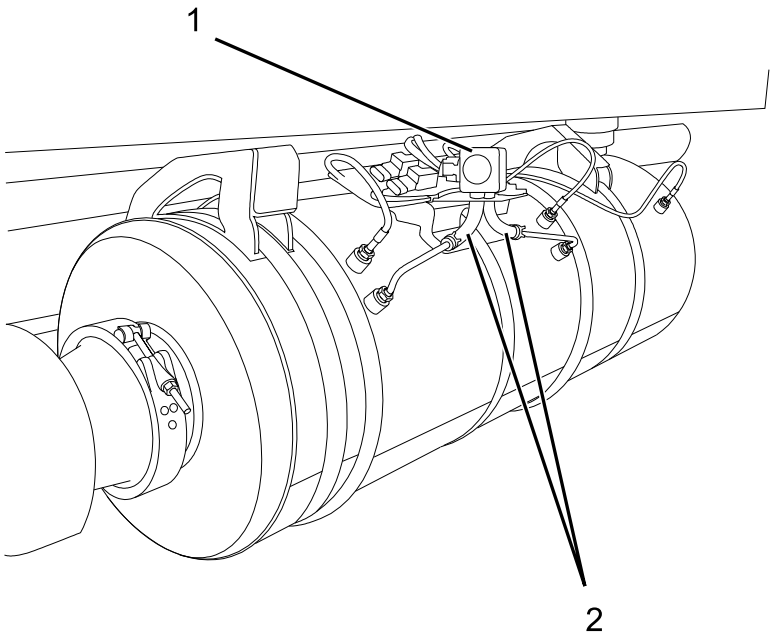


Figure 232 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

Step	Action	Decision
6	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP sensor hoses for improper routing, restrictions, or damage. Are the DPFDP sensor hoses routed correctly, free of damage, and unrestricted?	Yes: Replace DPFDP sensor. After repairs are complete, retest for SPN 3719 FMI 15. No: Repair or replace DPFDP sensor hose(s). After repairs are complete, retest for SPN 3719 FMI 15.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 3719 FMI 15. No: Go to step 8

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9. No: Go to step 10.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 3719 FMI 15. No: Repair failed valve train components. After repairs are complete retest for SPN 3719 FMI 15.

Step	Action	Decision
10	Determine if vehicle has an engine performance related driveability problem. Test drive the vehicle. Does engine have a performance problem.	Yes: Perform Engine Performance Diagnostics. After repairs are complete, retest for SPN 3719 FMI 15.

NOTE: After performing all diagnostic steps, if SPN 3719 FMI 15 remains, verify each step was completed correctly, and the proper decision was made. Notify supervisor for further action.

SPN 3719 FMI 16- DPF Soot Load - Moderate (level 2/3)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
DPF Differential Pressure (DPFDP) sensor data valid, but above normal operating range (moderately severe level).	DPFDP sensor has exceeded the recommended limits.	Key-On Engine-Running (KOER) Engine Speed > 500 rpm	1 event

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects the soot load of the Diesel Particulate Filter (DPF) has exceeded operating limits. Torque output of the engine will be reduced as soot load increases. Active and parked regeneration of the aftertreatment system will be disabled. See AFT System Overview for additional information.

Malfunction Indicator Lamp (MIL) Reaction

This fault does not illuminate the MIL when active.

Associated Faults

SPN 94 (FDP); SPN 102 (IMP); SPN 157 (FRP); SPN 651-656 (INJ/CYL); SPN 3246 FMI 2, 3, and 4 (DPFOT); SPN 3480 (AFTFP1); SPN 3482 (AFTFSV); SPN 3556 (AFT); SPN 4765 FMI 2, 3, and 4 (DOCIT); SPN 4766 (DOCOT); SPN 5541 (TC1TOP)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Fault Facts

This fault code may indicate exhaust temperature exiting the turbocharger are not high enough to actively regenerate the aftertreatment system. Driving the vehicle with long-term increased load may increase exhaust temperatures and decrease aftertreatment regeneration frequency.

Possible Causes

- Engine performance problem
- Engine mechanical
- Regen inhibited
- Failed DPFDP sensor
- Restricted DPFDP sensor hose(s)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 3246 FMI 2, 3, and 4 (DPFOT); SPN 3480 (AFTFP1); SPN 3482 (AFTFSV); SPN 3556 (AFT); SPN 4765 FMI 2, 3, and 4 (DOCIT); and SPN 4766 FMI 2, 3, and 4 (DOCOT). Is EST DTC list free of SPN 3246 FMI 2, 3, and 4; SPN 3480; SPN 3482; SPN 3556; SPN 4765 FMI 2, 3, and 4; and SPN 4766 FMI 2, 3, and 4?	Yes: Go to step 2. No: Repair SPN 3246 FMI 2, 3, and 4; SPN 3480; SPN 3482; SPN 3556; SPN 4765 FMI 2, 3, and 4; and SPN 4766 FMI 2, 3, and 4. After repairs are complete, retest for SPN 3719 FMI 16.

Step	Action	Decision
2	Check for engine performance problems. Using EST with ServiceMaxx™ software, check DTC list for SPN 94 (FDP), SPN 102 (IMP), SPN 157 (FRP), SPN 651-656 (INJ / CYL), and SPN 5541 (TC1TOP). Is EST DTC list free of SPN 94, SPN 102, SPN 157, SPN 651-656, and SPN 5541?	Yes: Go to step 3. No: Repair SPN 94, SPN 102, SPN 157, SPN 651-656, and SPN 5541. After repairs are complete, retest for SPN 3719 FMI 16.

Step	Action	Decision
3	Determine if a regen inhibitor is inhibiting regeneration of the aftertreatment system. Using EST with ServiceMaxx software, go to Procedures > KOER Aftertreatment Procedures > DPF Filter Regeneration > Inhibitors > and click Begin Test. Does DPF Filter Regeneration procedure run without any active Inhibitors?	Yes: Retest for SPN 3719 FMI 15. Go to step 4. No: Correct active regen inhibitors ((page 319) and ServiceMaxx Aftertreatment DPF Filter Regeneration Inhibitors tab). After repairs are complete, retest for SPN 3719 FMI 16.

Step	Action	Decision
4	Inspect connections at Diesel Particulate Filter Differential Pressure (DPFDP) sensor. Key OFF, disconnect DPFDP sensor. Check DPFDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the DPFDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3719 FMI 16.

Step	Action	Decision
5	Monitor DPFDP sensor signal. Key-On Engine-Running, using EST with ServiceMaxx software, load the Signals session and monitor DPFDP. Is DPFDP below 0.5 psi (normal operation)?	Yes: Go to step 7. No: Go to step 6.

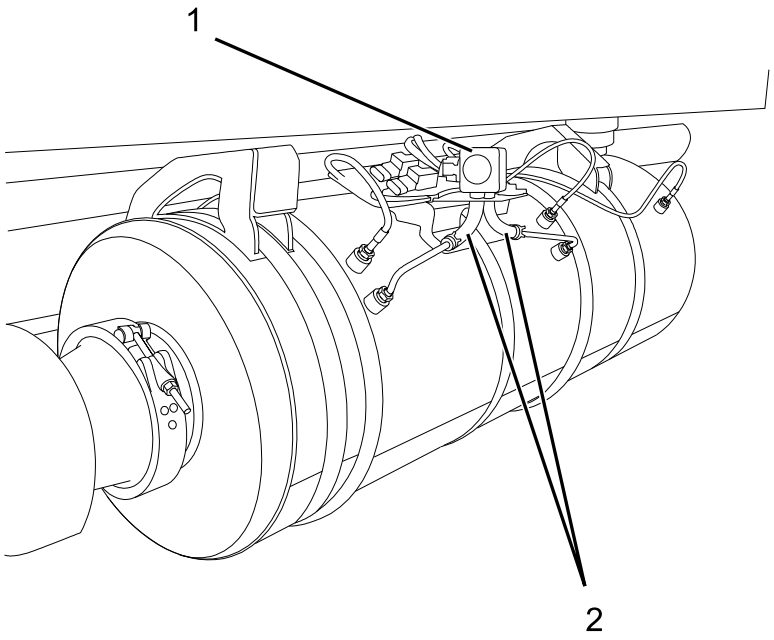


Figure 233 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

Step	Action	Decision
6	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP sensor hoses for improper routing, restrictions, or damage. Are the DPFDP sensor hoses routed correctly, free of damage, and unrestricted?	Yes: Replace DPFDP sensor. After repairs are complete, retest for SPN 3719 FMI 16. No: Repair or replace DPFDP sensor hose(s). After repairs are complete, retest for SPN 3719 FMI 16.

Step	Action	Decision
7	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 3719 FMI 16. No: Go to step 8

Step	Action	Decision
8	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 9. No: Go to step 10.

Step	Action	Decision
9	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 3719 FMI 16. No: Repair failed valve train components. After repairs are complete retest for SPN 3719 FMI 16.

Step	Action	Decision
10	Determine if vehicle has an engine performance related driveability problem. Test drive the vehicle. Does engine have a performance problem.	Yes: Perform Engine Performance Diagnostics. After repairs are complete, retest for SPN 3719 FMI 16.

NOTE: After performing all diagnostic steps, if SPN 3719 FMI 16 remains, verify each step was completed correctly, and the proper decision was made. Notify supervisor for further action.

SPN 3720 FMI 0 - DPF Ash load at maximum limit

Fault Overview

The Diesel Particulate Filter (DPF) must be at soot level 3, when the DPF lamp is flashing and the buzzer sounding. This notifies operator the soot level has reached a critical level and the engine is de-rated further.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN's 27, 102, 1189, 2791, 3251, 3480, 4077, 5456, and 5541.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

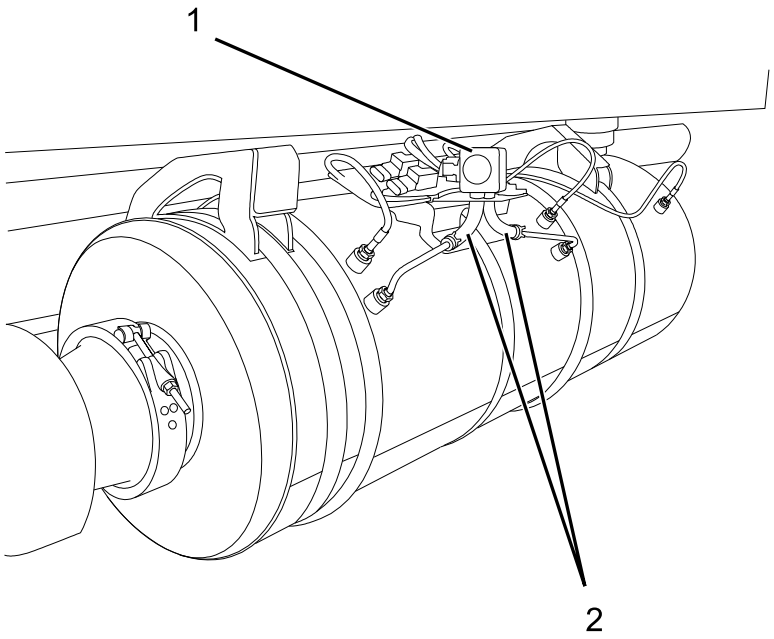


Figure 234 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3720 FMI 0 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3720 FMI 0.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, monitor Diesel Particulate Filter Differential Pressure (DPFDP) signal with Key-On Engine-Off (KOEO). See "Appendix A (page 953)" for DPFDP specifications. Is DPFDP within specifications?	Yes: Go to step 4. No: Go to step 3.

Step	Action	Decision
3	Check for biased DPFDP sensor. Do DPFDP sensor biased check (page 514). Are DPFDP sensor and circuits within specifications?	Yes: Go to step 5. No: Repair DPFDP sensor or circuits. After DPFDP circuits are repaired, go to step 5.

Step	Action	Decision
4	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to step 5. No: Repair DPFDP hoses. After repairs are complete, go to step 5.

Step	Action	Decision
5	Start an Onboard Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort message in ServiceMaxx?	Yes: Go to Step 6. No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="10">6</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specification: Go to step 7.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="2">If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 3720 FMI 0.</td></tr>
<tr><td>Engine Coolant Temp (ECT)</td><td>Above 122°F (50°C) per ServiceMaxx</td><td></td></tr>
<tr><td>DOCIT</td><td>After 5 - 10 minutes above 500°F (260°C)</td><td></td><td rowspan="2">If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3720 FMI 0.</td></tr>
<tr><td>DOCOT</td><td>After 5 – 10 minutes above 986°F (530°C)</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td><td rowspan="3">If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 3720 FMI 0.</td></tr>
<tr><td>Aftertreatment Fuel Pressure 1 (AFTFP1)</td><td>> 110 psi during test</td><td></td></tr>
<tr><td>Aftertreatment Fuel Pressure 2 (AFTFP2)</td><td>Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.</td><td></td></tr>
</table>

Step	Action	Decision
7	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Go to step 8.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3720 FMI 0.

Step	Action	Decision
8	Determine if Intake Manifold Pressure (IMP) sensor or circuit is out of specifications. Using EST with ServiceMaxx software, do IMP Biased Sensor Check (page 717). Is IMP sensor within specifications?	Yes: Go to step 9.
		No: Repair IMP sensor or circuit. After repairs are complete, retest for SPN 3720 FMI 0.

Step	Action	Decision
9	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC) and Exhaust Gas Recirculation (EGR) valve are commanded On. Key-On Engine-Running (KOER). Run Air Management Test while monitoring IMP sensor signal. Does IMP sensor signal change: • When TC2WC is commanded On? • When EGR valve is commanded On?	IMP signal change only when TC2WC is commanded On: Do EGR Pinpoint Diagnostics (page 622) and check for EGR issue. After repairs are complete, retest for SPN 3720 FMI 0.
		IMP signal change only with EGR valve commanded On: Do TC2WC voltage and circuit checks (page 839). After repairs are complete, retest for SPN 3720 FMI 0.
		Neither change IMP signal when commanded On: Go to step 10.
		Both change IMP signal when commanded On: Go to step 11.

Step	Action	Decision
10	Verify IMP sensor and bore are not restricted due to carbon buildup. Remove and inspect IMP sensor and bore for carbon buildup. Is IMP sensor and bore free of carbon buildup?	Yes: Go to step 11.
		No: Clean IMP sensor bore of carbon deposits. After repairs are complete, retest for SPN 3720 FMI 0.

Step	Action	Decision
11	Do Road Test (Full load to highway speed) (page 161), 100% engine load (when safe to do so). Record a snapshot of the following signals: • Diesel Particulate Filter Differential Pressure (DPFDP) = 0.5 to 0.8 psi • Turbocharger 1 Turbine Outlet Pressure (TC1TOP) = 2 to 3 psi • Soot load < 40% Are DPFDP and TC1TOP signals within specifications? **NOTE: DPFDP and TC1TOP specifications only apply with soot load < 40%.**	**Both** TC1TOP and DPFDP signals are above specification: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		Only TC1TOP signal above specification: Remove Pre Diesel Oxidation Catalyst (PREDOC) and Diesel Oxidation Catalyst (DOC) for inspection and clean or replace as necessary. After repairs are complete, retest for SPN 3720 FMI 0.
		Neither signal above specification: Retest for SPN 3720 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 3720 FMI 0 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3936 FMI 10 - DPF Thermal Management Mode Failed to Raise DOC-In Temp as Expected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Hydrocarbon Injection (HCI) quantity does not exceed a calibrated threshold within a certain time after regeneration request	HCI fuel quantity less then expected within 17.5 minutes after regen request.	Regeneration Active Time after Key On > 0 seconds Ambient pressure > 10 psi (75 kPa) Battery voltage > 10.7 volts Battery voltage < 15 volts Engine operating in monitoring region: Function of engine speed > 600 rpm and load > 50% DOCIT > –58°F (–50°C) and < 932°F (500°C) DOCOT > –58°F (–50°C) and < 1166°F (630°C) DPFOT > –58°F (–50°C) and < 1250°F (675°C) Exhaust gas mass flow >= 0 kg/h	0.05 Seconds

Fault Overview

This fault sets when the Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor temperature can not be reached during dosing of fuel into the exhaust stream to establish full regeneration mode. Time is determined from calculations and AAT sensor input.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, no lamp will illuminate.

Associated Faults

SPN's 27, 51, 2791, 3464, 5542, and 5543.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3936 FMI 10 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3936 FMI 10.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Also, inspect the fuel system from fuel tank to AFI valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks, or physical damage. After repairs are complete, retest for SPN 3936 FMI 10.

Step	Action	Decision
3	Determine if DOCIT sensor or circuit is out of specification. Key-On Engine-Off, using EST with ServiceMaxx software, open Sessions / Aftertreatment / Temperature. Key-On, Engine-On. Run engine at 1400 — 1500 rpm for 10 minutes (No load and stationary). Compare DPFOT, Diesel Oxidation Catalyst Inlet Temperature (DOCIT), and DOC Outlet Temperature (DOCOT). Sensor temperatures should be within 15°C (25°F) of each other. Is DOCIT sensor within 15°C (25°F) of DOC and DOCOT sensors?	Yes: Go to step 4. No: Do DOCIT Circuit Checks (page 487). After repairs are complete, retest for SPN 3936 FMI 10.

Step	Action	Decision
4	Using EST with ServiceMaxx™ software, run Continuous Monitor session and determin if AAT sensor (page 207) is biased (best results if checked after cold soak). Is the sensor within specifications? (Wiggle test may be necessary if code is inactive or pending.)	Yes: Go to step 5. No: Do AAT Circuit Checks (page 207) After repairs are complete, retest for SPN 3936 FMI 10.

Step	Action	Decision
5	Using EST with ServiceMaxx™ software, do KOEO Actuator Test and actuate the EGRV (page 622), ETV (page 643), and EBPV (page 579). Did all of the actuators respond properly?	Yes: Go to step 6. No: Diagnose and repair malfunctioning actuator as necessary. After repairs are complete, retest for SPN 3936 FMI 10.

Step	Action	Decision
6	Using EST with ServiceMaxx software, start an Onboard Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx?	Yes: Go to step 7. No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="11">7</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specification: Go to step 8.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="2">If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 3936 FMI 10.</td></tr>
<tr><td>Engine Coolant Temp (ECT)</td><td>Above 122°F (50°C) per ServiceMaxx</td><td></td></tr>
<tr><td>DOCIT</td><td>After 5 - 10 minutes above 500°F (260°C)</td><td></td><td rowspan="2">If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3936 FMI 10.</td></tr>
<tr><td>DOCOT</td><td>After 5 – 10 minutes above 986°F (530°C)</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td><td rowspan="3">If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 3936 FMI 10.</td></tr>
<tr><td>Aftertreatment Fuel Pressure 1 (AFTFP1)</td><td>> 110 psi during test</td><td></td></tr>
<tr><td>Aftertreatment Fuel Pressure 2 (AFTFP2)</td><td>Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.</td><td></td></tr>
</table>

Step	Action	Decision
8	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3936 FMI 10.

SPN 3936 FMI 20 - High Regen Frequency

Fault Overview

Fault sets when the ECM determines the number of exhaust regenerations has been exceeded within a predetermined time.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN's 102, 1189, 3246, 3251, 4765, 4766, and 5541.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

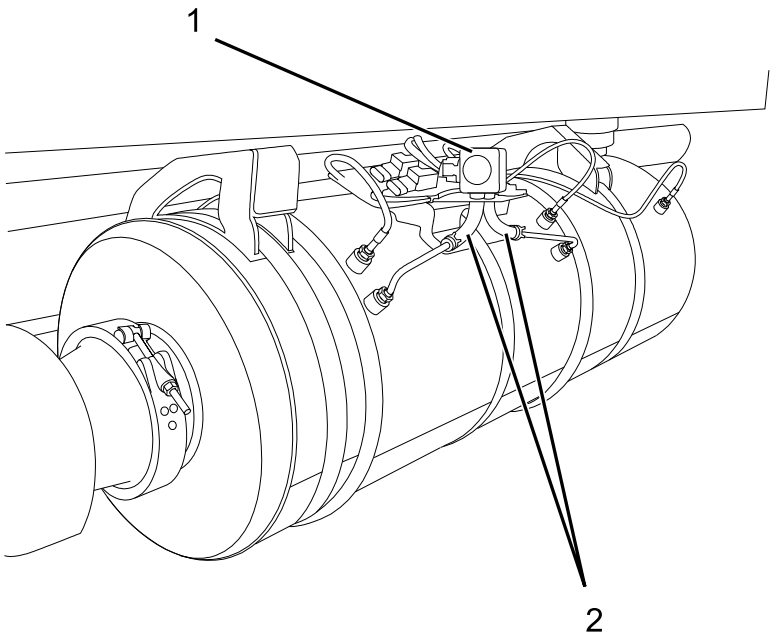


Figure 235 DPFDP Sensor Location (Typical)

1. DPFDP sensor
2. DPFDP sensor hoses

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3936 FMI 20 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Also, inspect the fuel system from fuel tank to AFI valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
3	Using EST with ServiceMaxx™ software, with the Key-On Engine-Off (KOEO), monitor Intake Manifold Pressure (IMP) (page 717). Use the KOEO values found in “Appendix A:Performance Specifications”. Is IMP sensor within specifications?	Yes: Go to step 4. No: Repair IMP sensor circuit. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
4	Using EST with ServiceMaxx™ software, KOEO, monitor Turbocharger 1 Turbine Outlet Pressure (TC1TOP) (page 832). Use the KOEO values found in “Appendix A:Performance Specifications”. Is TC1TOP sensor within specifications?	Yes: Go to step 5. No: Repair TC1TOP sensor circuit. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
5	Using EST with ServiceMaxx™ software, KOEO, monitor Diesel Particulate Filter Differential (DPFDP) (page 514). Use the KOEO values found in “Appendix A: Performance Specifications.” Is DPFDP sensor within specifications?	Yes: Go to step 6. No: Repair DPFDP sensor circuit. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
6	Using EST with ServiceMaxx™ software KOEO, monitor Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor. Using the Component Specification values found in “Appendix A: Performance Specifications (page 956).” Is DOCIT sensor within specifications?	Yes: Go to step 7. No: Repair DOCIT sensor circuit (page 487). After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
7	Using EST with ServiceMaxx™ software KOEO, monitor Diesel Oxidation Catalyst Outlet Temperature (DOCOT) sensor. Using the Component Specification values found in “Appendix A:Performance Specifications (page 956).” Is the DOCOT sensor within specifications?	Yes: Go to step 8. No: Repair DOCOT sensor circuit (page 503). After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
8	Using EST with ServiceMaxx™ software KOEO, monitor Diesel Particulate Filter Outlet Temperature (DPFOT) sensor. Using the Component Specification values found in “Appendix A:Performance Specifications (page 956).” Is the DPFOT sensor within specifications?	Yes: Go to step 9. No: Repair DPFOT sensor circuit (page 514). After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
9	Using EST with ServiceMaxx™ software, run the Continuous Monitor session and determine if the O_2 sensor is biased (page 819). Is the O_2 sensor within specifications?	Yes: Go to step 10. No: Repair O_2 sensor circuit (page 819) and then retest for SPN 3936 FMI 20.

Step	Action	Decision
10	Check for biased DPFDP sensor. Do DPFDP sensor biased check (page 514). Are DPFDP sensor and circuits within specification?	Yes: Go to step 11. No: Repair DPFDP sensor or circuits. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
11	Check DPFDP sensor hoses for correct routing and restrictions. Inspect the DPFDP hoses for kinks, improper hose routing, reversed hoses or damage. See DPFDP sensor locator for correct routing of hoses. Are the DPFDP hoses routed correctly and free of damage?	Yes: Go to step 12. No: Repair DPFDP hoses. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
12	Determine if Intake Manifold Pressure (IMP) sensor or circuit is out of specifications. Using EST with ServiceMaxx™ software, do IMP Biased Sensor or Circuit Check (page 717). Is IMP sensor within specifications?	Yes: Go to step 13. No: Repair IMP sensor or circuit. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
13	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC) and Exhaust Gas Recirculation (EGR) valve are commanded On. Key-On Engine-Running (KOER). Run Air Management Test while monitoring IMP sensor signal. Does IMP sensor signal change: • When TC2WC is commanded On? • When EGR valve is commanded On?	IMP signal change only when TC2WC is commanded On: Do EGR Pinpoint Diagnostics (page 622) and check for EGR issue. After repairs are complete, retest for SPN 3936 FMI 20.
		IMP signal change only with EGR valve commanded On: Do TC2WC voltage and circuit checks (page 839). After repairs are complete, retest for SPN 3936 FMI 20.
		Neither change IMP signal when commanded On: Go to step 14.
		Both change IMP signal when commanded On: Go to step 15.

Step	Action	Decision
14	Verify IMP sensor and bore are not restricted due to carbon buildup. Remove and inspect IMP sensor and bore for carbon buildup. Is IMP sensor and bore free of carbon buildup?	Yes: Go to step 15.
		No: Clean IMP sensor bore of carbon deposits. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
15	Do Road Test (Full load to highway speed) (page 161), 100% engine load (when safe to do so). Record a snapshot of the following signals: • Diesel Particulate Filter Differential Pressure (DPFDP) = 0.5 to 0.8 psi • Turbocharger 1 Turbine Outlet Pressure (TC1TOP) = 2 to 3 psi • Soot load < 40% Are DPFDP and TC1TOP signals within specifications? **NOTE: DPFDP and TC1TOP specifications only apply with soot load < 40%.**	**Both** TC1TOP and DPFDP signals are above specification: Go to step 16.
		Only TC1TOP signal above specification: Remove Pre Diesel Oxidation Catalyst (Pre-DOC) and Diesel Oxidation Catalyst (DOC) for inspection and clean or replace as necessary. After repairs are complete, retest for SPN 3936 FMI 20.
		Neither signal is high, go to step 17.

Step	Action	Decision
16	Using EST with ServiceMaxx software, start an Onboard Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 17.
		No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

Step	Action			Decision
17	While running OBFCT, inspect for exhaust leaks and monitor following signals during test: Are Parked Regen Checks within specification during OBFCT?			If Parked Regen Checks are within specification: Go to step 18.
	Parked Regen Checks	**Specifications**	**Pass / Fail**	
	Engine condition	Smooth, not stumbling		If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 3936 FMI 20.
	Engine Coolant Temp (ECT)	Above 122°F (50°C) per ServiceMaxx		
	DOCIT	After 5 - 10 minutes above 500°F (260°C)		If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 3936 FMI 20.
	DOCOT	After 5 – 10 minutes above 986°F (530°C)		
	DPFOT	Below 1292°F (700°C)		If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 3936 FMI 20.
	Aftertreatment Fuel Pressure 1 (AFTFP1)	> 110 psi during test		
	Aftertreatment Fuel Pressure 2 (AFTFP2)	Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.		

Step	Action	Decision
18	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Go to step 19.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 3936 FMI 20.

Step	Action	Decision
19	Is the vehicle being operated outside torque curve creating excessive soot?	Yes: Check application of vehicle and rear axle gear ratio for correct RPM range during vehicle usage.
		No: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EBPV (Exhaust Back Pressure Valve)

SPN	FMI	Condition	Possible Causes
5542	15	TC1TOP above desired	• Restricted Exhaust • Stuck or sticking closed EBPV
5542	17	TC1TOP below desired	• EBPV not closing when commanded
5543	3	EBPC short to PWR	• EBPV circuit short to PWR • Failed EBPV
5543	4	EBPC short to GND	• EBPV circuit short to GND • Failed EBPV
5543	5	EBPC open load/circuit	• EBPC circuit OPEN • Failed EBPV

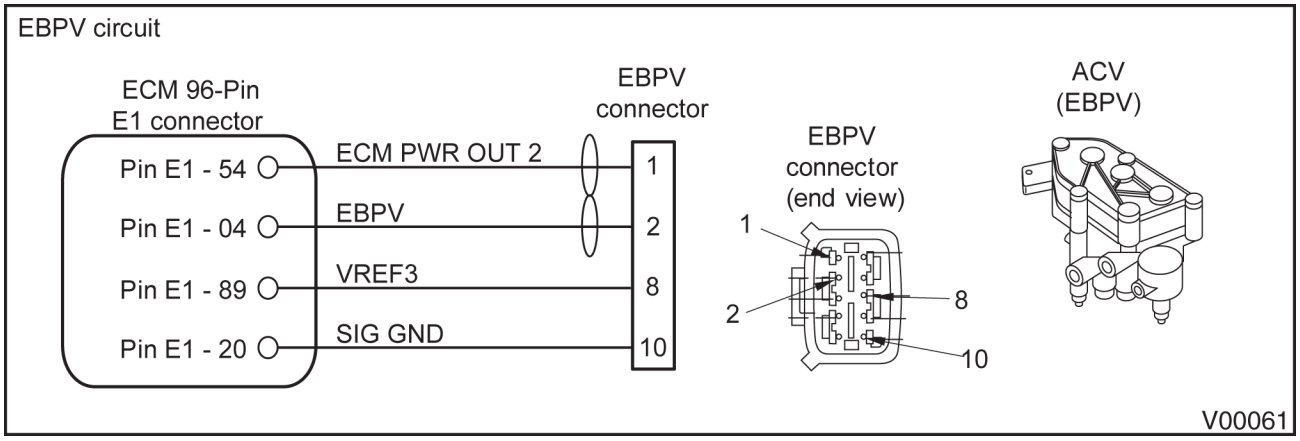


Figure 236 EBPV circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6003 (EBPV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

NOTE: The EBPV, TC1TOP, TC1WC, and TC2WC circuits share the same connector to the ACV assembly.

Connector Voltage Check – EBPV Disconnected

NOTE: Excessive backpressure in the exhaust system, such as a plugged Diesel Oxidation Catalyst (DOC), could set this fault. Check for exhaust system damage and proper aftertreatment system operation before performing electrical checks.

Connect Breakout Harness ZTSE6003 to EBPV engine harness, and leave EBPV disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check (page 580).
2 to GND	3.5 V ± 1.0 V	If < 2.5 V, check for OPEN circuit, Do Harness Resistance Check (page 580).
8 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF for short to PWR. If < 4.5 V, check VREF for OPEN or short to GND. Do Harness Resistance Check (page 580).
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure air tanks have at least 90 psi (621 kPa) of pressure.

1. Connect Breakout Harness ZTSE6003 between EBPV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Exhaust Back Pressure Valve from the drop-down menu.
3. Command Exhaust Back Pressure Valve to 5%.
4. Use DMM to measure voltage.
5. Command Exhaust Back Pressure Valve to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 12 V ± 2.0 V	If < 10 V, check for OPEN circuit.
2 to GND	95% = 0.5 V ± 0.5 V	If > 1 V, check for OPEN circuit or failed EBPV.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6003 to EBPV and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment
1 to 2	4 Ω to 8 Ω	If not within specification, replace the EBPV.
If measurements are within specifications, go to Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with Breakout Harness 00-01468-00 to ECM E1 connector and leave ECM disconnected. Connect Breakout Harness ZTSE6003 to vehicle harness and leave EBPV disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-54	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-04	< 5 Ω	If > 5 Ω, check for OPEN circuit.
8 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
8 to E1-89	< 5 Ω	If > 5 Ω, check for OPEN circuit.
10 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
10 to E1-20	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, check for DTCs. If DTC returns, replace EBPV.		

ECB1 (Engine Compression Brake 1)

SPN	FMI	Condition	Possible Causes
1072	3	ECB1 Control short to PWR	• ECB1 control circuit short to PWR • Failed ECB1 solenoid
1072	4	ECB1 Control short to GND	• ECB1 control circuit short to GND • Failed ECB1 solenoid
1072	5	ECB1 Control open load/circuit	• ECB1 control OPEN circuit • Failed ECB1 solenoid

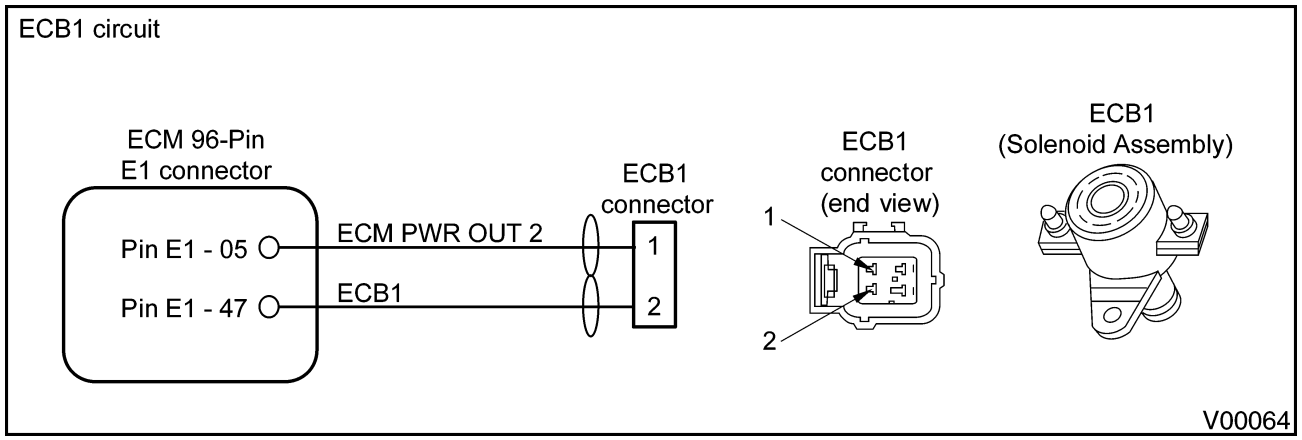


Figure 237 ECB1 circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6004 (ECB)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Connector Voltage Check – ECB1 Disconnected

Connect Breakout Harness ZTSE6004 to ECB1 engine harness, and leave ECB1 disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check.
2 to GND	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check.
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE6004 between ECB1 and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Engine Compression Brake 1 from the drop-down menu.
3. Command ECB1 to 5%.
4. Use DMM to measure voltage.
5. Command ECB1 to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 12 V ± 2.0 V	If < 10 V, check for OPEN circuit.
2 to GND	95% = 2.5 V ± 0.5 V	If > 3 V, check for OPEN circuit or failed ECB1.

Actuator Resistance Check

Turn ignition switch to OFF. Connect Breakout Harness ZTSE6004 to ECB1 and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment
1 to 2	9 Ω	If not within specification, replace the ECB1.
If measurements are within specifications, go to Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE6004 to ECB1 engine harness, and leave ECB1 disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1–05	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-47	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, check for DTCs. If DTC returns, replace ECB1.		

ECB2 (Engine Compression Brake 2)

SPN	FMI	Condition	Possible Causes
1073	3	ECB2 Control short to PWR	• ECB2 control circuit short to PWR • Failed ECB2 solenoid
1073	4	ECB2 Control short to GND	• ECB2 control circuit short to GND • Failed ECB2 solenoid
1073	5	ECB2 Control open load/circuit	• ECB2 control circuit OPEN • Failed ECB2 solenoid

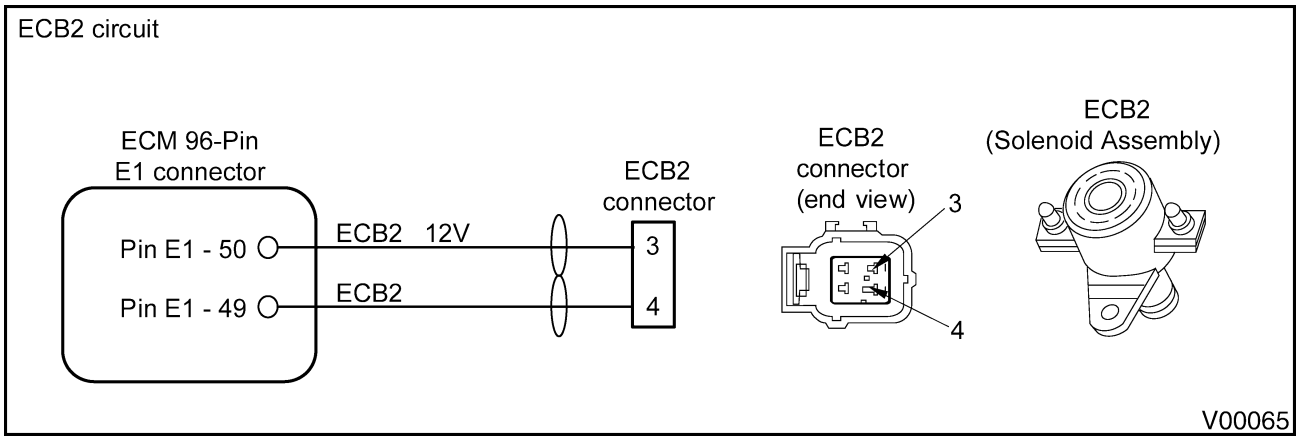


Figure 238 ECB2 circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6004 (ECB)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Connector Voltage Check – ECB2 Disconnected

Connect Breakout Harness ZTSE6004 to ECB2 engine harness, and leave ECB2 disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
3 to GND	1 V ± 0.5 V	If < 1 V, check for OPEN circuit. Do Harness Resistance Check.
4 to GND	1 V ± 0.5 V	If < 1 V, check for OPEN circuit. Do Harness Resistance Check.
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE6004 between ECB2 and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Engine Compression Brake 2 from the drop-down menu.
3. Command ECB2 to 5%.
4. Use DMM to measure voltage.
5. Command ECB2 to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
4 to GND	5% = 1 V ± 0.5 V	If < 0.5 V, check for OPEN circuit.
4 to GND	95% = 2.5 V ± 0.5 V	If < 2 V, check for OPEN circuit or failed ECB1.

Actuator Resistance Check

Turn ignition switch OFF. Connect Breakout Harness ZTSE6004 to ECB2 and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
3 to 4	9 Ω	If not within specification, replace the ECB2.
If measurements are within specifications, go to Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch OFF. Connect 180-Pin Breakout Box with Breakout Harness 00-01468-00 with ECM E1 and E2 harness to ECM E1 connector, and leave ECM disconnected. Connect Breakout Harness ZTSE6004 to ECB2 engine harness and leave ECB2 disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to E1–50	< 5 Ω	If > 5 Ω, check for OPEN circuit.
4 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
4 to E1-49	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, check for DTCs. If DTC returns, replace the ECB1.		

ECL Switch (Engine Coolant Level)

SPN	FMI	Condition	Possible Causes
111	1	Low Engine Coolant level	• Low coolant level • Checks for leaks or boiling out

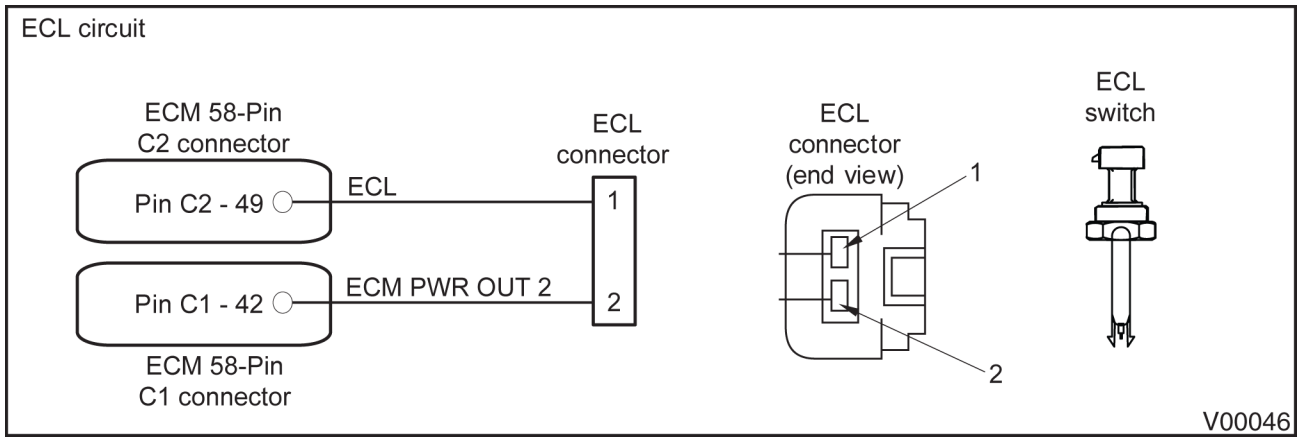


Figure 239 ECL switch circuit diagram

Tools Required

- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Pinpoint Diagnostics With ServiceMaxx™ Software

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, verify DTC is active for this sensor.
   - If code is previously active, wiggle the harness of the suspect sensor. If the circuit is interrupted, the DTC will go active.
   - If code is active, proceed to Pinpoint ECL System Fault.

NOTE: Inspect connectors for damaged, corrosion, or loose pins. Repair if necessary.

SPN 111 FMI 1 – Low Engine Coolant level

Pinpoint ECL System Fault

1. Check for low coolant level. If coolant is not low, go to Connector Voltage Check.

Connector Voltage Check

Disconnect ECL switch. Using Big Bore Terminal Test Probe Kit ZTSE4899 insert proper terminal into ECL engine harness connector. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	0 V	If > 0.5 V, check for short to PWR.
2 to GND	12 V ± 2.0 V	If < 10.0 V, check for OPEN circuit.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 connectors, and leave ECM disconnected. Using Big Bore Terminal Test Probe Kit ZTSE4899 insert proper terminal into ECL engine harness connector. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to C2-49	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to C1-42	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ECM Power (Engine Control Module)

SPN	FMI	Condition	Possible Causes
158	15	ECM Switched voltage too HIGH	• Jump start using more than system voltage • Batteries wired incorrectly
158	17	ECM Switched voltage too LOW	• Low discharged batteries • Charging system failure • High resistance in ECM powering circuits

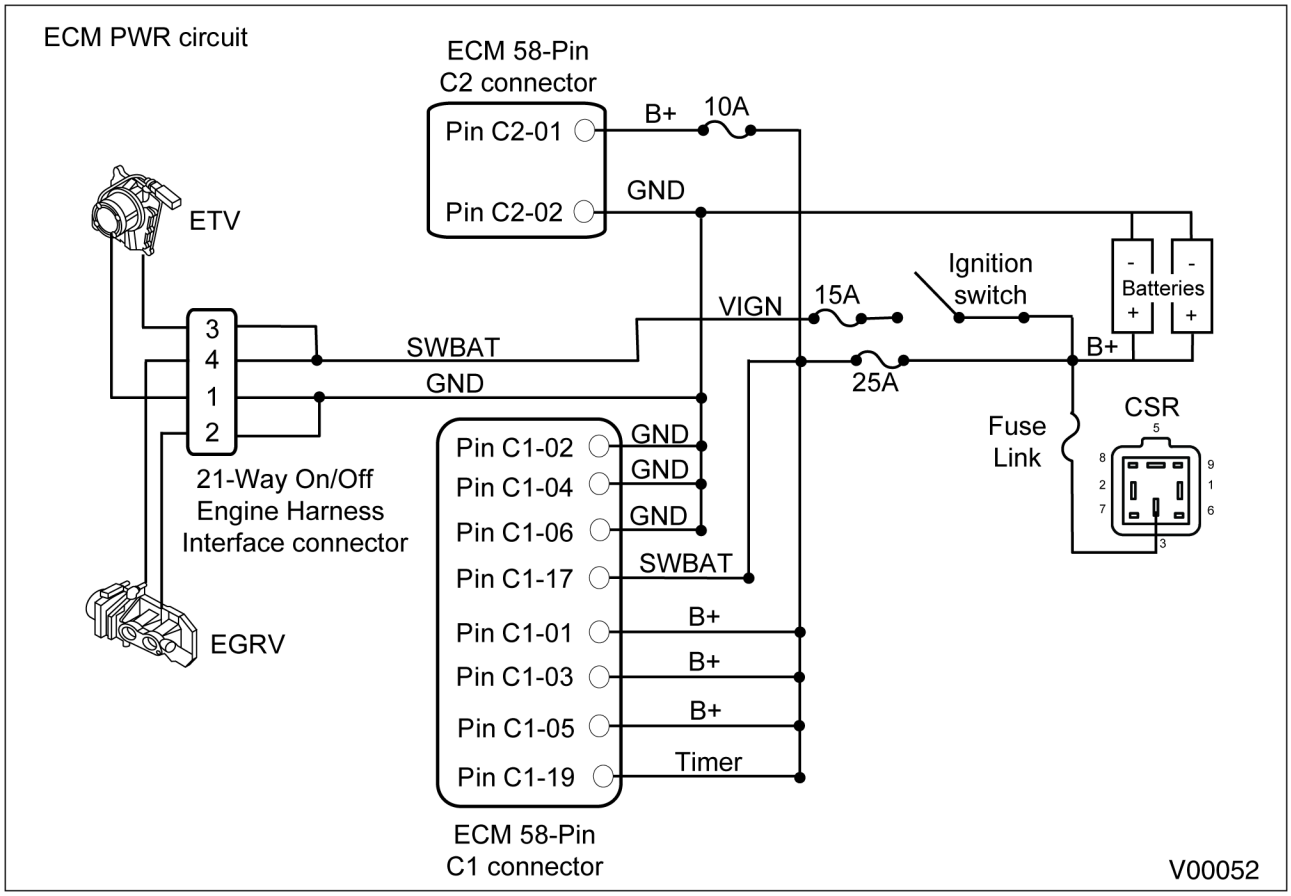


Figure 240 ECM PWR (Input Power) circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN 158 FMI 15- ECM Switched voltage too HIGH

Pin-point ECM System Fault

1. Turn engine OFF and measure battery voltage.
   - If battery voltage is above 16 V, batteries are wired incorrectly. Repair circuitry.
2. Start engine and measure battery voltage.
   - If battery voltage is above 16 V, repair charging system.

SPN 158 FMI 17- ECM Switched voltage too LOW

Pin-point ECM System Fault

1. Start engine and measure battery voltage.
   - If battery voltage is below 10 V, repair charging system.
   - If voltage is above 12 V, continue to next step.
2. Using ServiceMaxx™ software, monitor Switched Battery voltage.
   - If battery voltage is below 10 V, continue pinpoint diagnostics.

Voltage Checks at ECM

Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
C1-01 to GND	B+	If < B+, check for OPEN in B+ circuit.
C1-03 to GND	B+	If < B+, check for OPEN in B+ circuit.
C1-05 to GND	B+	If < B+, check for OPEN in B+ circuit.
C2-01 to GND	B+	If < B+, check for OPEN in B+ circuit.
C1-19 to GND	B+	If < B+, check for OPEN in Timer circuit.
C1-17 to GND	B+	If < B+, check for OPEN in SWBAT circuit.
C1-02 to B+	B+	If < B+, check for OPEN in ground circuit.
C1-04 to B+	B+	If < B+, check for OPEN in ground circuit.
C1-06 to B+	B+	If < B+, check for OPEN in ground circuit.
C2-02 to B+	B+	If < B+, check for OPEN in ground circuit.

ECM Power Output (Engine Control Module)

SPN	FMI	Condition	Possible Causes
3597	4	ECM Power Output 1 below normal ECM Pins: C1-31, C1-33, C1-54, C2-51, E1-01 and E1-51	• ECM Power Output 1 circuit short to GND
3598	4	ECM Power Output 2 below normal ECM Pins: C1-42, C2-06, E1-05, E1-28, E1-29 and E1-54	• ECM Power Output 2 circuit short to GND
3599	4	ECM Power Output 3 below normal ECM Pins: C1-30, C2-03, E1-24, E1-26, and E1-27	• ECM Power Output 3 circuit short to GND

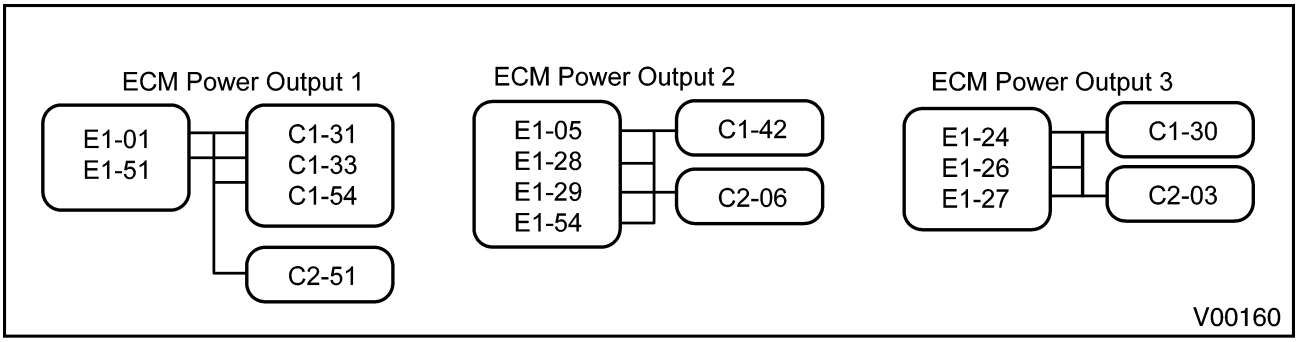


Figure 241 ECM PWR (Output Power) circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN 3597 FMI 4 – ECM Power Output 1

Voltage Check

Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
C1-31 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
C1-33 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
C1-54 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
C2-51 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.

Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
E1-01 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
E1-51 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.

Harness Resistance Check

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C1-31 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
C1-33 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
C1-54 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
C2-51 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E1-01 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-51 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

SPN 3598 FMI 4 – ECM Power Output 2

Voltage Check

Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
C1-42 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
C2-06 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.

Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
E1-05 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
E1-28 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
E1-29 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
E1-54 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.

Harness Resistance Check

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C1-42 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
C2-06 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-05 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-28 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-29 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-54 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E1-05 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-28 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-29 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-54 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

SPN 3599 FMI 4 – ECM Power Output 3

Voltage Check

Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
C1-30 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
C2-03 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.

Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
E1-24 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
E1-26 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.
E1-27 to GND	B+	If < B+, check for short to GND or internally shorted component. Do Harness Resistance Check.

Harness Resistance Check

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C1-30 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
C2-03 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E1-24 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-26 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-27 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

ECM (Engine Control Module) Self-Diagnostics

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN	FMI	Condition	Possible Causes
108	3	BARO signal Out of Range HIGH	Internal ECM failure, replace ECM and perform Crank Position (CKP) relearn procedure (page 598).
108	4	BARO signal Out of Range LOW	Internal ECM failure, replace ECM and perform CKP relearn procedure (page 598)
628	12	ECM Memory Error	Internal ECM failure, replace ECM and perform CKP relearn procedure (page 598)
629	2	ECM Error –Level 2 Monitoring	Internal ECM failure, replace ECM and perform CKP relearn procedure (page 598)
629	8	Engine Off timer fault	Internal ECM failure, replace ECM and perform CKP relearn procedure (page 598)
629	12	ECM Internal chip Error	Internal ECM failure, replace ECM and perform CKP relearn procedure (page 598)
629	14	ECM Internal component	Internal ECM failure, replace ECM and perform CKP relearn procedure (page 598)
1110	31	ECM Internal component	Internal ECM failure, replace ECM and perform CKP relearn procedure (page 598)

NOTE: Ensure battery voltage is at or above 12 V, before running the following procedures.

SPN 108 FMI 3- BARO signal Out of Range HIGH

Checks whether the signal from the Barometric Pressure (BARO) sensor is above the maximum threshold.

Pin-point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM and perform CKP relearn procedure (page 598).

SPN 108 FMI 4 - BARO signal Out of Range LOW

Checks whether the signal from the BARO sensor is below the minimum threshold.

Pin-point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM and perform CKP relearn procedure (page 598).

SPN 628 FMI 12 - ECM Memory Error

Pin-point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM and perform CKP relearn procedure (page 598).

SPN 629 FMI 2- ECM Error- Level 2 Monitoring

Pin-point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM and perform CKP relearn procedure (page 598).

SPN 629 FMI 8 - Engine Off timer fault

Pin-point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM and perform CKP relearn procedure (page 598).

SPN 629 FMI 12 - ECM Internal chip Error

Pin-point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM and perform CKP relearn procedure (page 598).

SPN 629 FMI 14 - ECM Internal component

Pin-point ECM Self-Diagnostic Fault

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM and perform CKP relearn procedure (page 598).

SPN 1110 FMI 31 – ECM Detects Fueling Without Demand

1. Clear DTC, cycle ignition switch.
2. If DTC is still active, replace ECM and perform CKP relearn procedure (page 598).

Crank Sensor Relearn Procedure

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Function

To perform Crankshaft Position (CKP) sensor relearn after replacing the ECM, CMP, or CKP sensor.

1. Turn ignition switch to ON, engine OFF.
2. Connect EST to vehicle's Diagnostic Connector.
3. Start ServiceMaxx™ software.
4. From sessions drop-down menu select Programming.
5. Search for parameter Crankshaft Position Learning Reset Request (ID 95232).
6. Click in Value field and select Yes from drop-down menu.
7. Click on Program Engine button.
8. After programming is complete, the value will switch back to No.

ECS (Engine Coolant System)

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN	FMI	Condition	Possible Causes	Actions
110	17	Engine Coolant System below OBD monitoring temperature	• Low coolant level • Failed Engine Coolant Temperature 1 (ECT1) sensor • Failed engine cooling fan (stuck on) • Failed thermostat	Step-Based Diagnostics (page 600)
110	18	Engine coolant system below closed loop minimum temperature	• Low coolant level • Failed Engine Coolant Temperature 1 (ECT1) sensor • Failed engine cooling fan (stuck on) • Failed thermostat	Step-Based Diagnostics (page 602)
1659	20	ECT1 below expected: Check Thermostat	• Failed thermostat	Pin-Point Diagnostics (page 604)
4752	4	EGR Cooler Efficiency: EGR Outlet Temp above expected	• Low coolant level • EGR cooler failure	Pin-Point Diagnostics (page 604)

Overview

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

SPN 110 FMI 17- Engine Coolant System below OBD monitoring temperature

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Minimum Onboard Diagnostics (OBD) coolant temperature not reached.	Engine Coolant Temperature 1 (ECT1) < 158°F (70°C)	Expected Engine Coolant Temperature > 158°F (70°C) Limp home mode inactive DPF regeneration inactive Power Take Off (PTO) inactive Barometric (BARO) pressure > 11 psi (75 kPa) Engine running > 30 seconds Ambient Air Temp (AAT) > -40°F (-40°C)	60 seconds

Fault Overview

Fault code sets when the signal from Engine Coolant Temperature 1 (ECT1) is not increasing as expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 110 FMI 3 and 4 (ECT1)

Fault Facts

In cold climates, operating the vehicle for extended periods of time at idle, or Without a winter front, may cause this fault to set.

Drive Cycle to Determine Fault Status

Drive Cycle 13 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low coolant level
- Failed Engine Coolant Temperature 1 (ECT1) sensor
- Failed engine cooling fan (stuck on)
- Failed thermostat (stuck Open)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 3,4 (ECT1). Is EST DTC list free of SPN 110 FMI 3,4?	Yes: Go to step 2. No: Repair SPN 110 FMI 3,4. After repairs are complete, retest for SPN 110 FMI 17.

Step	Action	Decision
2	Inspect coolant level. Check the coolant for correct level and condition. Is coolant filled to correct level?	Yes: Go to step 3. No: Perform Coolant Loss (page 79) test. After repairs are complete, retest for SPN 110 FMI 17.

Step	Action	Decision
3	Check for stuck on engine cooling fan. Using EST with ServiceMaxx™, go to Tests > KOER Tests > Engine Fan Test. Determine fans ability to maintain desired speeds. Is the fan operating properly?	Yes: Go to step 4. No: Repair or replace radiator fan assembly. After repairs are complete, retest for SPN 110 FMI 17.

Step	Action	Decision
4	Check for a failed ECT1 sensor. Using EST, perform the Coolant Control Valve Test. Go to Tests > KOER Tests > Coolant Control Valve Test. Set the Coolant Mixer Valve to On (95%) and run the engine at high idle. Are ECT1 and ECT2 within 10°F (6°C) of each other?	Yes: Replace Thermostats. After repairs are complete, retest for SPN 110 FMI 17. No: Replace Engine Coolant Temperature 1 (ECT1) sensor. After repairs are complete, retest for SPN 110 FMI 17.

NOTE: After performing all diagnostic steps, if SPN 110 FMI 17 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 110 FMI 18- Engine Coolant System below closed loop minimum temperature

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Minimum closed-loop coolant temperature not reached.	ECT1 < 50°F (10°C)	Calculated Engine Coolant Temperature > 50°F (10°C) Limp home mode inactive DPF regeneration inactive Power Take Off (PTO) inactive Barometric (BARO) pressure > 11 psi (75 kPa) Engine running > 30 seconds Ambient Air Temp (AAT) > -40° F (-40°C)	60 seconds

Fault Overview

Fault code sets when the signal from Engine Coolant Temperature 1 (ECT1) does not allow for closed-loop operation.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 110 FMI 3 and 4 (ECT1)

Fault Facts

In cold climates, operating the vehicle for extended periods of time at idle, or Without a winter front, may cause this fault to set.

Drive Cycle to Determine Fault Status

Drive Cycle 13 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low coolant level
- Failed Engine Coolant Temperature 1 (ECT1) sensor
- Failed engine cooling fan (stuck on)
- Failed thermostat (stuck Open)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 3,4 (ECT1). Is EST DTC list free of SPN 110 FMI 3,4?	Yes: Go to step 2. No: Repair SPN 110 FMI 3,4. After repairs are complete, retest for SPN 110 FMI 18.

Step	Action	Decision
2	Inspect coolant level. Check the coolant for correct level. Is coolant filled to correct level?	Yes: Go to step 3. No: Perform Coolant Loss (page 79) test. After repairs are complete, retest for SPN 110 FMI 18.

Step	Action	Decision
3	Check for a stuck on engine cooling fan. Using EST with ServiceMaxx™ go to Tests > KOER Tests > Engine Fan Test. Determine fans ability to maintain desired speeds. Is the fan operating properly?	Yes: Go to step 4. No: Repair or replace fan assembly. After repairs are complete, retest for SPN 110 FMI 18.

Step	Action	Decision
4	Check for a failed ECT1 sensor. Using EST, perform the Coolant Control Valve Test. Go to Tests > KOER Tests > Coolant Control Valve Test. Set the Coolant Mixer Valve to On (95%) and run the engine at high idle. Are ECT1 and ECT2 within 10°F (6°C) of each other?	Yes: Replace Thermostats. After repairs are complete, retest for SPN 110 FMI 18. No: Replace Engine Coolant Temperature 1 (ECT1) sensor. After repairs are complete, retest for SPN 110 FMI 18.

NOTE: After performing all diagnostic steps, if SPN 110 FMI 18 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 8 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Default session.
3. Compare Engine Coolant Temperature 1 (ECT1) to Engine Coolant Temperature 2 (ECT2). Sensor temperatures should be within 10°F (6°C) of each other.
   - If ECT1 is 10°F (6°C) or more above or below ECT2, check for poor circuitry going to the ECT1 sensor.
4. Verify engine fan is not stuck ON. Using ServiceMaxx™ software, run the Engine Fan Procedure.
5. Remove thermostats using procedure in the *Engine Service Manual*.
   - If the thermostat assemblies are stuck open, damaged, cracked, or not operating properly, replace them.
   - If engine fan or thermostat are not the cause, verify if code was set due to extended idle time in very cold ambient temperatures while running a large cabin heater.

ECT1 Sensor (Engine Coolant Temperature 1)

SPN	FMI	Condition	Possible Causes
110	3	ECT1 signal Out of Range HIGH	• ECT1 signal OPEN or short to PWR • SIG GND circuit OPEN • Failed ECT1 sensor
110	4	ECT1 signal Out of Range LOW	• ECT1 signal circuit short to GND • Failed ECT1 sensor

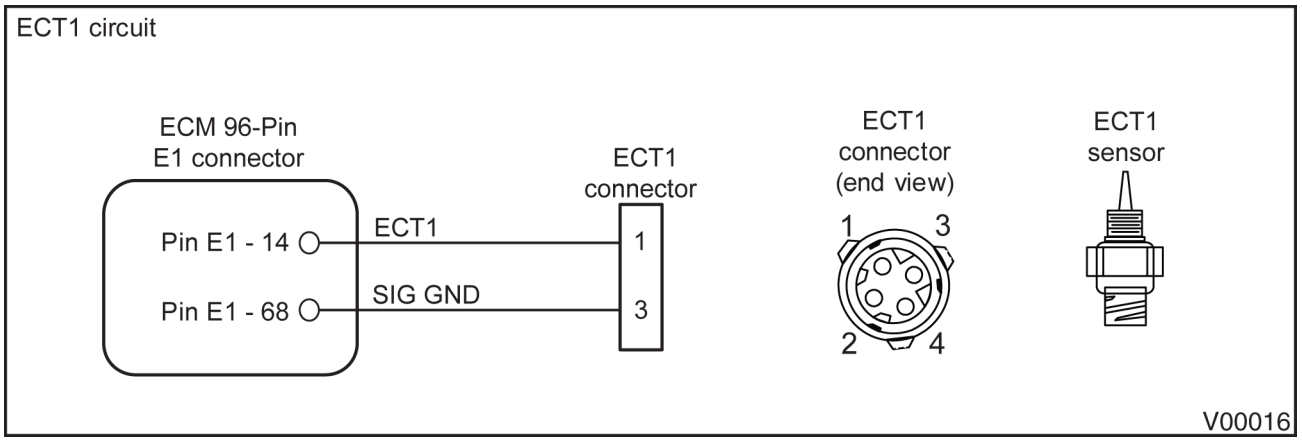


Figure 242 ECT1 sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4827 (ECT1)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Sensor Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4827 to ECT1 vehicle harness, and leave ECT1 sensor disconnected. Connect 180-Pin Breakout Box with ECM E1 and E2 harness between ECM E1 and E2 connectors and ECM. Turn ignition ON. Use a DMM to measure voltage.

Test Point	Specification	Comment– < Less than, > Greater than
Measure pin E1-71 to GND	4.5 V to 5 V	If < 4.5 V, check ECT1 signal circuit for short to GND.
Measure pin E1-71 to GND Short ECT1 pin-1 to GND	0 V	If > 0.25 V, check ECT1 signal circuit for OPEN. Do Harness Resistance Check (page 606).
Measure pin E1-71 to GND Short ECT1 pin-1 to pin-3	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 606).
Measure pin E1-71 to GND Short 500 Ω resistor between ECT1 pin-1 and pin-3	< 1.0 V	If > 1.0 V, check ECT1 signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace ECT1 sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4827 to ECT1 engine harness, and leave ECT1 sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND.
3 to B+	B+	If < B+, check for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4827 to ECT1 engine harness and leave ECT1 sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-14	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to E1-68	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ECT2 Sensor (Engine Coolant Temperature 2)

SPN	FMI	Condition	Possible Causes	Actions
4076	2	ECT2 signal erratic, intermittent, or incorrect	• Aftermarket block heater installed • Failed ECT2 sensor • High resistance in ECT2 circuit • High resistance in SIG GND circuit	Step-Based Diagnostics (page 609)
4076	3	ECT2 signal Out of Range HIGH	• ECT2 signal circuit OPEN or short to PWR • Failed ECT2 sensor	Pin-Point Diagnostics (page 612)
4076	4	ECT2 signal Out of Range LOW	• ECT2 signal circuit short to GND • Failed ECT2 sensor	Pin-Point Diagnostics (page 612)
4076	17	ECT2 signal stuck low, not warming up	• Failed Coolant Flow Valve (CFV) or circuit • Failed Coolant Mixer Valve (CMV) or circuit	Pin-Point Diagnostics (page 612)

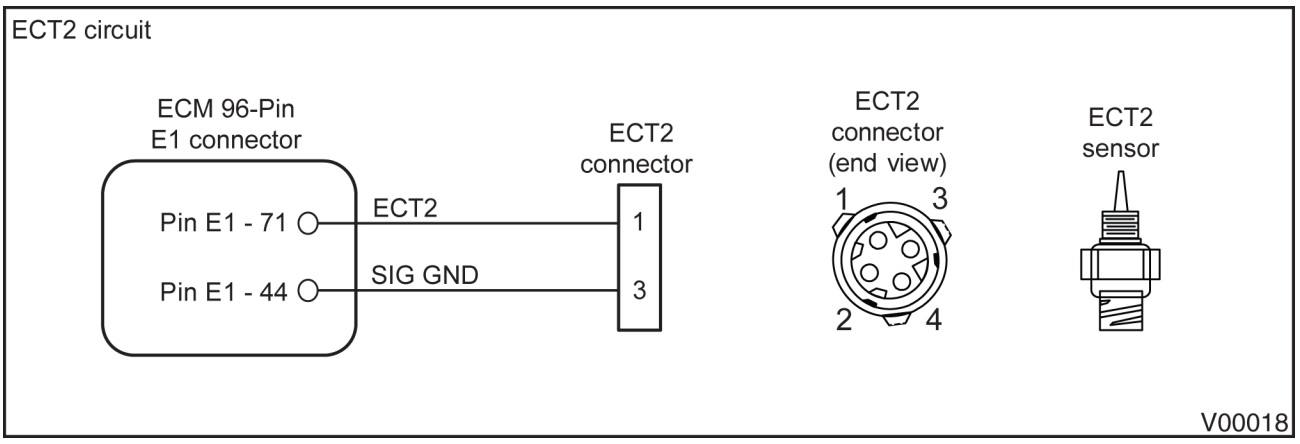


Figure 243 ECT2 sensor circuit diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The ECT2 sensor is a thermistor that is supplied 5 V VREF at pin-1 from ECM pin E1-71. The sensor is grounded at pin-3 from ECM pin E1-44. As the coolant temperature increases the resistance of the thermistor decreases, causing the signal voltage to decrease.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- ECM Breakout Harness 00-01468-00
- Breakout Harness ZTSE4827
- 500 Ohm Resistor Harness ZTSE4497
- Big Bore Terminal Test Probe Kit ZTSE4899
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

SPN 4076 FMI 2 ECT2 signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Coolant Temperature 2 (ECT2) does not agree with other sensors.	ECT2 difference from Inlet Air Temp (IAT) > 10°F (6°C)	Key-On Engine is cold soaked Difference between Engine Coolant Temperature 1 (ECT1), Ambient Air Temperature (AAT), and Exhaust Gas Temperature 1 (EGT1) at Key on < 27°F (15°C)	Immediate

Fault Overview

Fault code sets when Engine Coolant Temperature 2 (ECT2) differs from Inlet Air Temp (IAT) > 10°F (6°C) after a cold soak.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Fault Facts

Diagnostic runs at initial Key-On after a minimum of an 8 hour cold soak.

Drive Cycle to Determine Fault Status

Drive Cycle 10 then 4 in 2013 HD-OBD Diagnostic Reference Manual.

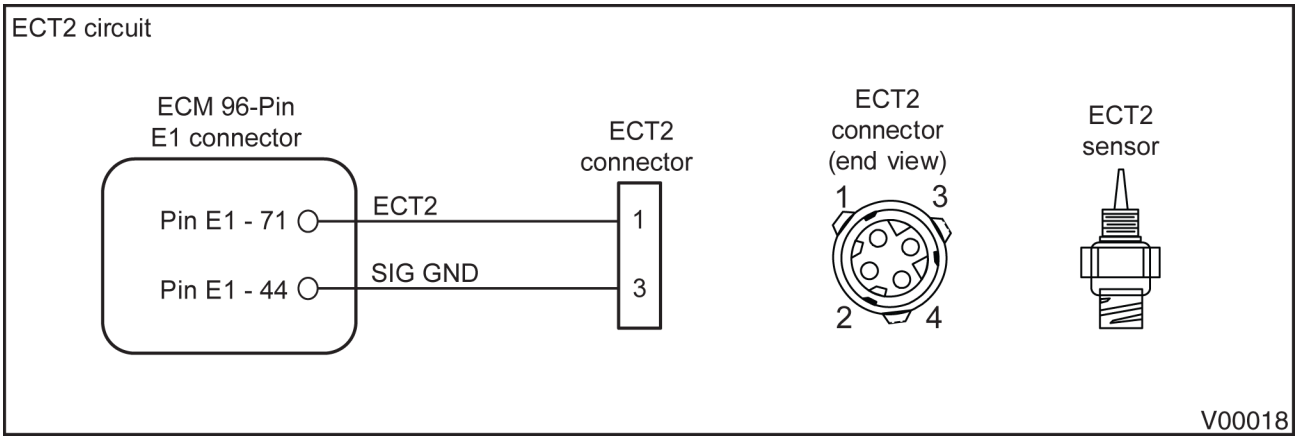


Figure 244 ECT2 sensor circuit diagram

Possible Causes

- Aftermarket block heater installed
- Failed ECT2 sensor
- High resistance in ECT2 circuit
- High resistance in SIG GND circuit

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 105 FMI 3, 4 and SPN 4076 FMI 0, 3, 4, 15, 17(ECT2). Is EST DTC list free of SPN 105 FMI 3, 4 and SPN 4076 FMI 0, 3, 4, 15, 17?	Yes: Go to step 2. No: Repair SPN 105 FMI 3, 4 and SPN 4076 FMI 0, 3, 4, 15, 17. After repairs are complete, retest for SPN 4076 FMI 2.

Step	Action	Decision
2	Check ECT2 circuit for high resistance. Connect Breakout Harness ZTSE4827 to ECT2 harness and leave ECT2 disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01468-00 to ECM E1 harness, and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness ZTSE4827 pin-1 and 180-pin Breakout Box pin E1-71. Is resistance less than 5 ohms?	Yes: Go to step 3. No: Repair high resistance between ECT2 connector pin-1 and ECM connector pin E1-71. After repairs are complete, retest for SPN 4076 FMI 2.

Step	Action	Decision
3	Check SIG GND circuit for high resistance. Connect Breakout Harness ZTSE4827 to ECT2 harness and leave ECT2 disconnected. Connect 180-pin Breakout Box with ECM Breakout Harness 00-01468-00 to ECM E1 harness , and leave ECM disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness ZTSE4827 pin-3 and 180-pin Breakout Box pin E1-44. Is resistance less than 5 ohms?	Yes: Go to step 4. No: Repair high resistance between ECT2 connector pin-3 and ECM connector pin E1-44. After repairs are complete, retest for SPN 4076 FMI 2.

NOTE: An aftermarket block heater could set this fault.

Step	Action	Decision
4	Check for a failed ECT2 sensor. If installed, disconnect aftermarket block heater. After performing drive cycle 10, using ServiceMaxx™ software, open the Continuous Monitor session. Compare ECT2 with Inlet Air Temp (IAT). Is the ECT2 difference greater than 10°F (6°C) of IAT value?	Yes: Replace ECT2 sensor. After repairs are complete, retest for SPN 4076 FMI 2. No: Aftermarket block heater causing fault code to set.

NOTE: After performing all diagnostic steps, if SPN 4076 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pinpoint Diagnostics With ServiceMaxx™ Software

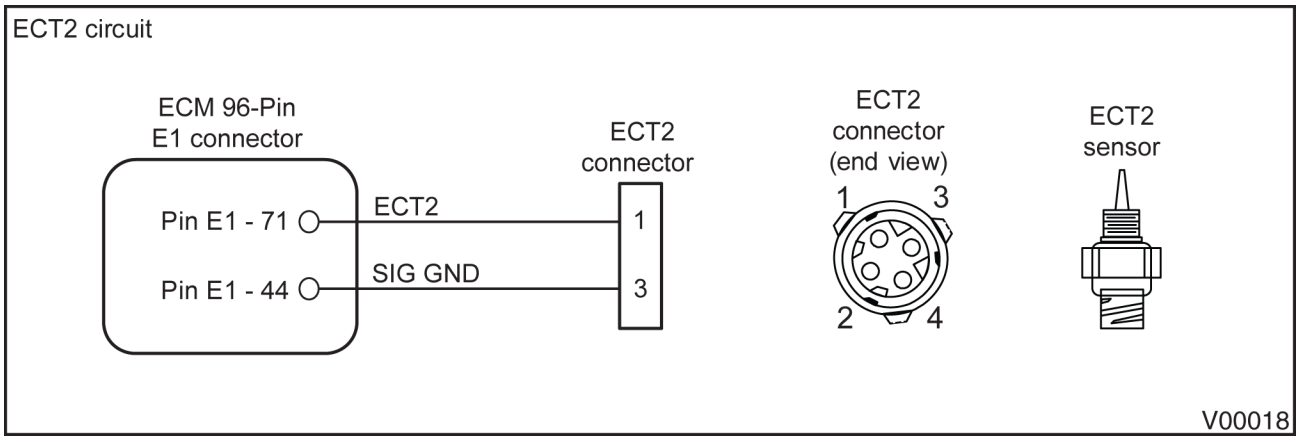


Figure 245 ECT2 sensor circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Cold Soak Sensor Compare Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

SPN 4076 FMI 16 – ECT2 signal does not agree with other sensors (Cold soak)

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 8 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Default session.
3. Compare ECT2, Engine Coolant Temperature 1 (ECT1), and Engine Oil Temperature (EOT). Sensor temperatures should be within 5 °C (10 °F) of each other.
   - If ECT2 is 5 °C (10 °F) above or below the ECT1 or EOT, check for poor circuitry going to the ECT2 sensor.
   - If circuits are within specification, replace ECT2 sensor.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4827 to ECT2 connector and leave sensor disconnected. Connect 180-pin Breakout Box with Breakout Harness 00-01468-00. Key ON, use a DMM to measure voltage.

Test Point	Specification	Comment– < Less than, > Greater than
Measure pin E1-14 to GND	4.5 V to 5 V	If <4.5 V, check ECT2 signal circuit for short to GND.
Measure pin E1-14 to GND Short ECT2 pin-1 to GND	0 V	If > 0.25 V, check ECT2 signal circuit for OPEN. Do Harness Resistance Check (page 614).
Measure pin E1-14 to GND Short ECT2 pin-1 to pin-3	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 614).
Measure pin E1-14 to GND Short 500 Ω resistor between ECT2 pin-1 and pin-3	< 1.0 V	If > 1.0 V, check ECT2 signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace ECT2 sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4827 to ECT2 engine harness, and leave ECT2 sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND.
3 to B+	B+	If < B+, check for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4827 to ECT2 engine harness, and leave ECT2 sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-71	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to E1-44	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EFC (Engine Fan Control) – Two Speed and Variable

SPN	FMI	Condition	Possible Causes
647	3	EFC short to PWR	• EFC circuit short to PWR
647	4	EFC short to GND	• EFC circuit short to GND
647	5	EFC open load/circuit	• EFC circuit OPEN • EFC failure

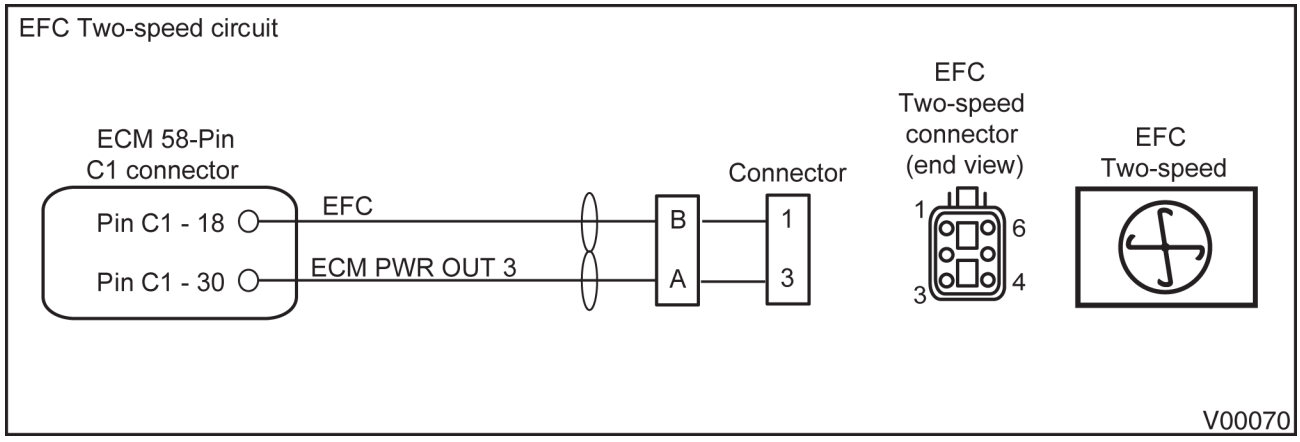


Figure 246 Two-Speed EFC circuit diagram

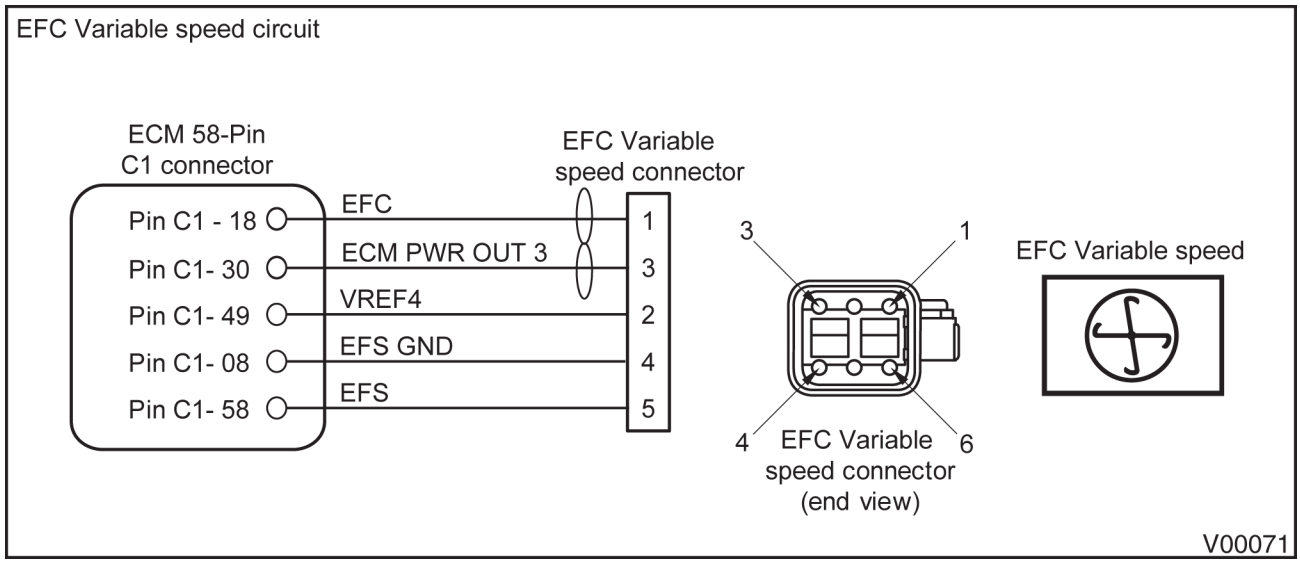


Figure 247 Variable EFC circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4844 (EFAN)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Function Two-Speed EFC

The purpose of the engine fan is to force a higher airflow through the radiator when the A/C is on or the ECT goes above a set temperature.

The single-speed EFC is an air-actuated belt-driven on-off design. When engaged the fan runs at input sheave speed, and when disengaged the fan speed is close to zero.

The two-speed EFC is an air actuated belt-driven two-speed drive. When engaged the fan runs at input sheave speed, and when the air clutch releases, the fan runs at a nominal speed driven by a magnetic eddy current system that produces 300-400 rpm at idle and 700-900 rpm at when the engine rpm is 1900. This provides improved cooling and delays the fan coming on in high ambient temperatures or at high loads.

The difference between the single speed and two-speed EFCs is internal to the fan hub; both fans have identical external circuitry.

Function Variable EFC

The purpose of the variable electronic engine fan is to force a higher airflow through the radiator when the A/C is on or when the ECT goes above a set temperature.

The variable EFC is a direct-driven electronically controlled viscous fan drive. The fan has a number of operating regions.

- From 300 to 1100 engine rpm it is an on-off drive. Off is under 300 rpm, on is 99% of input speed.
- From 1100 to 1750 engine rpm it is a variable speed drive with an effective range of 800 rpm to 99% of input speed.
- From 1750 to 2150 engine rpm it is on-off again.
- From 2150 to 2450 engine rpm it is either off or 2625 rpm.
- Above 2450 engine rpm it is off.

EFC – Two Speed Sensor Circuit Operation

The default state of the EFC is ON. B+ is needed to turn the fan OFF.

ECM Pin C1-18 controls the EFC to shut off by supplying PWR to the EFC deactivating it.

EFC – Variable Sensor Circuit Operation

The default state of the EFC is ON. B+ is needed to turn the fan OFF.

ECM Pin C1-18 controls the EFC to shut off by supplying B+ to the EFC, deactivating it.

ECM Pin C1-58 controls EFC speed by supplying a Pulse Width Modulated (PWM) signal to the EFC.

Voltage Check at Single or Two-Speed EFC Connector - Actuator Test

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE4844 to single or two-speed EFC 2-pin connector, and leave EFC disconnected.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Engine Fan Control from the drop-down menu.
3. Command Engine Fan Control to 5%.
4. Use DMM to measure voltage.
5. Command Engine Fan Control to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
A to GND	B+	If < B+, check for open in ECM PWR OUT 3.
B to GND	0 V to 0.25 V	If > 0.25 V, check for short to PWR.
Actuator Test - at 5% state		
B to GND	0 V to 0.25 V	If > 0.25 V, check for short to PWR.
Actuator Test - at 95% state		
B to GND	B+	If < B+, check EFC circuit for OPEN or short to GND. Do Harness Resistance Check.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4484 to EFC vehicle harness, and leave EFC disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C1-30 to A	< 5 Ω	If > 5 Ω, check for OPEN circuit between ECM pin C1-30 and EFC pin A.
C1-18 to B	< 5 Ω	If > 5 Ω, check for OPEN circuit between ECM pin C1-18 and EFC pin B.
If voltage and resistance measurements are within specification but DTC is still active, or EFC does not work, replace the EFC.		

EGRT Sensor (Exhaust Gas Recirculation Temperature)

SPN	FMI	Condition	Possible Causes	Actions
412	1	EGRT signal stuck low, not warming up	• Biased EGRT sensor or circuit	Pin-Point Diagnostics (page 619)
412	2	EGRT signal does not agree with other sensors	• Biased EGRT sensor or circuit	Pin-Point Diagnostics (page 619)
412	3	EGRT signal Out of Range HIGH	• EGRT signal circuit OPEN or shorted to PWR • SIG GND circuit OPEN • Failed EGRT sensor	Pin-Point Diagnostics (page 619)
412	4	EGRT signal Out of Range LOW	• EGRT signal circuit short to GND • Failed EGRT sensor or circuit	Pin-Point Diagnostics (page 619)

EGRT circuit

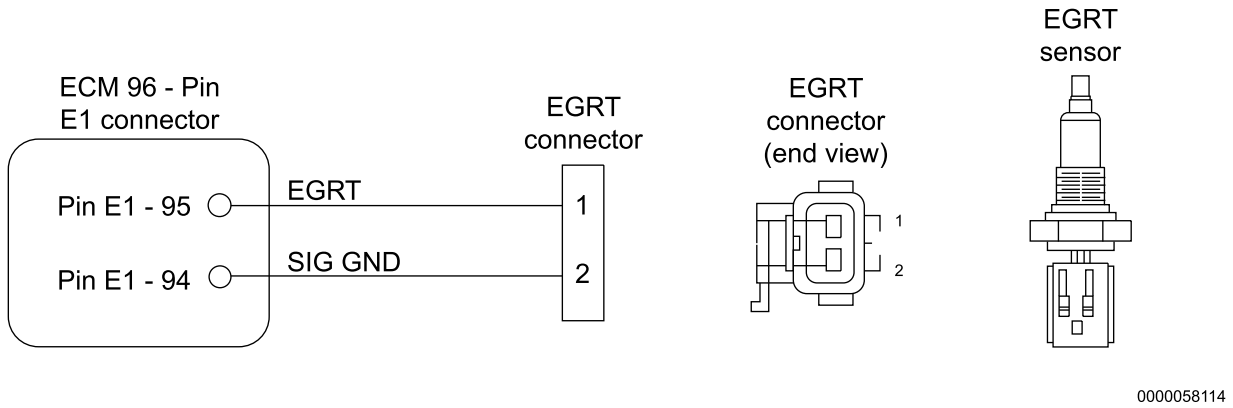


Figure 248 EGRT sensor circuit diagram

Tools Required

- 180-Pin Breakout Box 00-00956-08
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- 3-Banana Plug Harness ZTSE4498
- 500 Ohm Resistor Harness ZTSE4497
- Big Bore Terminal Test Probe Kit ZTSE4899
- Breakout Harness ZTSE4760A (EGRT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Pinpoint Diagnostics With ServiceMaxx™ Software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Cold Soak Sensor Compare Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

SPN 412 FMI 2 – EGRT signal does not agree with other sensors

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 8 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Default session.
3. Compare EGRT, Engine Coolant Temperature 1 (ECT1), and Engine Coolant Temperature 2 (ECT2). Sensor temperatures should be within 5 °C (10 °F) of each other.
   - If EGRT is 5 °C (10 °F) above or below the ECT1 and ECT2, check for poor circuitry going to the EGRT sensor.
   - If circuits are within specification, replace EGRT sensor.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4760A to EGRT engine harness, and leave EGRT sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment– < Less than, > Greater than
EST – Monitor EGRTv	4.5 – 5 V	If <4.5 V, check EGRT signal circuit for short to GND.
EST – Monitor EGRTv Short pin 1 to GND	0 V	If > 0.25 V, check EGRT signal circuit for OPEN. Do Harness Resistance Check.
EST – Monitor EGRTv Short pin 1 to 2	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check.
EST – Monitor EGRTv Short 500 Ω resistor across pins 1 and 2	< 1.0 V	If > 1.0 V, check EGRT signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EGRT sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4760A to EGRT engine harness, and leave EGRT sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5 V	If < 4.5 V, check EGRT signal circuit for short to GND.
2 to B+	B+	If < B+, check SIG GND for OPEN circuit.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 vehicle harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4760A to EGRT engine harness, and leave EGRT sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-95	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-94	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EGR (Exhaust Gas Recirculation) Valve

SPN	FMI	Condition	Possible Causes
27	0	EGRP fault: over temperature	• EGR overheated • Low coolant flow through EGR • Hot soaking after hard run and shut down • Low coolant level • Failed Coolant Flow Valve (CFV)
27	3	EGRP signal Out of Range HIGH	• EGRP circuit short to PWR
27	4	EGRP signal Out of Range LOW	• EGRP Open circuit • EGRP circuit short to GND
27	7	EGRP does not agree with commanded position	• Sticking or failed EGR valve • EGRP circuit fault • EGRC circuit fault
2791	3	EGRC short to PWR	• EGRC circuit short to PWR
2791	5	EGRC open load/circuit	• EGRC circuit OPEN • Failed EGR valve • Sensor or connector terminals: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing.
2791	8	EGR valve not receiving ECM PWM signal	• Broken return spring in EGR valve • Sensor or connector terminals: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing.

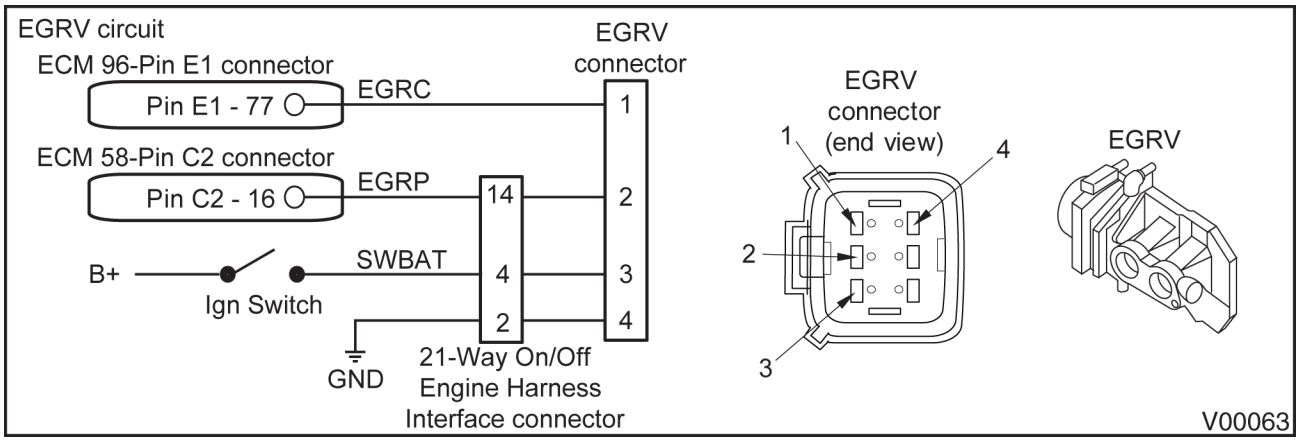


Figure 249 EGR Valve circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6016 (EGR Valve)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the 2010 Actuator session.
2. Select EGR Position from the Actuator drop-down menu on the right side.
3. Command actuator movement by clicking on the Start Test button. Monitor EGR Position (EGRP) and EGR Valve CTL (EGRC).
   - If EGRP does not closely match EGRC, check EGR valve for mechanical problem.
   - If EGR valve does not move, continue to Connector Voltage Check.

SPN 27 FMI 7 – EGRP does not agree with commanded position

1. Check coolant level. Low coolant level will cause coolant flow problems through the EGR cooler and valve.
2. Use ServiceMaxx™ software to run KOER Coolant Valve Test. Verify Coolant Flow Valve (CFV) and Coolant Mixer Valve (CMV) are working and interstage cooler is sending cooled coolant to the EGR valve.
3. Interview the driver. Ask the driver if they shut the engine down right after a hard run. Instruct them to let the engine idle for 5 minutes before shutting down. This will give the coolant a chance to cool the EGR valve.

Connector Voltage Check — EGR Valve Disconnected

Connect Breakout Harness ZTSE6016 to EGR valve engine harness, and leave EGR valve disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
4 to battery positive	B+	If < B+, check for OPEN in GND circuit. Do Harness Resistance Check (page 624).
3 to GND	B+	If < B+, check for OPEN in SWBAT circuit or blown fuse.
2 to GND	5.0 V ± 1.0 V	If > 6 V, check for short to PWR. If < 4 V, check for OPEN or short to GND. Do Harness Resistance Check (page 624).
1 to GND	0 V to 1 V	If > 1 V, check for short to PWR.
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE6016 between EGR valve and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select EGR Position from the drop-down menu.
3. Command EGRP to 5%.
4. Use DMM to measure voltage.
5. Command EGRP to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 3.0 V ± 1.0 V	If > 4.0 V, check for OPEN or short to PWR. If < 2.0 V, check for short circuit or failed EGR valve.
2 to GND	95% = 0.8 V ± 0.5 V	If > 1.3 V, check for OPEN or short to PWR.
1 to GND	5% = 7.5 V ± 1.0 V	If > 8.5 V, check for short to PWR. If < 6.5 V, check for short circuit.
1 to GND	95% = 0.5 V ± 0.5 V	If > 1.0 V, check for OPEN circuit or failed EGR valve.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE6016 to EGR engine harness, and leave EGR valve disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1–77	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to C2-16	< 5 Ω	If >5 Ω, check for OPEN circuit.
4 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.

If voltage and resistance checks are within specifications, check for DTCs. If the DTC returns, replace the EGR valve.

Exhaust Gas Recirculation (EGR) System Monitor

SPN	FMI	Condition	Possible Causes	Actions
3058	0	Engine did not go into Open loop EGR control when expected	• Biased Oxygen (O_2) sensor or circuit • Biased Engine Coolant Temperature 1 (ECT1) sensor or circuit • Biased Barometric Pressure (BARO) sensor or circuit • Biased Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor or circuit • Exhaust Gas Recirculation Valve (EGRV) or circuit failure • Engine Throttle Valve (ETV) or circuit failure • Exhaust Back Pressure Valve (EBPV) or circuit failure	Step-Based Diagnostics (page 626)
3058	10	Engine did not go into Closed loop EGR control when expected	• Biased O_2 sensor or circuit • O_2 heater or circuit • Biased BARO sensor or circuit • EGR valve or circuit failure • Intake Throttle Valve (ITV) or circuit failure	Step-Based Diagnostics (page 629)

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN 3058 FMI 0 - Engine Did Not Go Into Open Loop EGR Control When Expected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitors the time it takes for EGR to enter open loop control	Function of initialized Engine Coolant Temperature 1 (ECT1) sensor at engine start x barometric pressure.	Cold Ambient Protection (CAP) inactive Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts Engine Compression brake inactive	0.05 Seconds

Fault Overview

Fault code sets when O_2 sensor is unable to reach required operating temperature or EGR valve failed to react to enter open loop operation. Open loop operation occurs when the engine operates the EGRV based on calculations rather than on feedback from the O_2. Operating the EGRV before the engine reaches operating temperature and establishes open loop operation could cause performance issues.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN's 27, 51, 108, 110, 724, 2791, 3223, 3464, 4765, 5542, and 5543.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3058 FMI 0 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3058 FMI 0.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Also, inspect the fuel system from fuel tank to AFI valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 3058 FMI 0.

Step	Action	Decision
3	Using EST with ServiceMaxx™ software, run Continuous Monitor session and monitor Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor (Wiggle test may be necessary if code is inactive or pending.). Is DOCIT sensor within specifications?	Yes: Go to step 4. No: Do Hot Run Sensor Comparison Test (page 72). After repairs are complete, retest for SPN 3058 FMI 0.

Step	Action	Decision
4	Using EST with ServiceMaxx™ software, run Continuous Monitor session and monitor Oxygen (O^2S) sensor (Wiggle test may be necessary if code is inactive or pending.). Is O^2S sensor within specifications?	Yes: Go to step 5. No: Do O^2S Biased Sensor or Circuit Check (page 819). After repairs are complete, retest for SPN 3058 FMI 0.

Step	Action	Decision
5	Using EST with ServiceMaxx™ software, run Continuous Monitor session and monitor Barometric Pressure (BARO) sensor. See Key-On Engine-Off Barometric Pressure (page 953) for sensor value (Wiggle test may be necessary if code is inactive or pending.). Is the BARO sensor within specifications?	Yes: Go to step 6. No: Do ECM Self-Diagnostics (page 596). After repairs are complete, retest for SPN 3058 FMI 0.

Step	Action	Decision
6	Using EST with ServiceMaxx™ software, run Continuous Monitor session and monitor Engine Coolant Temperature 1 (ECT1) sensor. See Component Specification in “Appendix A: Performance Specifications” (page 956) for sensor value (Wiggle test may be necessary if code is inactive or pending.). Is the ECT1 sensor within specifications?	Yes: Go to step 7. No: Do ECT1 sensor Circuit Checks (page 606). After repairs are complete, retest for SPN 3058 FMI 0.

Step	Action	Decision
7	Using EST with ServiceMaxx™ software, see Exhaust Gas Recirculation (EGR) Valve Pinpoint Diagnostics (page 622) for EGR Valve Actuator command test. Is EGR Valve within specifications?	Yes: Go to step 8. No: Correct EGR Valve issues and retest for SPN 3058 FMI.

Step	Action	Decision
8	Using EST with ServiceMaxx™ software, see Engine Throttle Valve (ETV) Pinpoint Diagnostics (page 642) for ETV Valve Actuator command test. Is ETV Valve within specifications?	Yes: Go to step 9. No: Correct ETV issues and retest for SPN 3058 FMI 0.

Step	Action	Decision
9	Using EST with ServiceMaxx™ software, do Exhaust Back Pressure Valve (EBPV) test (page 163) for EBPV Actuator test. Is EBPV within specifications?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Correct EBPV issues and retest for SPN 3058 FMI 0.

SPN 3058 FMI 10 - Engine Did Not Go Into Closed Loop EGR Control When Expected

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Monitor the time it takes for EGR to enter closed loop control	ECM not entering closed loop operation within 61 minutes after engine starts.	Cold Ambient Protection (CAP) inactive Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts Engine Compression brake inactive Engine in required speed > 1000 rpm and load > 40% enable region.	0.05 Seconds

Fault Overview

Fault code sets when O_2 sensor is unable to reach required operating temperature or EGR valve failed to react to enter open loop operation. Open loop operation occurs when the engine operates the EGRV based on calculations rather than on feedback from the O_2. Operating the EGRV before the engine reaches operating temperature and establishes open loop operation could cause performance issues.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Associated Faults

SPN's 27, 51, 108, 724, 2791, 3223, 3464, 4765, 5542, and 5543.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 3058 FMI 10 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 3058 FMI 10.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Also, inspect the fuel system from fuel tank to AFI valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 3058 FMI 10.

Step	Action	Decision
3	Using EST with ServiceMaxx™ software, run Continuous Monitor session and monitor Diesel Oxidation Catalyst Inlet Temperature (DOCIT) sensor (Wiggle test may be necessary if code is inactive or pending.). Is DOCIT sensor within specifications?	Yes: Go to step 4. No: Do Hot Run Sensor Comparison Test (page 72). After repairs are complete, retest for SPN 3058 FMI 10.

Step	Action	Decision
4	Using EST with ServiceMaxx™ software, run Continuous Monitor session and monitor Oxygen (O^2S) sensor (Wiggle test may be necessary if code is inactive or pending.). Is O^2S sensor within specifications?	Yes: Go to step 5. No: Do O^2S Biased Sensor or Circuit Check (page 819) and retest for SPN 3058 FMI 10.

Step	Action	Decision
5	Using EST with ServiceMaxx™ software, run Continuous Monitor session and monitor Barometric Pressure (BARO) sensor. See Key-On Engine-Off Barometric Pressure (page 953) for sensor value (Wiggle test may be necessary if code is inactive or pending.). Is the BARO sensor within specifications?	Yes: Go to step 6. No: Do ECM Self-Diagnostics (page 596) and retest for SPN 3058 FMI 10.

Step	Action	Decision
		Yes: Go to step 7.
6	Using EST with ServiceMaxx™ software, see Exhaust Gas Recirculation (EGR) Valve Pinpoint Diagnostics (page 622) for EGR Valve Actuator command test. Is EGR Valve within specifications?	No: Correct EGR Valve issues and retest for SPN 3058 FMI 10.

Step	Action	Decision
7	Using EST with ServiceMaxx™ software, see Engine Throttle Valve (ETV) Pinpoint Diagnostics (page 642) for ETV Valve Actuator command test. Is ETV Valve within specifications?	Yes: Go to step 8. No: Correct ETV issues and retest for SPN 3058 FMI 10.

Step	Action	Decision
8	Using EST with ServiceMaxx™ software, do Exhaust Back Pressure Valve (EBPV) test (page 163) for EBPV Actuator test. Is EBPV within specifications?	Yes: Verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Correct EBPV issues and retest for SPN 3058 FMI 10.

EOL Sensor (Engine Oil Level)

SPN	FMI	Condition	Possible Causes
98	3	EOL signal Out of Range HIGH	• EOL signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed EOL sensor
98	4	EOL signal Out of Range LOW	• EOL signal circuit short to GND • Failed EOL sensor
1135	3	EOT2 signal Out of Range HIGH	• EOT2 signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed EOL sensor
1135	4	EOT2 signal Out-of-Range LOW	• EOL signal circuit short to GND • Failed EOL sensor

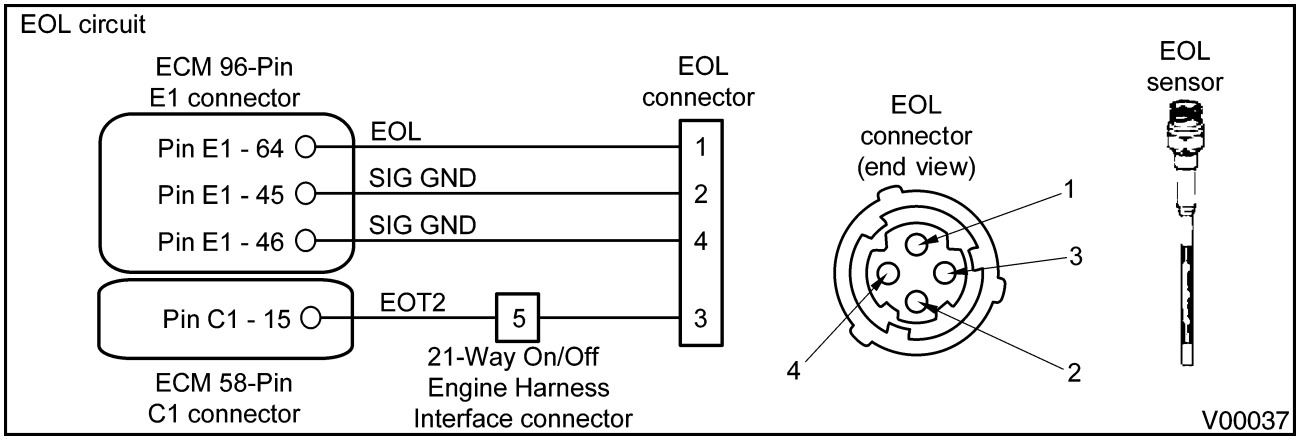


Figure 250 EOL sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4827 (EOL)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor session.
2. Monitor sensor voltage. Verify an active DTC for the sensor.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal will spike and the DTC will go active.
   - If DTC is active, continue to Sensor Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, loose pins. Repair if necessary.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4827 to EOL vehicle harness, and leave EOL sensor disconnected. Turn ignition ON..

Test Point	Specification	Comment– < Less than, > Greater than
EST – Monitor EOLv	4.5 V – 5 V	If < 4.5 V, check EOL circuit for short to GND.
EST – Monitor EOT2v	4.5 V – 5 V	If < 4.5 V, check EOT2 circuit for short to GND.
EST – Monitor EOLv Short pin 1 to GND	0 V	If > 0.5 V, check EOL circuit for OPEN. Do Harness Resistance Check.
EST – Monitor EOLv Short pin 1 to 4	0 V	If > 0.5 V, check SIG GND circuit for OPEN. Do Harness Resistance Check.
EST – Monitor EOT2v Short pin 3 to GND	0 V	If > 0.5 V, check EOT2 circuit for OPEN. Do Harness Resistance Check.
EST – Monitor EOT2v Short pin 2 to 3	0 V	If > 0.5 V, check SIG GND circuit for OPEN. Do Harness Resistance Check.

If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EOL sensor.

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4827. Leave EOL sensor disconnected. Turn ignition switch ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5 V ± 5 V	If > 5.5 V, check EOL for short to PWR. If < 4.5 V, check EOL for OPEN or short to GND. Do Harness Resistance Check.
3 to GND	5 V	If > 5.5 V, check EOT2 for short to PWR. If < 4.5 V, check EOT2 for OPEN or short to GND. Do Harness Resistance Check.
2 to B+	B+	If < B+, check SIG GND for OPEN circuit.
4 to B+	B+	If < B+, check SIG GND for OPEN circuit.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 vehicle harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4827 to EOL vehicle harness, and leave EOL sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short GND in EOL circuit.
1 to E1-64	< 5 Ω	If > 5 Ω, check for OPEN in EOL circuit.
2 to E1-45	< 5 Ω	If > 5 Ω, check for OPEN in SIG GND circuit.
3 to GND	>1k Ω	If < 1k Ω, check for short to GND in EOT2 circuit.
3 to C1-15	< 5 Ω	If > 5 Ω, check for OPEN in EOT2 circuit.
4 to E1-46	< 5 Ω	If > 5 Ω, check for OPEN in SIG GND circuit.

EOP Sensor (Engine Oil Pressure)

SPN	FMI	Condition	Possible Causes	Actions
100	3	EOP signal Out of Range HIGH	• EOP signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed EOP sensor	Pin-Point Diagnostics (page 635)
100	4	EOP signal Out of Range LOW	• EOP signal circuit short to GND • VREF5 circuit OPEN • Failed EOP sensor	Pin-Point Diagnostics (page 635)

EOP circuit

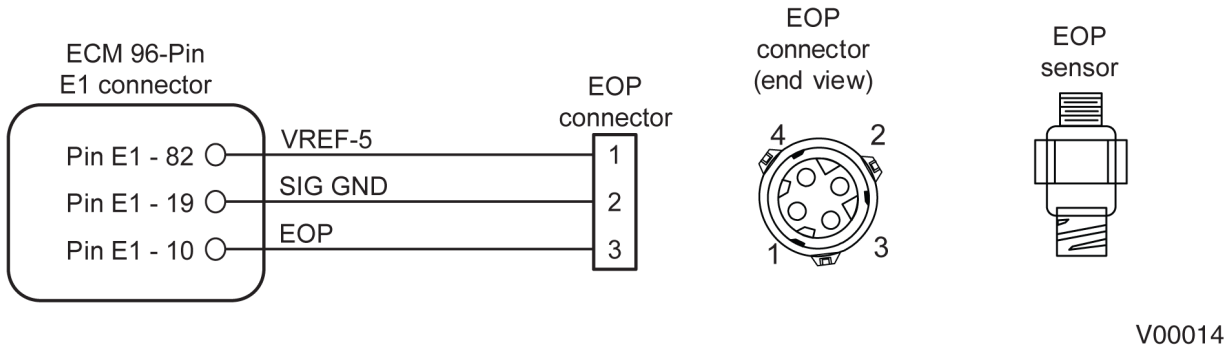


Figure 251 EOP sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4882 (EOP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.

2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Sensor Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Sensor Circuit Check

Connect Breakout Harness ZTSE4882 to EOP engine harness, and leave EOP sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor EOPv	5.0 V ± 0.5 V	If < 4.5 V, check EOP signal circuit for short to GND
DMM – Measure volts 1 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF5 circuit for short to PWR. If < 4.5 V, check VREF5 circuit for OPEN or short to GND. Do Harness Resistance Check (page 637).
DMM – Measure voltage 1 to 2	5 V ± 0.5 V	If < 4.5 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 637).
EST – Monitor EOPv Short across Breakout Harness ZTSE4882 pins 2 and 3	0 V	If > 0.5 V, check EOP signal circuit for OPEN. Do Harness Resistance Check (page 637).
If checks are within specification, connect sensor and clear DTCs. If active DTC remains, replace EOP sensor.		

Connector Voltage Check

Connect Breakout Harness ZTSE4882 to EOP engine harness, and leave EOP sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF5 circuit for short to PWR. If < 4.5 V, check VREF5 circuit for OPEN or short to GND. Do Harness Resistance Check (page 637).
2 to GND	0 V	If > 0.25V, check SIG GND circuit for short to PWR.
3 to GND	5 V ± 0.5 V	If < 4.5 V, check EOP signal circuit for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 vehicle harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4882 to EOP engine harness, and leave EOP sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
1 to E1-82	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
2 to E1-19	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
3 to E1-10	< 5 Ω	If > 5 Ω, check for OPEN circuit.

EOT Sensor (Engine Oil Temperature)

SPN	FMI	Condition	Possible Causes	Action
175	3	EOT signal Out of Range High	• EOT signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed EOT sensor	Pin-Point Diagnostics (page 638)
175	4	EOT signal Out of Range LOW	• EOT signal circuit short to GND • Failed EOT sensor	Pin-Point Diagnostics (page 638)

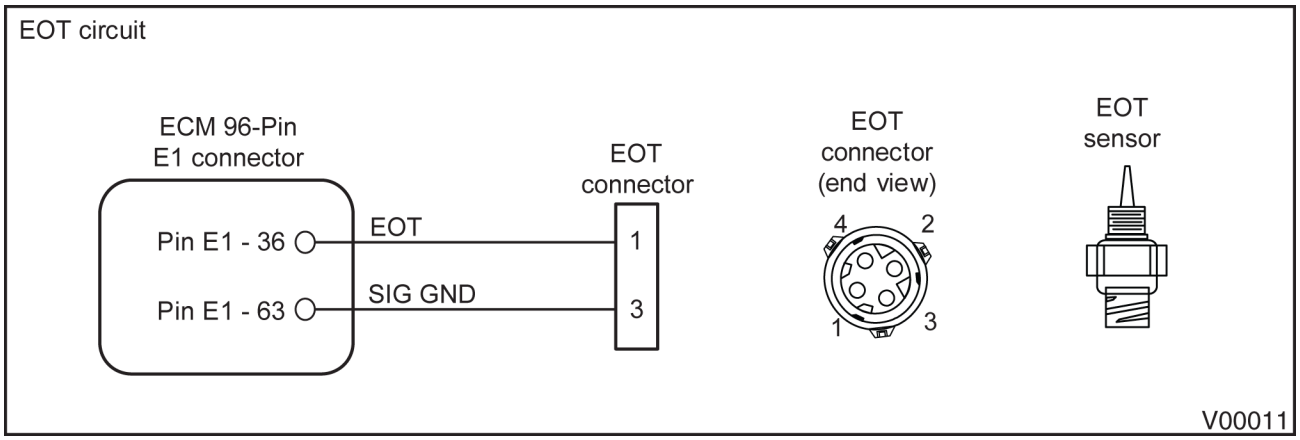


Figure 252 EOT sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4827 (EOT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Sensor Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4827 to EOT engine harness, and leave EOT sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment– < Less than, > Greater than
EST – Monitor EOTv	4.5 V to 5 V	If < 4.5 V, check EOT signal circuit for short to GND.
EST – Monitor EOTv Short pin 1 to GND	0 V	If > 0.25 V, check EOT signal circuit for OPEN. Do Harness Resistance Check (page 639).
EST – Monitor EOTv Short pin 1 to 3	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check (page 639).
EST – Monitor EOTv Short 500 Ω resistor across pins 1 and 3	< 1.0 V	If > 1.0 V, check EOT signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace EOT sensor.		

Pinpoint Diagnostics Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4827 to EOT engine harness, and leave EOT sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND.
3 to B+	B+	If < B+, check for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 vehicle harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4827 to EOT engine harness, and leave EOT sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-36	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to E1-63	< 5 Ω	If > 5 Ω, check for OPEN circuit.

ETV (Engine Throttle Valve)

SPN	FMI	Condition	Possible Causes	Actions
51	0	ETP fault: over temperature	• ETV internal failure	Pin-Point Diagnostics (page 642)
51	3	ETP signal Out of Range HIGH	• ETP circuit short to PWR	Pin-Point Diagnostics (page 642)
51	4	ETP signal Out of Range LOW	• ETP Open Circuit • ETP circuit short to GND	Pin-Point Diagnostics (page 642)
51	7	ETP does not agree with commanded position	• Sticking or failed ETV • ETP circuit fault • ETC circuit fault	Step-Based Diagnostics (page 645)
3464	3	ETC short to PWR	• ETC circuit short to PWR • Failed ETV	Pin-Point Diagnostics (page 642)
3464	5	ETC open load/circuit	• ETC circuit OPEN • Failed ETV	Pin-Point Diagnostics (page 642)
3464	8	ETC not receiving command from ECM	• ETC circuit fault	Pin-Point Diagnostics (page 642)

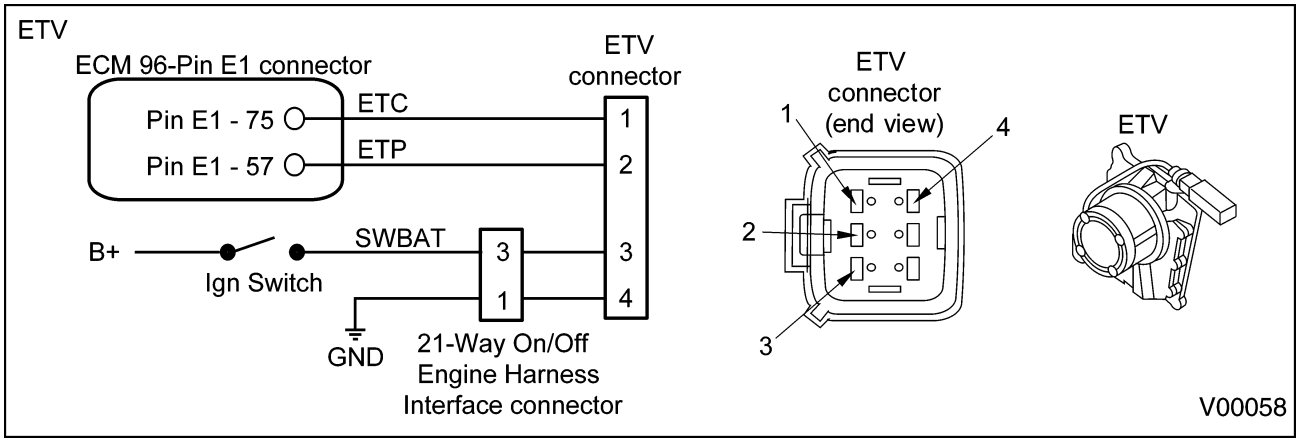
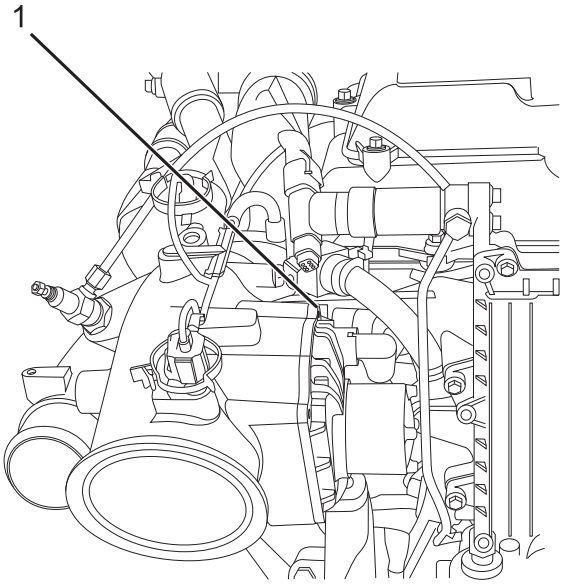


Figure 253 ETV valve circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6016 (ETV)
- Digital Multimeter (DMM)

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device



0000048972

Figure 254 ETV Location

1. Engine Throttle Valve (ETV)

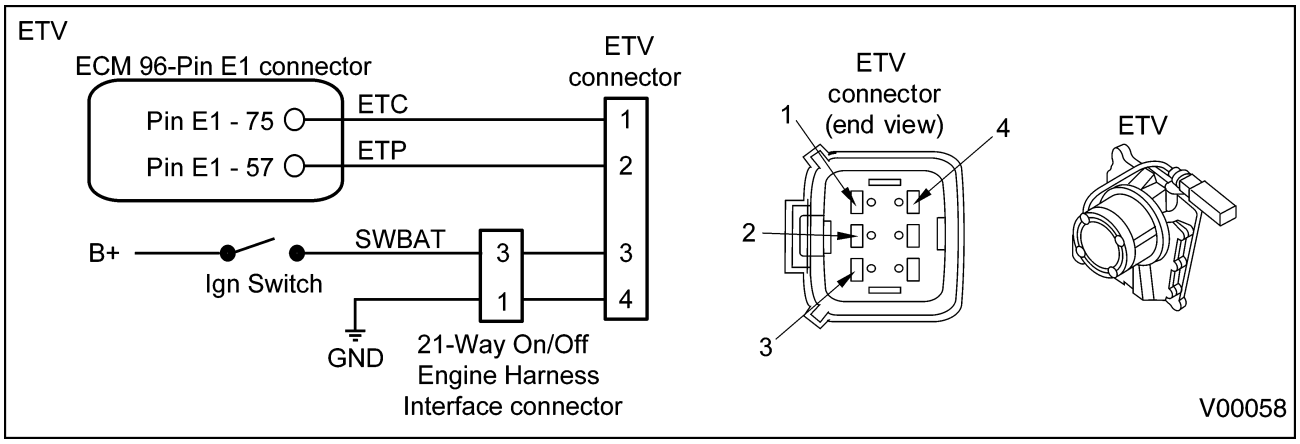


Figure 255 ETV valve circuit diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test.
2. Select ETV Position from the Actuator drop-down menu on the right side.
3. Command actuator movement by clicking on the Start Test button. Monitor Engine Throttle Position (ETP) and Engine Throttle CTL (ETC).
   - If ETP does not closely match ETC, check ETV for mechanical problem.
   - If ETV does not move, continue to Connector Voltage Check.

Connector Voltage Check — ETV Disconnected

Connect Breakout Harness ZTSE6016 to ETV engine harness, and leave ETV disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
4 to battery positive	B+	If < B+, check for OPEN in GND circuit. Do Harness Resistance Check (page 644).
3 to GND	B+	If < B+, check for OPEN in SWBAT circuit or blown fuse.
2 to GND	12 V ± 2.0 V	If < 10 V, check for OPEN or short to GND. Do Harness Resistance Check (page 644).
1 to GND	0 V to 1 V	If > 1 V, check for short to power.
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE6016 between ETV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select ETV Position from the drop-down menu.
3. Command ETVP to 5%.
4. Use DMM to measure voltage.
5. Command ETVP to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	5% = 3.0 V ± 1.0 V	If > 4.0 V, check for OPEN or short to PWR. If < 2.0 V, check for short circuit or failed ETV.
2 to GND	95% = 0.8 V ± 0.5 V	If > 1.3 V, check for OPEN or short to PWR.
1 to GND	5% = 7.5 V ± 1.0 V	If > 8.5 V, check for short to PWR. If < 6.5 V, check for short circuit.
1 to GND	95% = 0.5 V ± 0.5 V	If > 1.0 V, check for OPEN circuit or failed ETV.

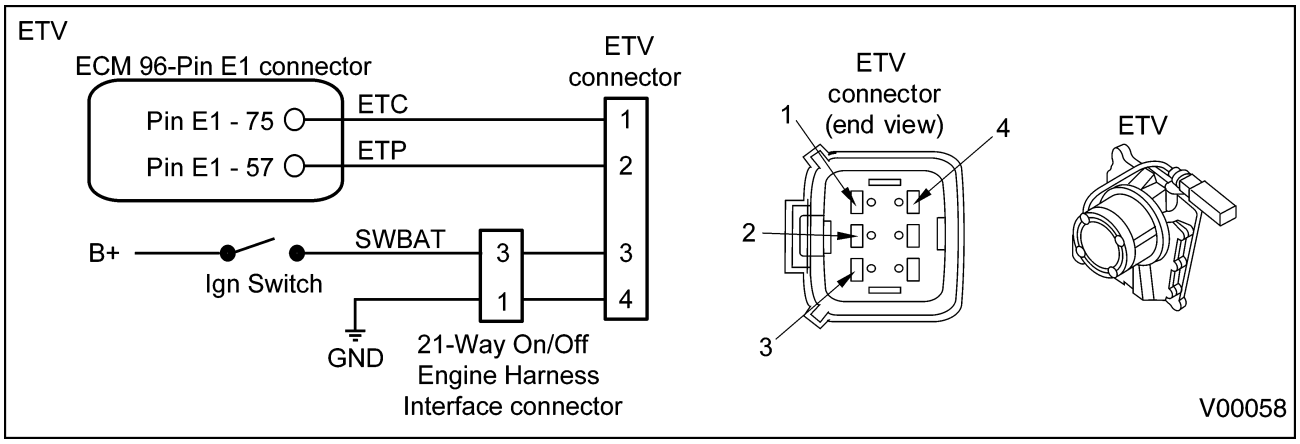


Figure 256 ETV valve circuit diagram

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE6016 to ETV engine harness, and leave APP sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-75	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-57	< 5 Ω	If > 5 Ω, check for OPEN circuit.
4 to GND	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, check for DTCs. If the DTC returns, replace the ETV.		

SPN 51 FMI 10 - ETP sensor feedback deviation during CSER

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Throttle Position (ETP) sensor does not a agree with ECM commanded position	Engine Throttle Valve (ETV) position > 10% from commanded position	Key ON	8 seconds

Fault Overview

Fault code sets when feedback from the Engine Throttle Position (ETP) sensor does not agree with the Engine Control Module (ECM) commanded position during Cold Start Emission Reduction (CSER).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 51 FMI 7.

Drive Cycle to Determine Fault Status

Drive Cycle 18 then 4 in 2013 HD-OBD Diagnostic Reference Manual.

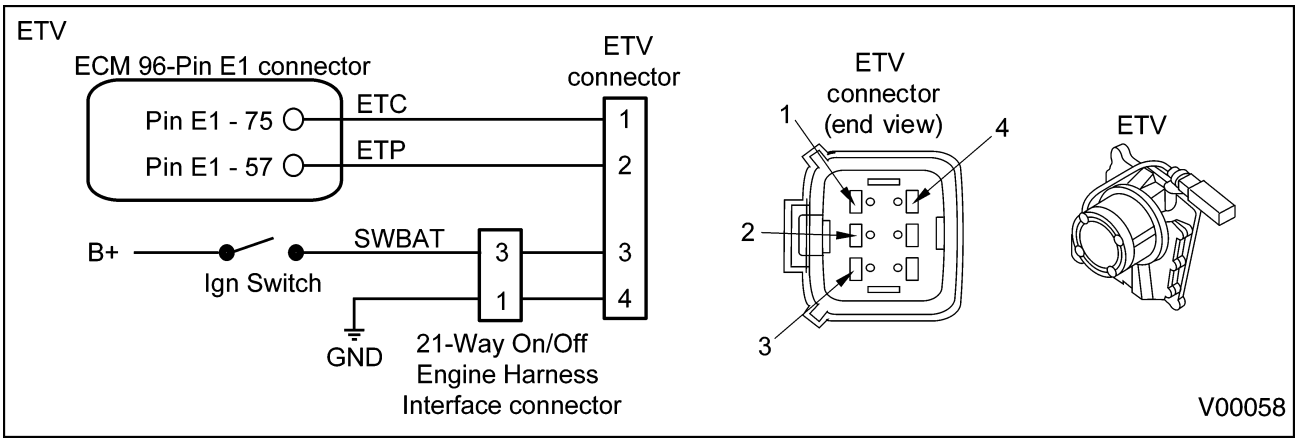


Figure 257 ETV valve circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 51 FMI 3, SPN 51 FMI 4, SPN 3464 FMI 3, and SPN 3464 FMI 5. Is SPN 51 FMI 10 the only fault code active?	Yes: Do Operational Voltage Check (page 643). After repairs are complete, retest for SPN 51 FMI 10.
		No: Repair other fault code(s). After repairs are complete, retest for SPN 51 FMI 10.

NOTE: After doing all diagnostic steps, if SPN 51 FMI 10 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

EWPS (Engine Warning Protection System)

SPN	FMI	Condition	Possible Causes	Actions
100	1	Engine Oil System below critical pressure	• Biased EOP sensor or circuit • Engine oil system mechanical failure	EWPS Programmable Parameters (page 651)
100	11	Engine oil pressure below dealer programmed engine RPM value	• Lubrication system suction side leak (pickup tube) • Engine oil system mechanical failure • Biased EOP sensor or circuit	EWPS Programmable Parameters (page 651)
100	17	Low Oil Pressure vehicle event fault	• Oil pressure regulator stuck open • Biased EOP sensor or circuit • Engine oil system mechanical failure	EWPS Programmable Parameters (page 651)
100	18	Engine Oil System below Warning Pressure	• Biased EOP sensor or circuit • Engine oil system mechanical failure	EWPS Programmable Parameters (page 651)
110	0	Engine Coolant System above Critical Temperature	• Biased ECT1 sensor or circuit • Low coolant level • Engine cooling system mechanical failure	Step-Based Diagnostics (page 654)
110	11	Event Logger, Coolant Temp Hot, Extreme	• Incorrect value in Programmable Parameter (PP) 8332 • Blockage between radiator and Charge Air Cooler (CAC) or Low Temperature Radiator (LTR) • Cooling system overheating • Degraded coolant	Step-Based Diagnostics (page 656)

110	15	Engine Coolant System above Warning Temperature	• Incorrect value in Programmable Parameter (PP) 77012 • Failed Thermostat • Low Temperature Radiator (LTR) Plugged • Blockage between Charge Air Cooler (CAC) and Radiator • Degraded Coolant • Failed Water pump • Failed CCV	Step-Based Diagnostics (page 656)
110	16	Engine Coolant System above OBD maximum temperature	• Low coolant level • Check for leaks or boiling out	EWPS Programmable Parameters (page 651)
111	1	Low Engine Coolant Level	• Biased ECT1 sensor or circuit • Low coolant level • Engine cooling system mechanical failure	EWPS Programmable Parameters (page 651)
175	0	Engine Coolant System above critical temperature	• Biased EOT sensor or circuit • Failed Engine oil cooler	EWPS Programmable Parameters (page 651)
175	11	Engine Oil System above critical temperature	• Biased EOT sensor or circuit • Failed engine oil cooler	EWPS Programmable Parameters (page 651)
175	15	Engine Coolant System above warning temperature	• Biased EOT sensor or circuit	EWPS Programmable Parameters (page 651)
188	0	Engine unable to achieve desired idle speed (too high)	• Engine over-fueling • External fuel source • Lube oil leak to intake • Fuel leak to intake • Contaminated fuel	Step-Based Diagnostics (page 658)

188	1	Engine unable to achieve desired idle speed (too low)	• Low Fuel Rail Pressure (FRP) • Low Fuel Delivery Pressure (FDP) • Low cylinder compression • Clutch or Power Take Off (PTO) engagement without command • Injector or injector circuit fault	Step-Based Diagnostics (page 660)
190	0	Engine overspeed most severe level	• Failed Turbocharger • Contaminated fuel • Failed fuel injector • Air born combustibles	Step-based Diagnostics (page 663)
190	11	Engine overspeed vehicle event fault	• Transmission in too low of a gear at high vehicle speed	EWPS Programmable Parameters (page 651)
190	15	Engine overspeed detected	• Transmission in too low of a gear at high vehicle speed	EWPS Programmable Parameters (page 651)
190	16	Engine above 2250 rpm	• Transmission in too low of a gear at high vehicle speed	EWPS Programmable Parameters (page 651)
2588	0	Vehicle overspeed 1, event log, extreme	• Vehicle speed has exceeded the value in PP 77232	Step-Based Diagnostics (page 665)
2588	15	Vehicle overspeed 1, event log, non extreme	• Vehicle speed has exceeded the value in PP 77232	Step-Based Diagnostics (page 666)
2589	0	Vehicle overspeed 2, event log, extreme	• Vehicle speed has exceeded the value in PP 77242	Step-Based Diagnostics (page 667)
2589	15	Vehicle overspeed 2, event log, non extreme	• Vehicle speed has exceeded the value in PP 77242	Step-Based Diagnostics (page 668)
4076	0	ECT2 above Critical (EWPS programmable limit)	• Biased ECT2 sensor or circuit • Low coolant level • Engine cooling system mechanical failure	EWPS Programmable Parameters (page 651)

4076	15	ECT2 above Warning (EWPS programmable limit)	• Biased ECT2 sensor or circuit • Low coolant level • Engine cooling system mechanical failure	EWPS Programmable Parameters (page 651)
5395	0	Engine unable to achieve desired idle torque (too high)	• Failed fuel injector • Aftermarket PTO system not installed correctly • Aftermarket PTO system not programmed correctly	Step-Based Diagnostics (page 669)
5395	1	Engine unable to achieve desired idle torque (too low)	• Engine mechanical failure • Failed cylinder • External fuel source • Lube oil leak to intake • Fuel leak to intake • Contaminated fuel	Step-Based Diagnostics (page 671)

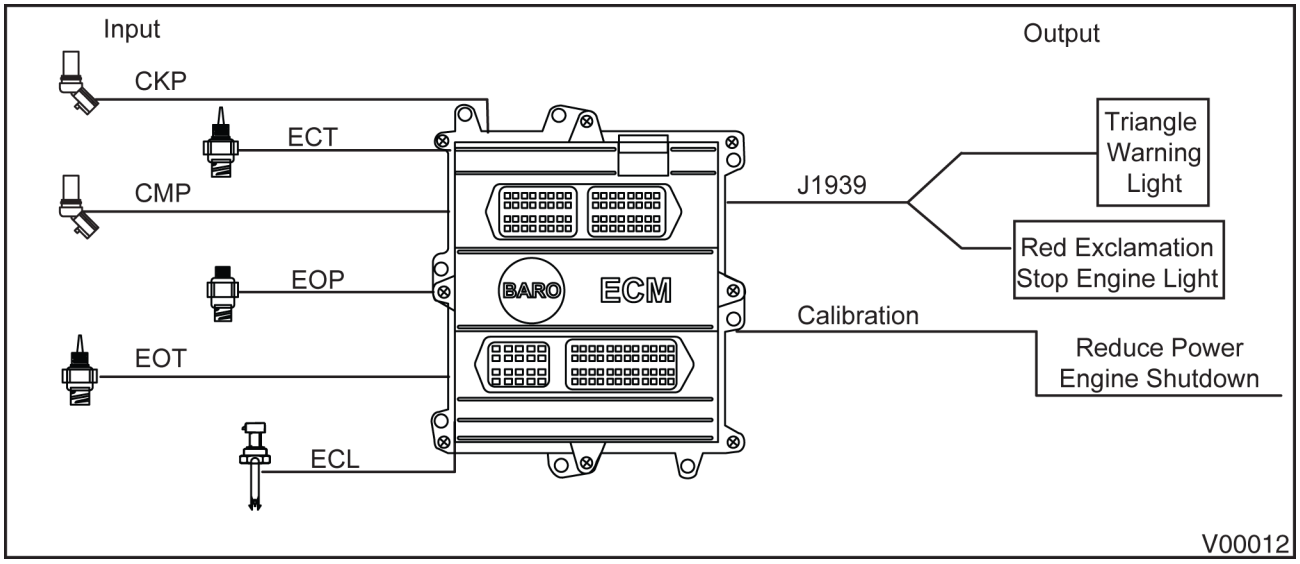


Figure 258 Functional diagram for the EWPS

Function

The EWPS warns the operator of conditions that can damage the engine.

The Standard Warning System is the base system in which all engines are equipped. If one of these faults are detected, the ECM illuminates the red engine lamp and sets a corresponding DTC.

The following optional features to this base system provide added warning or protection.

Standard Warning – No engine shutdown available.

- ECT - Engine overheat warning
- EOP - Low engine oil pressure warning

3-way Warning – No engine shutdown available.

- ECT - Engine overheat warning

- EOP - Low engine oil pressure warning
- ECL - Low engine coolant level warning

3-way Protection – Engine shutdown is available if critical condition is detected.

- ECT, EOP, ECL - Same as 3-way Warning
- ECT - Engine overheat critical protection
- EOP - Low engine oil pressure critical protection
- ECL - Low engine coolant level critical protection

Warning (Amber Triangle Light) – Temperature above specific threshold sounds a buzzer, illuminates the red OIL/WATER (OWL) lamp and sets a DTC.

Critical (Exclamation Mark Stop Lamp) – Temperature above specific threshold shuts down the engine and sets a DTC.

Event log (NOTE: Don't have yet but is supposed to be in the software) – This feature logs occurrences of the event according to the engine hours and odometer readings.

EWPS Programmable Parameters

- 1 = 3-way Warning
- 2 = 3-way Protection
- 3 = Standard Warning

ECT Warning Temperature – Specifies temperature threshold where the Triangle Warning light and warning buzzer is turned on.

ECT Critical Temperature – Specifies temperature threshold where an engine shutdown is commanded (Exclamation Engine Stop lamp).

EOP Engine Speed Region Boundary 1 (600 RPM) – Specifies at what RPM a specified oil pressure (EOP Critical Pressure for Region 1) should be detected.

EOP Engine Speed Region Boundary 2 (800 RPM) – Specifies at what RPM a specified oil pressure (EOP Critical Pressure for Region 2) should be detected.

EOP Engine Speed Region Boundary 3 (1000 RPM) – Specifies at what RPM a specified oil pressure (EOP Critical Pressure for Region 3) should be detected.

EOP Warning Pressure for Region 1 (10 psi / 69 kPa) – Specifies the minimum oil pressure with engine speed greater than (EOP Engine Speed Region Boundary 1). Failure to meet set point turns on the OIL/WATER lamp and warning buzzer.

EOP Warning pressure for Region 2 (16 psi / 110 kPa) – Specifies the minimum oil pressure with engine speed greater than (EOP Engine Speed Region Boundary 1), but less than (EOP Engine Speed Region Boundary 2). Failure to meet set point turns on the OIL/WATER lamp and warning buzzer.

EOP Warning Pressure for Region 3 (20 psi / 138 kPa) – Specifies the minimum oil pressure with engine speed greater than (EOP Engine Speed Region Boundary 2), but less than (EOP Engine Speed Region Boundary 3). Failure to meet set point turns on the OIL/WATER lamp and warning buzzer.

EOP Critical Pressure for Region 1 (7.5 psi / 52 kPa) – Specifies the minimum oil pressure with engine speed greater than (EOP Engine Speed Region Boundary 1). Failure to meet set point commands an engine shut down.

EOP Critical Pressure for Region 2 (12 psi / 83 kPa) – Specifies the minimum oil pressure with engine speed greater than (EOP Engine Speed Region Boundary 1), but less than (EOP Engine Speed Region Boundary 2). Failure to meet set point commands an engine shutdown.

EOP Critical Pressure for Region 3. (15 psi / 103 kPa) – Specifies the minimum oil pressure with engine speed greater than (EOP Engine Speed Region Boundary 2), but less than (EOP Engine Speed Region Boundary 3). Failure to meet set point commands an engine shutdown.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN 110 FMI 0 - Engine Coolant System above Critical Temperature

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine Coolant Temperature 1 (ECT1) above critical temperature	ECT1 > value programmed into Programmable Parameter (PP) 77022	Key-On Engine-Running	Immediate

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that Engine Coolant Temperature 1 (ECT1) is above Programmable Parameter (PP) 77022.

Malfunction Indicator Lamp (MIL) Reaction

Engine shutdown is commanded and Red Stop Lamp (RSL) active.

Associated Faults

SPN 110 FMI 2, 3, 4 (ECT1)

Fault Facts

Air pockets in the cooling system can interfere with coolant flow or prevent the thermostats from opening when needed, resulting in this fault.

Drive Cycle to Determine Fault Status

Drive cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Incorrect value in Programmable Parameter (PP) 77022
- Blockage between radiator and Charge Air Cooler (CAC) or Low Temperature Radiator (LTR)
- Cooling system overheating
- Degraded coolant

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 2, 3, 4 (ECT1). Is EST DTC list free of SPN 110 FMI 2, 3, 4?	Yes: Go to step 2. No: Repair SPN 110 FMI 2, 3, 4 (ECT1). After repairs are complete, retest SPN 110 FMI 0.

Step	Action	Decision
2	Check for blockage between radiator and Charge-Air Cooler (CAC) or Low Temperature Radiator (LTR). Inspect the between the radiator and CAC / LTR for blockage. Is there any blockage between the radiator and CAC or LTR?	Yes: Clean blockage between the CAC and LTR. After repairs are complete, retest for SPN 110 FMI 11.
		No: Go to step 3.

Step	Action	Decision
3	Check Programmable Parameter (PP) 77022. Using EST with ServiceMaxx™ software, go to Sessions > Programming > Engine Warn Protection System. Check value, verify with customer desired temperature limit and compare to normal operating temperature. Is PP 77022 programmed correctly?	Yes: Go to step 4.
		No: Program PP 77022 to correct value. After repairs are complete, retest for SPN 110 FMI 0.

Step	Action	Decision
4	Check for degraded coolant. Using Coolant And Battery Refractometer ZTSE4796, determine condition of coolant. Is coolant filled to spec, clean, and Not degraded?	Yes: Go to step 5.
		No: Perform coolant flush and fill coolant to spec. After repairs are complete, retest for SPN 110 FMI 0.

Step	Action	Decision
5	Determine coolant over temperature condition. Perform Coolant Over-Temperature tests (page 87). Is cooling system free from physical damage and Not leaking?	Yes: Retest for SPN 110 FMI 0.
		No: Repair engine cooling system. After repairs are complete, retest for SPN 110 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 110 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 110 FMI 11 - Event Logger, Coolant Temp Hot, Extreme

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine coolant at Engine Coolant Temperature 1 (ECT1) is above critical temperature	ECT1 > value programmed into Programmable Parameter (PP) 8332	Key-On Engine-Running	Immediate

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that engine coolant at Engine Coolant Temperature 1 (ECT1) is above Programmable Parameter (PP) 8332.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 110 FMI 2, 3, 4 (ECT1)

Fault Facts

Air pockets in the cooling system can interfere with coolant flow or prevent the thermostats from opening when needed, resulting in this fault.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

- Incorrect value in Programmable Parameter (PP) 8332
- Blockage between radiator and Charge Air Cooler (CAC) or Low Temperature Radiator (LTR)
- Cooling system overheating
- Degraded coolant

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 2, 3, 4 (ECT1). Is EST DTC list free of SPN 110 FMI 2, 3, 4?	Yes: Go to step 2. No: Repair SPN 110 FMI 2, 3, 4. After repairs are complete, retest SPN 110 FMI 11.

Step	Action	Decision
2	Check for blockage between radiator and Charge-Air Cooler (CAC) or Low Temperature Radiator (LTR). Inspect the between the radiator and CAC / LTR for blockage. Is there any blockage between the radiator and CAC or LTR?	Yes: Clean blockage between the CAC and LTR. After repairs are complete, retest for SPN 110 FMI 11.
		No: Go to step 3.

Step	Action	Decision
3	Check Programmable Parameter (PP) 8332. Using EST with ServiceMaxx™ software, go to Sessions > Programming > Engine Warn Protection System. Check value, verify with customer desired temperature limit and compare to normal operating temperature. Is PP 8332 programmed correctly?	Yes: Go to step 4.
		No: Program PP 8332 to correct value. After repairs are complete, retest for SPN 110 FMI 11.

Step	Action	Decision
4	Check for degraded and low coolant. Using Coolant And Battery Refractometer ZTSE4796, determine condition of coolant. Is coolant filled to spec, clean, and Not degraded?	Yes: Go to step 5.
		No: Perform coolant flush and fill coolant to spec. After repairs are complete, retest for SPN 110 FMI 11.

Step	Action	Decision
5	Determine coolant over temperature condition. Perform Coolant Over-Temperature (page 87). Is cooling system free from physical damage and Not leaking?	Yes: Retest for SPN 110 FMI 11.
		No: Repair engine cooling system. After repairs are complete, retest for SPN 110 FMI 11.

NOTE: After doing all diagnostic steps, if SPN 110 FMI 11 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 110 FMI 15 - Engine Coolant System above Warning Temperature

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine coolant at Engine Coolant Temperature 1 (ECT1) is above Warning temperature.	ECT1 > value programmed into Programmable Parameter (PP) 77012	Key-On Engine-Running (KOER)	Immediate

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects that engine coolant at Engine Coolant Temperature 1 (ECT1) is above Programmable Parameter (PP) 77012.

Malfunction Indicator Lamp (MIL) Reaction

Warning Lamp set and Warning buzzer turned ON.

Associated Faults

SPN 110 FMI 2, 3, 4 (ECT1)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Incorrect value in Programmable Parameter (PP) 77012
- Failed Thermostat
- Low Temperature Radiator (LTR) Plugged
- Blockage between Charge Air Cooler (CAC) and Radiator
- Degraded Coolant
- Failed Water pump
- Failed CCV

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 2, 3, 4 (ECT1). Is EST DTC list free of SPN 110 FMI 2, 3, 4?	Yes: Go to step 2. No: Repair SPN 110 FMI 2, 3, 4. After repairs are complete, retest SPN 110 FMI 15.

Step	Action	Decision
2	Check for blockage stuck between Charge-Air Cooler (CAC) and Low Temperature Radiator (LTR). Inspect the between the CAC and LTR for blockage. Is there a blockage between the CAC and LTR?	Yes: Go to step 3. No: Clean blockage between the CAC and LTR. After repairs are complete, retest for SPN 110 FMI 15.

Step	Action	Decision
3	Check Programmable Parameter (PP) 77012. Using EST with ServiceMaxx™ software, go to Sessions > Programming > Engine Warn Protection System. Check value, verify with customer desired temperature limit and compare to normal operating temperature. Is PP 77012 programmed correctly?	Yes: Go to step 4. No: Program PP 77012 to correct value. After repairs are complete, retest for SPN 110 FMI 15.

Step	Action	Decision
4	Check for degraded and low coolant. Using Coolant And Battery Refractometer ZTSE4796, determine condition of coolant. Is coolant filled to spec, clean, and Not degraded?	Yes: Go to step 5. No: Perform coolant flush and fill coolant to spec. After repairs are complete, retest for SPN 110 FMI 15.

Step	Action	Decision
5	Determine coolant over temperature condition. Perform Coolant Over- Temperature (page 87). Is cooling system free from physical damage and Not leaking?	Yes: Go to step 6. No: Repair engine cooling system. After repairs are complete, retest for SPN 110 FMI 15.

Step	Action	Decision
6	Check for Failed Coolant Control Valve (CCV). Perform CCV Test (page 93). Is the CCV working correctly?	Yes: Retest for SPN 110 FMI 15. No: Replace Coolant Control Valve assembly. (CCV) . After repairs are complete, retest for SPN 110 FMI 15.

NOTE: After doing all diagnostic steps, if SPN 110 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 188 FMI 0 - Engine speed unable to achieve desired idle speed (too high)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine idle speed too high	Engine speed > 106.7% of desired idle speed	Key ON Engine Coolant Temperature 1 (ECT1) between 16°F (-9°C) and 248°F (120°C) Vehicle speed < 0.62 mph PTO not engaged Accelerator pedal position 0%	10 seconds

Fault Overview

Fault sets when vehicle is stationary and engine speed is greater than what is requested by the Engine Control Module (ECM).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 110 FMI 2 (ECT1); SPN 5395 FMI 0 (EWPS)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Cause

- Engine over-fueling
- External fuel source
- Lube oil leak to intake
- Fuel leak to intake
- Contaminated fuel

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 110 FMI 2 (ECT1); SPN 5395 FMI 0 (EWPS). Is EST DTC list free of SPN 110 FMI 2; SPN 5395 FMI 0?	Yes: Go to step 2. No: Repair SPN 110 FMI 2; SPN 5395 FMI 0. After repairs are complete, retest for SPN 188 FMI 0.

Step	Action	Decision
2	Inspect for airborne combustibles (such as propane saturated air, ether) near engine. Inspect air filter and intake system for stains, concentrations of contaminants, odors / smells from external fuel sources, and modifications. Is the engine intake system intact and free from any external fuel sources?	Yes: Go to step 3. No: Repair source of combustibles. After repairs are complete, retest for SPN 188 FMI 0.

Step	Action	Decision
3	Inspect for a lube oil leak to intake. Perform Lube Oil to Intake leak test (page 96). Is lube oil leaking to intake?	Yes: Go to step 4. No: Repair lube oil leak to intake. After repairs are complete, retest for SPN 188 FMI 0.

Step	Action	Decision
4	Inspect for a fuel leak to intake. Perform Fuel to Intake leak test (page 103). Is fuel leaking to intake?	Yes: Go to step 5. No: Repair fuel leak to intake. After repairs are complete, retest for SPN 188 FMI 0.

Step	Action	Decision
5	Inspect for contaminated fuel (alternate fuels other than Diesel fuel). Perform Fuel Quality Check (page 154). Is diesel fuel in good condition and Not contaminated?	Yes: Go to step 6. No: Drain fuel tank, and fill with clean and / or known good diesel fuel. After repairs are complete, retest for SPN 188 FMI 0.

Step	Action	Decision
6	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Replace fuel injector on suspected cylinder. After repairs are complete retest for SPN 188 FMI 0. No: Retest for SPN 188 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 188 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 188 FMI 1 - Engine speed unable to achieve desired idle speed (too low)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine idle speed too low	Engine speed < 93.3% of desired idle speed	Key ON Engine Coolant Temperature 1 (ECT1) between 16°F (-9°C) and 248°F (120°C) Vehicle speed < 0.62 mph PTO not engaged Accelerator pedal position 0%	10 seconds

Fault Overview

Fault sets when vehicle is stationary and engine speed is less than what is requested by the Engine Control Module (ECM).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 651, 652, 653, 654, 655, 656 (INJ); SPN 5395 FMI 1 (EWPS)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low Fuel Rail Pressure (FRP)
- Low Fuel Delivery Pressure (FDP)
- Low cylinder compression
- Clutch or Power Take Off (PTO) engagement without command
- Injector or injector circuit fault

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651, 652, 653, 654, 655, 656 (INJ); SPN 5395 FMI 1 (EWPS). Is EST DTC list free of SPN 651, 652, 653, 654, 655, 656; SPN 5395 FMI 0?	Yes: Go to step 2. No: Repair SPN 651, 652, 653, 654, 655, 656; SPN 5395 FMI 1. After repairs are complete, retest for SPN 188 FMI 1.

Step	Action	Decision
2	Verify Fuel Delivery Pressure (FDP) is within specification. Using Electronic Service Tool (EST) with ServiceMaxx™ software, Key-On Engine-Running (KOER) monitor FDP sensor. Is FDP between 60 and 120 psi?	Yes: Go to step 3. No: Perform Fuel Delivery Pressure Test (page 167). After repairs are complete, retest for SPN 188 FMI 1.

Step	Action	Decision
3	Determine if Fuel Rail Pressure (FRP) is within specification. Using EST with ServiceMaxx software, KOER monitor FRP sensor. Is FRP greater than 10,500 psi?	Yes: Go to step 4. No: Perform High-pressure Pump Inlet Test (High-pressure Pump Inlet Pressure Test, page 175). After repairs are complete, retest for SPN 188 FMI 1.

Step	Action	Decision
4	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 188 FMI 1. No: Go to step 5.

Step	Action	Decision
5	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 6. No: Go to step 7.

Step	Action	Decision
6	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 188 FMI 1. No: Repair failed valve train components. After repairs are complete retest for SPN 188 FMI 1.

Step	Action	Decision
7	Check for Power Take Off (PTO) engagement without command. KOER, monitor PTO output shaft rotation. Is PTO output shaft rotating without throttle?	Yes: Repair PTO unit. After repairs are complete, retest for SPN 188 FMI 1.
		No: Retest for SPN 188 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 188 FMI 1 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 190 - FMI 0 - Engine Overspeed Most Severe level

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine speed reaches most severe level with Accelerator Pedal Position (APP) and Vehicle Speed Sensor (VSS) at 0% or 0.	Engine speed exceeds 2600 rpm with no fuel being requested	Vehicle speed < 0.1 mph APP < 0.1% RAPP < 0.1% Engine speed > 2600 rpm	1 event

Fault Overview

Fault sets only when a vehicle is stationary and engine speed reaches 2600 rpm with no fuel being requested by the Engine Control Module (ECM). Once conditions are met, the ECM will initiate a protection strategy. The Engine Throttle Valve (ETV) and Exhaust Gas Recirculation (EGR) valve will be closed and fuel injectors disabled. The Fuel Pressure Control Valve (FPCV) will open to relieve fuel rail pressure in case of injector tip damage. A complete full engine analysis needs to be completed to asses damage due from excessive engine speed before the engine can be started.

Malfunction Indicator Lamp (MIL) Reaction

The Malfunction Indicator Lamp and Red Stop Lamp will illuminate when this fault is detected.

CAUTION: To prevent engine damage, do not attempt to start engine until a full engine analysis and all diagnostic steps have been completed.

NOTE:

Before beginning diagnosis:

- **Take pictures of all damage / failure evidence**
- **Do not replace any parts till complete inspection has been done**

Step	Action	Decision
1	Inspect for signs of an alternative fuel source that could be induced into the intake manifold with no fuel being requested by the ECM or driver inputs causing the engine to exceed 2600 RPM from the list below: • Engine oil consumption. See Engine Symptom Diagnostics, Lubrication System (page 95), for procedures to inspect for lube oil leaking into intake or exhaust system. • Air born combustibles (ex. propane saturated air, ether). Inspect air filter and intake system for stains, concentrations of contaminants, odors / smells from alternative fuel sources. • Fuel contamination (alternate fuels other than diesel fuel). See Hard Start and No Start Diagnostics, Fuel Quality Check (page 120) for procedures to inspect quality of vehicle's diesel fuel. • Operator error. Was an alternative fuel source found to be induced into the intake manifold or operator error causing the engine to exceed 2600 rpm?	After inspection is complete, notify supervisor with results for further action.

SPN 2588 FMI 0 - Vehicle overspeed 1, event log, extreme

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Vehicle over-speed level 1: This occurs when vehicle speed is above value in Programmable Parameter (PP) 77232.	Vehicle speed is greater than the value of PP 77232	Key-On Engine-Running (KOER)	

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects vehicle speed exceeds the value set in Programmable Parameter (PP) 77232.

Malfunction Indicator Lamp (MIL) Reaction

9 - Special error class for VETS faults

Associated Faults

SPN 191 (VSS).

Fault Facts

This fault indicates vehicle speed has exceeded the value programmed in PP 77232, and does not indicate a vehicle problem.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Vehicle speed has exceeded the value set in PP 77232

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 191 (VSS). Is EST DTC list free of SPN 191?	Yes: Verify PP 77232 is set to appropriate speed value. No: Repair SPN 191. After repairs are complete, retest for SPN 2588 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 2588 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2588 FMI 15 - Vehicle overspeed 1, event log, non extreme

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Vehicle over-speed level 1: This occurs when vehicle speed is above value in Programmable Parameter (PP) 77232.	Vehicle speed is greater than the value of PP 77232	Key-On Engine-Running (KOER)	

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects vehicle speed exceeds the value set in Programmable Parameter (PP) 77232.

Malfunction Indicator Lamp (MIL) Reaction

9 - Special error class for VETS faults

Associated Faults

SPN 191 (VSS).

Fault Facts

This fault indicates vehicle speed has exceeded the value programmed in PP 77232, and does not indicate a vehicle problem.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Vehicle speed has exceeded the value set in PP 77232

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 191 (VSS). Is EST DTC list free of SPN 191?	Yes: Yes: Verify PP 77232 is set to appropriate speed value. No: Repair SPN 191. After repairs are complete, retest for SPN 2588 FMI 15.

NOTE: After doing all diagnostic steps, if SPN 2588 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2589 FMI 0 - Vehicle overspeed 2, event log, extreme

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Vehicle over-speed level 2: This occurs when vehicle speed is above value in Programmable Parameter (PP) 77242.	Vehicle speed is greater than the value of PP 77242	Key-On Engine-Running (KOER)	

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects vehicle speed exceeds the value set in Programmable Parameter (PP) 77242.

Malfunction Indicator Lamp (MIL) Reaction

9 - Special error class for VETS faults

Associated Faults

SPN 191 (VSS).

Fault Facts

This fault indicates vehicle speed has exceeded the value programmed in PP 77242, and does not indicate a vehicle problem.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Vehicle speed has exceeded the value set in PP 77242

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 191 (VSS). Is EST DTC list free of SPN 191?	Yes: Verify PP 77242 is set to appropriate speed value. No: Repair SPN 191. After repairs are complete, retest for SPN 2589 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 2589 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2589 FMI 15 - Vehicle overspeed 2, event log, non extreme

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Vehicle over-speed level 2: This occurs when vehicle speed is above value in Programmable Parameter (PP) 77242.	Vehicle speed is greater than the value of PP 77242	Key-On Engine-Running (KOER)	

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects vehicle speed exceeds the value set in Programmable Parameter (PP) 77242.

Malfunction Indicator Lamp (MIL) Reaction

9 - Special error class for VETS faults

Associated Faults

SPN 191 (VSS).

Fault Facts

This fault indicates vehicle speed has exceeded the value programmed in PP 77242, and does not indicate a vehicle problem.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Vehicle speed has exceeded the value set in PP 77242

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 191 (VSS). Is EST DTC list free of SPN 191?	Yes: Verify PP 77242 is set to appropriate speed value. No: Repair SPN 191. After repairs are complete, retest for SPN 2589 FMI 15.

NOTE: After doing all diagnostic steps, if SPN 2589 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5395 FMI 0 - Engine Unable to Achieve Desired Idle Torque (Too High)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine idle fuel quantity too high, engine unable to achieve desired idle torque.	Engine speed and fuel quantity greater than expected.	Vehicle speed <0.62 mph Key ON Engine coolant temperature < 239°F (115°C) Engine coolant temperature > 16°F (–9°C) Engine speed > 560 rpm	10 Seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects fuel quantity is and engine speed is greater than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 188 FMI 1 (EWPS).

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Failed fuel injector
- Aftermarket PTO system not installed correctly
- Aftermarket PTO system not programmed correctly

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 188 FMI 1 (EWPS). Is EST DTC list free of SPN 188 FMI 1?	Yes: Go to step 2. No: Repair SPN 188 FMI 1. After repairs are complete, retest for SPN 5395 FMI 0.

Step	Action	Decision
2	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 5395 FMI 0.
		No: Go to step 3

Step	Action	Decision
3	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 4.
		No: Go to step 5.

Step	Action	Decision
4	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 5395 FMI 0.
		No: Repair failed valve train components. After repairs are complete retest for SPN 5395 FMI 0.

Step	Action	Decision
5	Inspect for installation of aftermarket PTO system. Was an aftermarket PTO system installed and programmed correctly?	Yes: Do Harness Resistance Check (page 827). After repairs are complete, retest for SPN 5395 FMI 0.
		No: After inspection is complete, notify supervisor with results for further action.

NOTE: After doing all diagnostic steps, if SPN 5395 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 5395 FMI 1 - Engine Unable to Achieve Desired Idle Torque (Too Low)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Engine idle fuel quantity too low, engine unable to achieve desired idle torque.	engine speed and fuel quantity less than expected.	Vehicle speed <0.62 mph Key ON Engine coolant temperature < 239°F (115°C) Engine coolant temperature > 16°F (–9°C) Engine speed > 560 rpm	10 Seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects an un-commanded load being placed on the engine at idle or detects fuel quantity is less than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 188 FMI 0 (EWPS).

Drive Cycle to Determine Fault Status

Drive Cycle 22 in 2013 HD-OBD Diagnostic Reference Manual.

- Engine mechanical failure
- Failed cylinder
- External fuel source
- Lube oil leak to intake
- Fuel leak to intake
- Contaminated fuel

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 188 FMI 0 (EWPS). Is EST DTC list free of SPN 188 FMI 0?	Yes: Go to step 2. No: Repair SPN 188 FMI 0. After repairs are complete, retest for SPN 5395 FMI 1.

Step	Action	Decision
2	Determine if the engine has a mechanical cylinder balance problem (compression loss). Perform Crankcase Pressure Test (page 179). Does engine have excessive crankcase pressure?	Yes: Repair base engine compression imbalance. After repairs are complete, retest for SPN 5395 FMI 1.
		No: Go to step 3

Step	Action	Decision
3	Determine if engine has a fuel injector problem. Perform Multiple Cylinder Cutout Test (page 182). Did one or more cylinders have significant speed difference(s) than the others?	Yes: Go to step 4.
		No: Go to step 5.

Step	Action	Decision
4	Inspect for failed valve train components. Remove upper valve cover (see Engine Service Manual). Inspect for bent valves, fallen bridges, and valves out of adjustment. Is valve train free of failed valve train components?	Yes: Replace injector suspected by Multiple Cylinder Cutout Test. After repairs are complete, retest for SPN 5395 FMI 1.
		No: Repair failed valve train components. After repairs are complete retest for SPN 5395 FMI 1.

Step	Action	Decision
5	Inspect for airborne combustibles (ex. propane saturated air, ether, etc.) near engine. Inspect air filter and intake system for stains, concentrations of contaminants, odors / smells from external fuel sources, and modifications. Is the engine intake system intact and free from any external fuel sources?	Yes: Go to step 6.
		No: Repair source of combustibles. After repairs are complete, retest for SPN 5395 FMI 1.

Step	Action	Decision
6	Inspect for a lube oil leak to intake. Perform Lube Oil to Intake leak test (page 96). Is lube oil leaking to intake?	Yes: Go to step 7.
		No: Repair lube oil leak to intake. After repairs are complete, retest for SPN 5395 FMI 1.

Step	Action	Decision
7	Inspect for a fuel leak to intake. Perform Fuel to Intake leak test (page 103). Is fuel leaking to intake?	Yes: Go to step 8.
		No: Repair fuel leak to intake. After repairs are complete, retest for SPN 5395 FMI 1.

Step	Action	Decision
8	Inspect for contaminated fuel (alternate fuels other than Diesel fuel). Perform Fuel Quality Check (page 154). Is diesel fuel in good condition and Not contaminated?	Yes: Retest for SPN 5395 FMI 1.
		No: Drain fuel tank, and fill with clean and / or known good diesel fuel. After repairs are complete, retest for SPN 5395 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 5395 FMI 1 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

FDP Sensor (Fuel Delivery Pressure)

SPN	FMI	Condition	Possible Causes	Actions
94	0	Fuel pressure above critical	• VREF5 circuit Open or high resistance • SIG GND circuit Open or high resistance • FDP circuit Open or high resistance • Restricted engine fuel filter • Restriction in return line to fuel tank • Failed Fuel Delivery Pressure (FDP) sensor	Step-Based Diagnostics (page 676)
94	3	FDP signal Out of Range HIGH	• FDP signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed FDP sensor	Pin-Point Diagnostics (page 679)
94	4	FDP signal Out of Range LOW	• FDP signal circuit short to GND • VREF5 circuit OPEN • Failed FDP sensor	Pin-Point Diagnostics (page 679)

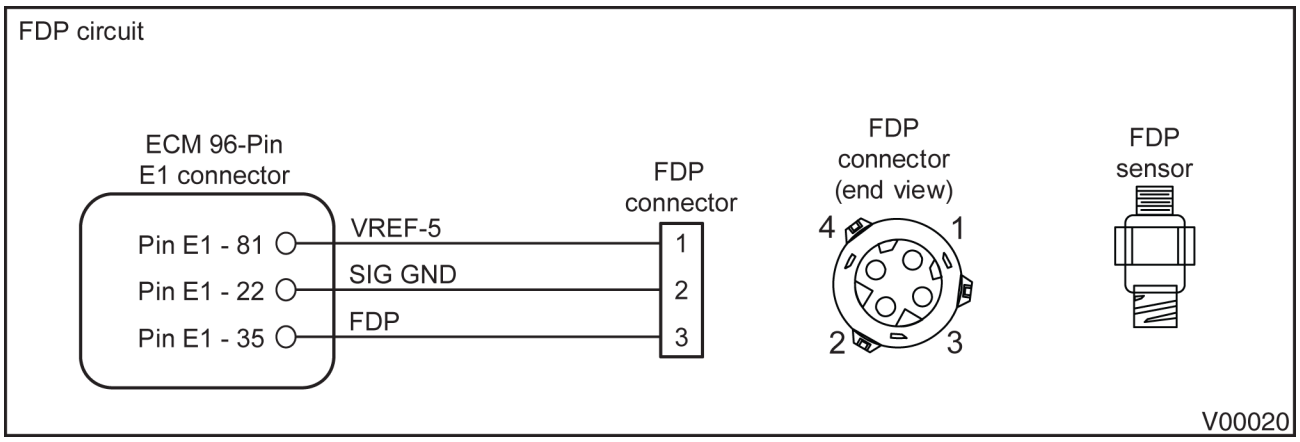


Figure 259 FDP sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- ZTSE4681 – Fuel Pressure Gauge
- ZTSE4886 – Fuel Inlet Restriction / Aeration Tool
- ZTSE4905 – Fuel Block Off Tool
- ZTSE4906 – Fuel Line Coupler
- ZTSE4760A – Breakout Harness 4760A (DOCIT, DOCOT, DPFOT, and EGRT)
- ZTSE4906 – Breakout Harness 4881 (FDP)
- Digital Multimeter (DMM)

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

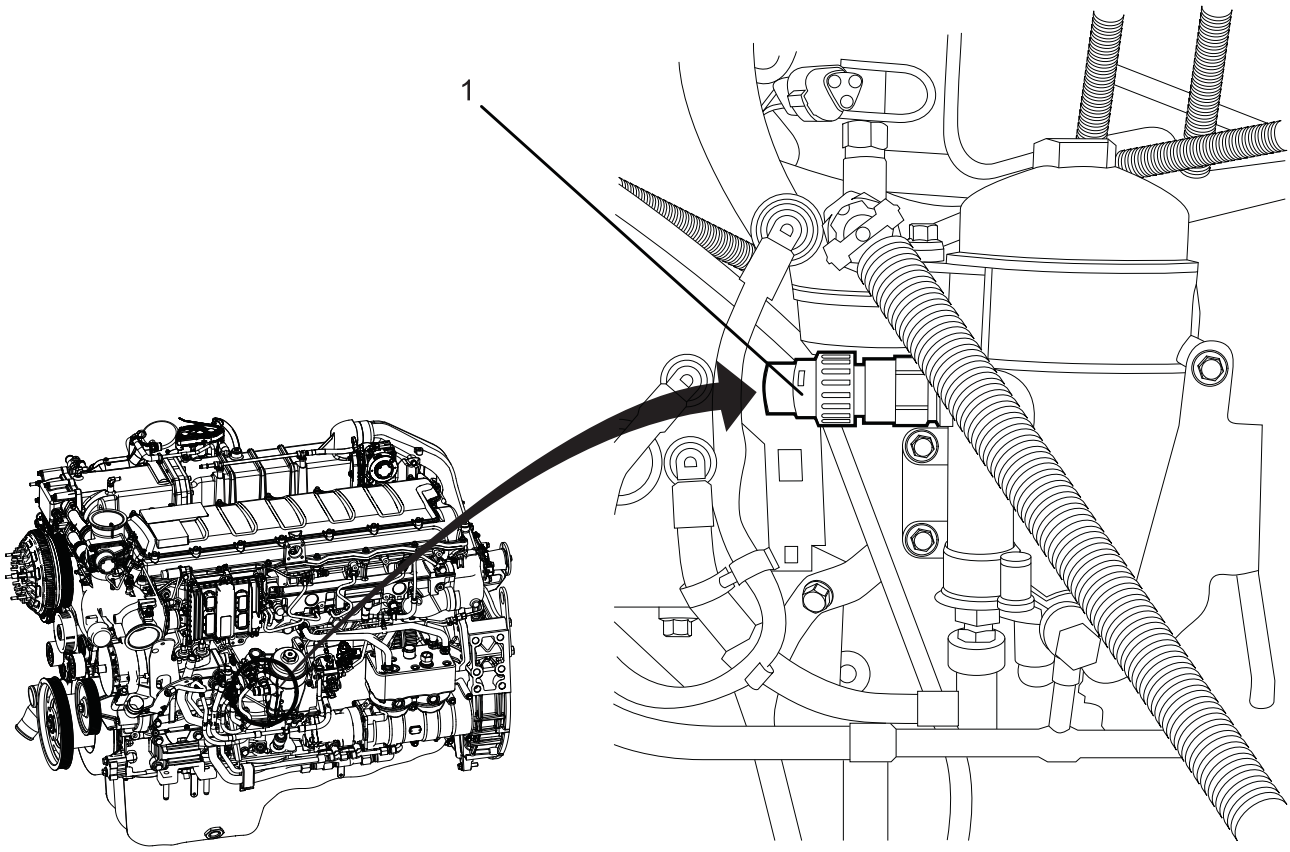


Figure 260 FDP Sensor Location

1. Fuel Delivery Pressure (FDP) sensor

SPN 94 FMI 0 - Fuel Delivery Pressure above Critical

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Signal from Fuel Delivery Pressure (FDP) sensor above expected (in-range, but not rational).	Fuel Delivery Pressure > 145 psi (1000 kPa) or (130 psi [900 kPa] at idle)	Key-On Engine-Running (KOER)	0 seconds

Fault Overview

Fault code sets when Engine Control Module (ECM) detects that Fuel Delivery Pressure (FDP) is over 130 psi (900 kPa) at idle, or over 145 psi (1000 kPa) when engine speed is above idle.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

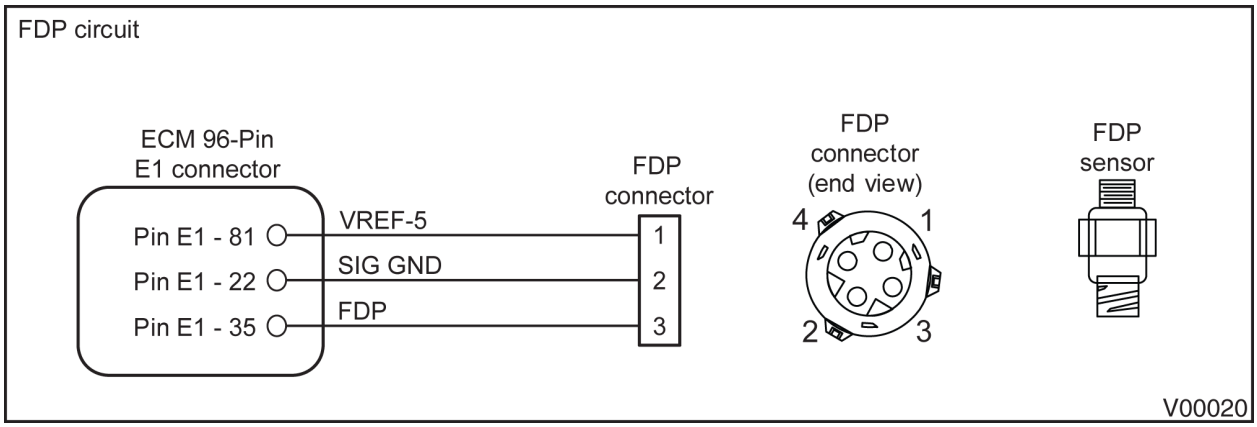


Figure 261 FDP Sensor Circuit Diagram

Possible Causes

- VREF5 circuit Open or high resistance
- SIG GND circuit Open or high resistance
- FDP circuit Open or high resistance
- Restricted secondary (engine) fuel filter
- Restriction in return line to fuel tank
- Failed Fuel Delivery Pressure (FDP) sensor

Step	Action	Decision
1	Inspect connections at Fuel Delivery Pressure (FDP) sensor. Key OFF, disconnect FDP sensor. Check FDP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the FDP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 94 FMI 0.

Step	Action	Decision
2	Check for a failed FDP sensor. Connect Fuel Inlet Restriction / Aeration Tool ZTSE4886 between low side pressure line and the inlet to the secondary (engine) mounted fuel filter. Connect Fuel Pressure Gauge ZTSE4681 to Fuel Inlet Restriction / Aeration Tool ZTSE4886. Run engine at idle and high idle, compare gauge with the ServiceMaxx value. (Note: ServiceMaxx reads 15 psi below gauge pressure). Do idle and high idle fuel pressure values stay within 2 psi each other?	Yes: Go to step 3. No: Go to step 5.

Step	Action	Decision
3	Check for a restricted secondary (engine mounted) fuel filter. Perform the High-pressure Pump Inlet Pressure Test (page 175). Is fuel pressure constantly between 85 and 120 psi at low and high idle?	Yes: Go to step 4. No: Replace secondary fuel filter. After repairs are complete, retest for SPN 94 FMI 0.

Step	Action	Decision
4	Check for restriction in return line to fuel tank. Perform the HP Pump Fuel Return Pressure Test (page 178). Is fuel pressure < 13 psi?	Yes: Replace the FDP sensor. After repairs are complete, retest for SPN 94 FMI 0. No: Repair restriction in return line to fuel tank. After repairs are complete, retest for SPN 94 FMI 0.

Step	Action	Decision
5	Check for Open or high resistance in VREF5 circuit. Connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness and leave Engine Control Module (ECM) disconnected. Connect Breakout Harness ZTSE4881 to vehicle harness and leave FDP sensor disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness pin-1 to 180-pin Breakout Box pin E1-81. Is resistance less than 5 ohms?	Yes: Go to step 6. No: Repair Open or high resistance between FDP connector pin-1 and ECM pin E1-81. After repairs are complete, retest for SPN 94 FMI 0.

Step	Action	Decision
6	Check for Open or high resistance in SIG GND circuit. Connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness and leave ECM disconnected. Connect Breakout Harness ZTSE4881 to vehicle harness and leave FDP sensor disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness ZTSE4881 pin-2 to 180-pin Breakout Box pin E1-22. Is resistance less than 5 ohms?	Yes: Go to step 7. No: Repair Open or high resistance between FDP connector pin-2 and ECM pin E1-22. After repairs are complete, retest for SPN 94 FMI 0.

Step	Action	Decision
7	Check for Open or high resistance in FDP circuit. Connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness and leave ECM disconnected. Connect Breakout Harness ZTSE4881 to vehicle harness and leave FDP sensor disconnected. Key OFF, use a DMM to measure resistance from Breakout Harness pin-3 to 180-pin Breakout Box pin E1-35. Is resistance less than 5 ohms?	No: Replace the FDP sensor. After repairs are complete, retest for SPN 94 FMI 0. No: Repair Open or high resistance between FDP connector pin-3 and ECM pin E1-35. After repairs are complete, retest for SPN 94 FMI 0.

NOTE: After performing all diagnostic steps, if SPN 94 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pinpoint Diagnostics With ServiceMaxx™ Software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Biased Sensor or Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4881 to FDP engine harness, and leave FDP sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor FDPv	5.0 V ± 0.5 V	If > 4.5 V, check FDP signal circuit for short to GND
DMM — Measure voltage 1 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF5 for short to PWR. If < 4.5 V, check VREF5 for OPEN or short to GND. Do Harness Resistance Check (page 680).
DMM — Measure voltage 1 and 2	5 V ± 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 680).
EST – Monitor FDPv Short across Breakout Harness ZTSE4881 pins 2 to 3	5 V ± 0.5 V	If > 0.5 V, check FDP signal circuit for OPEN. Do Harness Resistance Check (page 680).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace FDP sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4881 to FDP engine harness, and leave FDP sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5 V ± 0.5 V	If > 5.5 V, check VREF5 for short to PWR. If < 4.5 V, check VREF5 for OPEN or short to GND. Do Harness Resistance Check (page 680).
2 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
2 to GND	0 V	If > 5.5 V, check VREF5 for short to PWR. If < 4.5 V, check VREF5 for OPEN or short to GND. Do Harness Resistance Check (page 680).
3 to GND	5.0 V	If <, 4.5 V, check FDP signal circuit for short to GND.
3 to GND	5 V ± 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 680).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4881 to FDP engine harness, and leave FDP sensor disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
1 to E1–81	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
2 to E1–22	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
3 to E1–35	< 5 Ω	If > 5 Ω, check for OPEN circuit.

FPCV (Fuel Pressure Control Valve)

SPN	FMI	Condition	Possible Causes	Actions
633	3	FPCV short to PWR	• FPCV circuit short to PWR • Failed FPCV valve	Pin-Point Diagnostics (page 681)
633	4	FPCV short to GND	• FPCV circuit short to GND • Failed FPCV valve	Pin-Point Diagnostics (page 681)
633	5	FPCV open load/circuit	• FPCV circuit OPEN • Failed FPCV	Pin-Point Diagnostics (page 681)

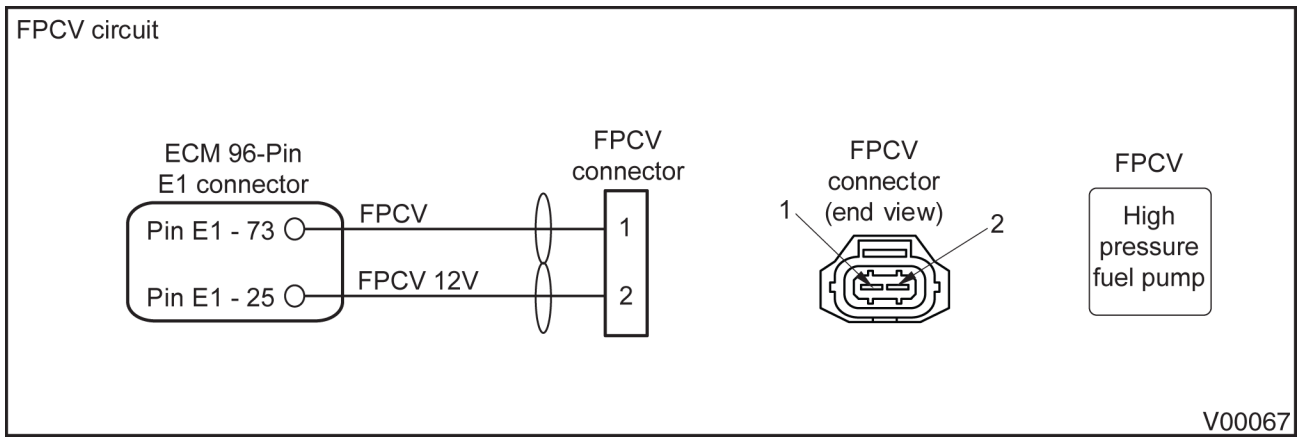


Figure 262 FPCV circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4828 (FPCV)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, select Tests > KOER Tests > High Pressure Pump Test.
2. Run High Pressure Pump Test.
   - If High Pressure Pump Test fails, check FPCV valve for mechanical problem.
   - If FPCV valve does not move, continue with pinpoint diagnostics.

Connector Voltage Check – FPCV Disconnected

Connect Breakout Harness ZTSE4828 to FPCV engine harness, and leave FPCV sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
2 to GND	B+	If < B+, OPEN circuit. Do Harness Resistance Check
1 to GND	0.8 V	If >1.3 V, Check for OPEN circuit. Do Harness Resistance Checks
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure battery voltage is at or above 12 V, before running this procedure.

1. Connect Breakout Harness ZTSE4828 between FPCV and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select Fuel Pressure Control Valve from the drop-down menu.
3. Command FPCV to 5%.
4. Use DMM to measure voltage.
5. Command FPCV to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5% = 8.5 V ± 1.0 V	If < 7.5 V, check for OPEN circuit. Do Harness Resistance Check.
1 to GND	95% = 1.5 V ± 0.5 V	If > 2.0 V, check for OPEN circuit or failed actuator.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4828 to FPCV engine harness, and leave FPCV sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
1 to E1-73	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for OPEN circuit.
2 to E1-25	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, the FPCV is working correctly. See High Pressure Fuel System (page 135) in “HARD START AND NO START DIAGNOSTICS."		

FRP Sensor (Fuel Rail Pressure)

SPN	FMI	Condition	Possible Causes	Actions
157	3	FRP signal Out of Range HIGH	• FRP signal circuit short to PWR • SIG GND circuit high resistance or Open • Failed FRP sensor	Circuit Checks (page 685)
157	4	FRP signal Out of Range LOW	• FRP signal circuit short to GND • FRP signal circuit high resistance or Open • Failed FRP sensor • VREF6 circuit high resistance or Open	Circuit Checks (page 685)
157	20	FRP signal Drifted HIGH	• FRP signal circuit short to PWR • SIG GND circuit high resistance or Open • Failed FRP sensor	Step-based Diagnostics (page 688)
157	21	FRP signal Drifted LOW	• FRP signal circuit short to GND • FRP signal circuit high resistance or Open • Failed FRP sensor • VREF6 circuit high resistance or Open	Step-based Diagnostics (page 690)

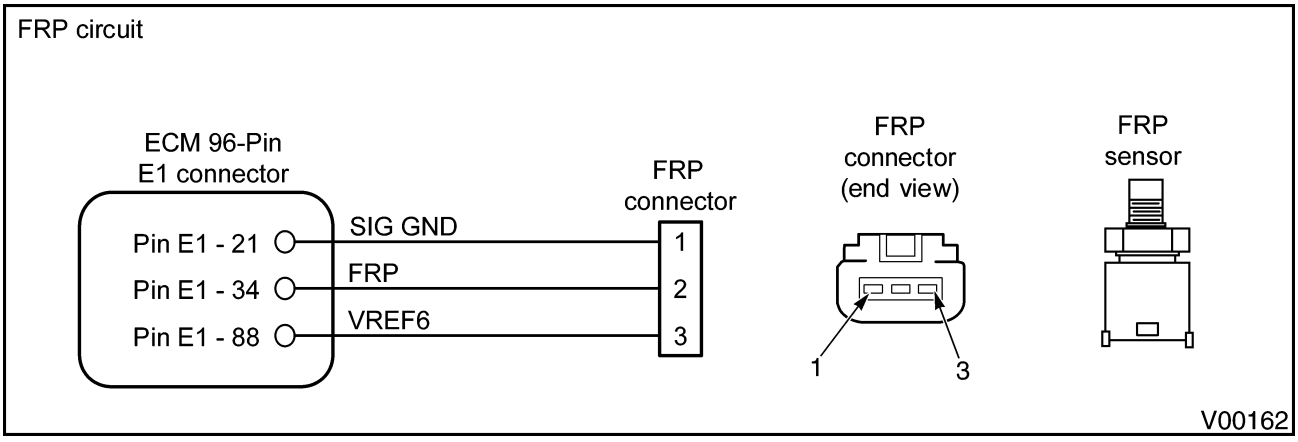


Figure 263 FRP sensor circuit diagram

Overview

The FRP sensor is a variable-capacitance sensor that measures fuel rail pressure at the high-pressure common fuel rail. As pressure increases, sensor capacitance changes causing the voltage sent to Engine Control Module (ECM) to change. The ECM adjusts the Fuel Pressure Control Valve (FPCV) duty cycle to match engine requirements for starting, engine load, speed, and temperature.

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4829 (FRP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

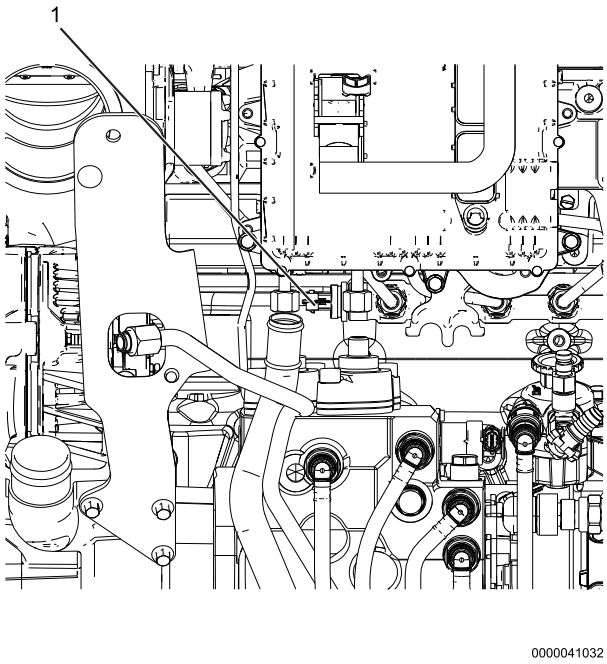


Figure 264 FRP Sensor Location

1. Fuel Rail Pressure (FRP) sensor

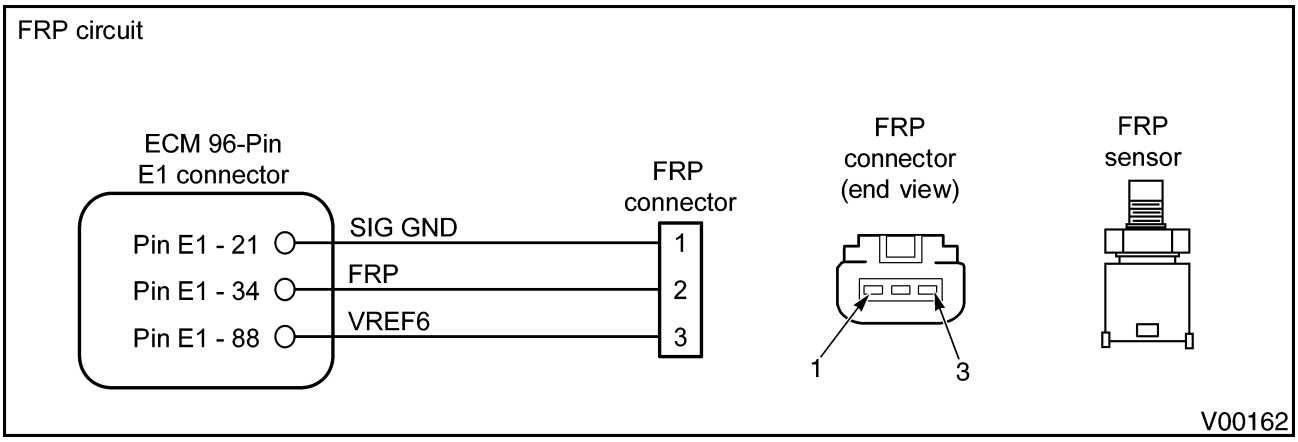


Figure 265 FRP sensor circuit diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike.
   - If DTC is active or pending, continue to Sensor Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4829 to FRP engine harness, and leave FRP sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor FRPv	5.0 V ± 0.5 V	If < 4.5 V, check FRP signal circuit for short to GND.
DMM — Measure volts 3 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF6 for short to PWR. If < 4.5 V, check VREF6 for OPEN or short to GND. Do Harness Resistance Check (page 687).
DMM — Measure voltage 1 to 3	5 V ± 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 687).
EST – Monitor FRPv Short across Breakout Harness ZTSE4829 pins 2 to 3	4.5 V to 5.5 V	If < 4.5 V, check FRP signal circuit for OPEN. Do Harness Resistance Check (page 687).
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace FRP sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4829 to FRP engine harness, and leave FRP sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
3 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF6 for short to PWR. If < 4.5 V, check VREF6 for OPEN or short to GND. Do Harness Resistance Check (page 687).
1 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
2 to GND	0 V	If < 4.5 V, check FRP signal circuit for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4829 to FRP engine harness, and leave FRP sensor disconnected. Use DMM to measure resistance.

Test Point	Specifications	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-21	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-34	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to E1-88	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 157 - FMI 20 FRP signal Drifted HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure rationality offset high (during after run)	Fuel Rail Pressure (FRP) greater than 0.609 volts	Engine coolant temp. > 138°F (60°C) Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts ECM in After Run (“house keeping”) Injector blank shot cycle complete	3 Events

Fault Overview

After shutdown, with enable conditions met, the Engine Control Module (ECM) operates after run cycle (for 30 to 45 seconds) to do needed "house keeping" operations. The after run cycle is the process the ECM goes through to save memory and shutdown.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

If SPN 3514 FMI 14 is active, correct and then retest for SPN 157 FMI 20.

Drive Cycle

See 2013 HD-OBD Diagnostic Reference Manual.

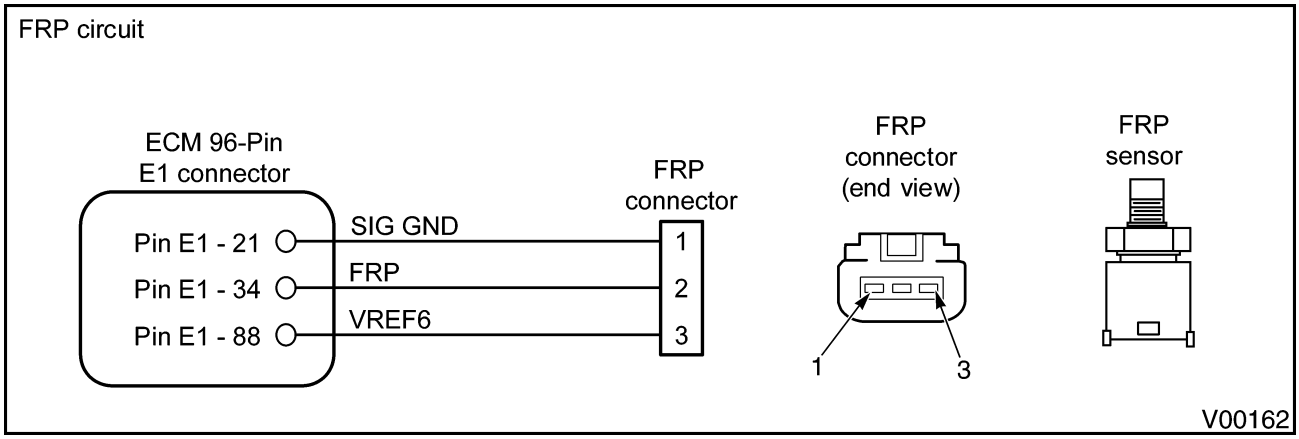


Figure 266 FRP sensor circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 157 FMI 20 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 157 FMI 20.

Step	Action	Decision
2	Inspect connections at FRP sensor. Key OFF, disconnect FRP sensor. Check FRP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the FRP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 157 FMI 20.

Step	Action	Decision
3	Check FRP circuit for short to power. Using EST with ServiceMaxx™, run Continuous Monitor session. Key-On Engine-Off, FRP sensor connected. Does ServiceMaxx™ software show FRP sensor voltage less than 5.0 volts?	Yes: Go to step 4. No: Repair short to power from FRP sensor connector pin 2 to ECM 96–pin connector E1 pin 34. After repairs are complete, retest for SPN 157 FMI 20.

Step	Action	Decision
4	Check SIG GND circuit for high resistance. With FRP sensor disconnected, connect Breakout Harness 4829. Measure resistance between FRP sensor connector pin 1 and a known good ground. Is resistance less than 5 ohms?	Yes: Replace FRP sensor. See Engine Service Manual. No: Repair high resistance between FRP sensor connector pin 1 and ECM 96–pin connector E1 pin 21. After repairs are complete, retest for SPN 157 FMI 20.

NOTE: After doing all diagnostic steps, if SPN 157 FMI 20 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 157 - FMI 21 FRP signal Drifted LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure rationality offset low (during after run)	Fuel Rail Pressure (FRP) less than 0.424 volts	Engine coolant temp. > 138°F (60°C) Time after Key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts ECM in After Run (“house keeping”) Injector blank shot cycle complete	3 Events

Fault Overview

After shutdown, with enable conditions met, the Engine Control Module (ECM) operates after run cycle (for 30 to 45 seconds) to do needed "house keeping" operations. The after run cycle is the process the ECM goes through to save memory and shutdown.

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

If SPN 3514 FMI 14 is active, correct and then retest for SPN 157 FMI 21.

Drive Cycle

See 2013 HD-OBD Diagnostic Reference Manual.

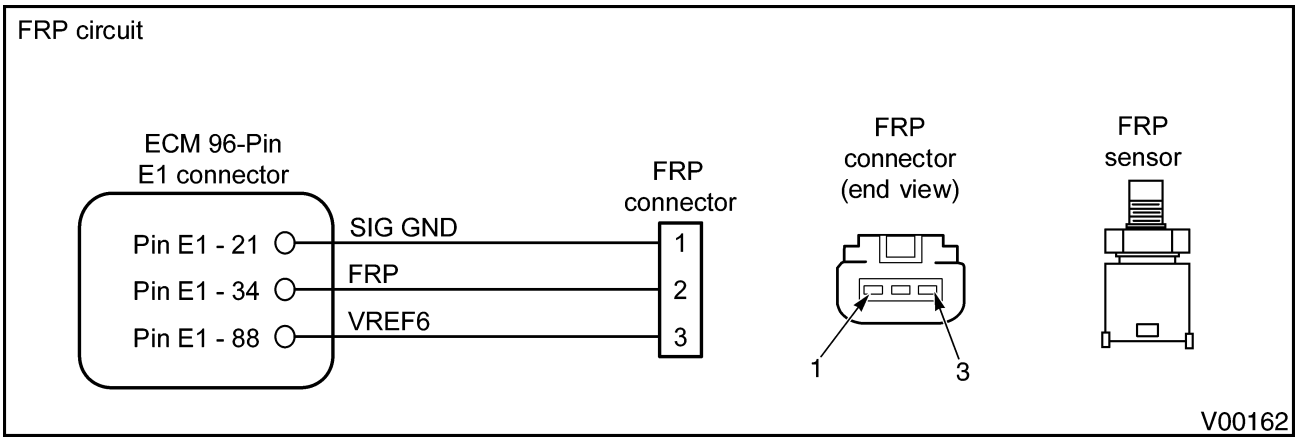


Figure 267 FRP sensor circuit diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 157 FMI 21 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 157 FMI 21.

Step	Action	Decision
2	Inspect connections at FRP sensor. Key OFF, disconnect FRP sensor. Check FRP sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the FRP sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 157 FMI 21.

Step	Action	Decision
3	Check FRP circuit for short to ground. Connect Breakout Harness 4829 to FRP sensor connector and leave FRP sensor disconnected. Use a DMM to measure resistance between Breakout harness 4829 test point 2 and a known, good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 4. No: Repair short to ground between FRP connector pin 2 and ECM 96–pin connector E1 pin 34. After repairs are complete, retest for SPN 157 FMI 21.

Step	Action	Decision
4	Check VREF6 circuit for Open or high resistance. Key-On Engine-Off, with Breakout Harness 4829 connected to FRP sensor connector, use a DMM to measure voltage between FRP sensor connector pin 3 and a known good ground. Is voltage 4.5 volts or greater?	Yes: Go to step 5. No: Repair high resistance between FRP sensor connector pin 3 and ECM 96–pin connector E1 pin 88. After repairs are complete, retest for SPN 157 FMI 21.

Step	Action	Decision
5	Check FRP circuit for high resistance or Open. Using EST with ServiceMaxx™ software, run Continuous Monitor session. Key-On Engine-Off, with Breakout Harness 4829 connected, short FRP sensor connector pin 3 to pin 2. Does ServiceMaxx™ software show FRP sensor voltage 4.5 volts or more?	Yes: Replace FRP sensor. See Engine Service Manual. No: Repair high resistance between FRP sensor connector pin 2 and ECM 96–pin connector E1 pin 34. After repairs are complete, retest for SPN 157 FMI 21.

NOTE: After doing all diagnostic steps, if SPN 157 FMI 21 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

FRP (Fuel Rail Pressure) System

SPN	FMI	Condition	Possible Causes	Actions
157	0	FRP relief valve opening fault	• Outdated ECM calibration	Calibration out-of-date (page 696)
157	14	FRP Relief Valve failure	• Outdated ECM calibration	Calibration out-of-date (page 696)
3055	0	FRP exceeded maximum	• Restricted high-pressure pump fuel return line • Failed Fuel Pressure Control Valve (FPCV) (sticking)	Step-Based Diagnostics (page 697)
3055	1	Low Fuel Pressure at start	• Fuel Rail Pressure (FRP) sensor or circuit fault • Low fuel level • Low-pressure fuel system leaks • Restricted engine mounted secondary fuel filter • Aerated fuel delivery • Restricted low pressure fuel system • Internal leak in high-pressure fuel system • Leaking fuel pressure relief valve • Leaking Piston Overflow Valve (KUEV) valve • Stuck or sticking FPCV • Failed low-pressure fuel pump • Failed high-pressure fuel pump	Step-Based Diagnostics (page 699)

3055	15	FRP below minimum with maximum command	• Low fuel level • Fuel pressure fuel system leaks • Restricted engine mounted secondary fuel filter • Aerated fuel delivery • Restricted fuel supply • Internal leak in high-pressure fuel system • Leaking fuel pressure relief valve • Leaking Piston Overflow Valve (KUEV) valve • Stuck or sticking FPCV • Failed low-pressure fuel pump • Failed high-pressure fuel pump	Step-Based Diagnostics (page 703)
3055	17	FRP above maximum with minimum command	• Restricted high-pressure pump fuel return line • Fuel Pressure Control Valve (FPCV) or circuit fault	Step-Based Diagnostics (page 707)

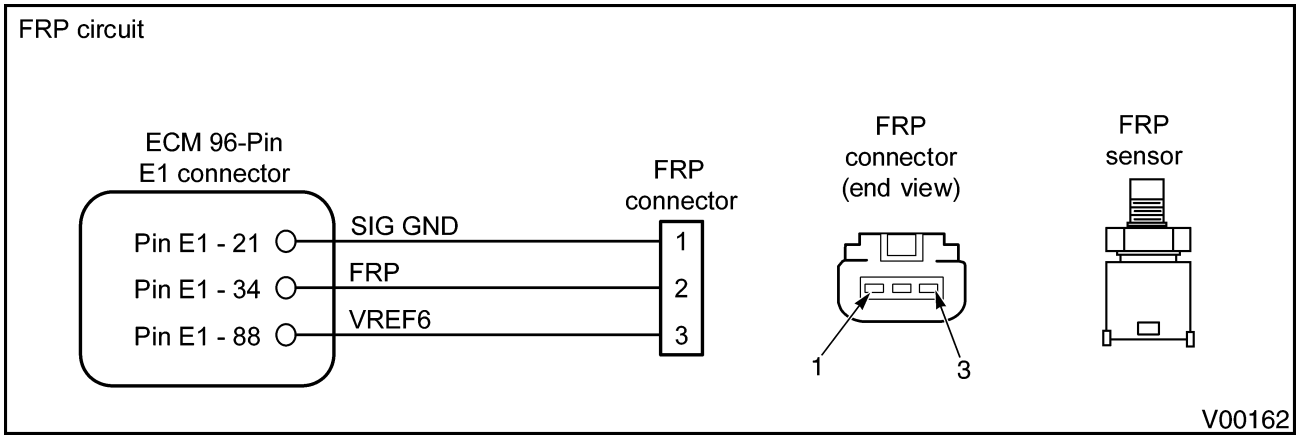


Figure 268 FRP Sensor Circuit Diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Fuel Rail Pressure (FRP) sensor is a variable-capacitance sensor that measures pressure at the high-pressure common fuel rail. As pressure increases, sensor capacitance changes causing voltage to Engine Control Module (ECM) to change. The ECM adjusts the Fuel Pressure Control Valve (FPCV) duty cycle to control fuel pressure for starting and for changing engine load, speed, and temperature.

Tools Required

- Breakout Harness ZTSE4828 (FPCV)
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- Fuel Inlet Restriction / Aeration Tool ZTSE4886
- Fuel Pressure Gauge ZTSE4681
- Fuel Line Coupler ZTSE4906
- ZTSE4526 - Compucheck Fitting
- Clean Fuel Source Tool 15-637-01
- Pressure Test Kit ZTSE4409
- High Pressure Return Line Tester ZTSE4887
- High Pressure Rail Plug ZTSE6098
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

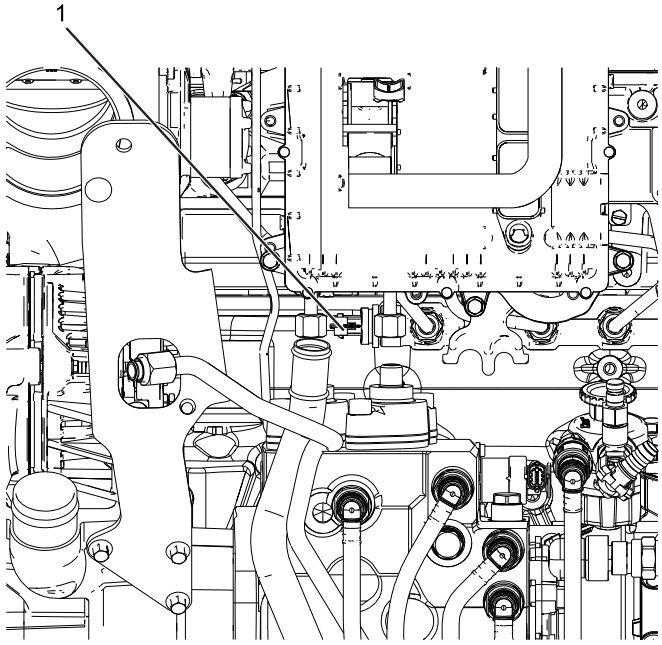


Figure 269 FRP Sensor Location

1. Fuel Rail Pressure (FRP) sensor

Pinpoint Diagnostics With ServiceMaxx™ Software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

SPN 157 FMI 0 - FRP relief valve opening fault

Re-flash Engine Control Module (ECM) software.

SPN 157 FMI 14 - FRP Relief Valve failure

Re-flash ECM software.

SPN 3055 FMI 0 - FRP Exceeded Maximum

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) above maximum pressure.	FRP greater than 34,000 psi (235,000 kpa)	Key ON Closed loop FRP control	0.25 seconds

Fault Overview

Fault code sets when signal from the Fuel Rail Pressure (FRP) sensor indicates FRP exceeds 34,000 psi (235,000 kPa).

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 FMI 0 (FDP); SPN 157 FMI 3, 4, 20, and 21 (FRP); and SPN 633 FMI 3, 4, and 5 (FPCV)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Restricted high-pressure pump fuel return line
- Failed Fuel Pressure Control Valve (FPCV) (sticking)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 0 (FDP); SPN 157 FMI 3, 4, 20, and 21 (FRP); and SPN 633 FMI 3, 4, and 5 (FPCV). Is the EST DTC list free of SPN 94 FMI 0; SPN 157 FMI 3, 4, 20, and 21 and SPN 633 FMI 3, 4, and 5?	Yes: Go to step 2. No: Repair SPN 94 FMI 0; SPN 157 FMI 3, 4, 20, and 21; and SPN 633 FMI 3, 4, and 5. After repairs are complete, retest for SPN 3055 FMI 0.

Step	Action	Decision
2	Check for restricted fuel return line. Perform HP Pump Fuel Return Pressure Test (page 178). Is pressure < 13 psi?	Yes: Go to step 3. No: Repair restriction in fuel return line between high-pressure fuel pump and fuel tank. After repairs are complete, retest for SPN 3055 FMI 0.

Step	Action	Decision
3	Check for a failed Fuel Pressure Control Valve (FPCV). Key OFF, connect Breakout Harness ZTSE4828 to FPCV and leave vehicle harness disconnected. Using a DMM, measure resistance between ZTSE4828 pin-1 and pin-2. Is resistance between 2.6 and 3.2 ohms?	Yes: Go to step 4. No: Replace FPCV. After repairs are complete, retest for SPN 3055 FMI 0.

Step	Action	Decision
4	Check for a sticking FPCV. Run engine at idle. Using EST, monitor the difference between the desired and actual fuel rail pressure for 5 minutes. Does pressure difference remain < 1160 psi (80 Bar) throughout the test?	Yes: Retest for SPN 3055 FMI 0. No: Replace FPCV. After repairs are complete, retest for SPN 3055 FMI 0.

NOTE: After performing all diagnostic steps, if SPN 3055 FMI 0 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 1 - Low Fuel Pressure at Start

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) below minimum pressure.	FRP less than 1,450 psi (10,000 kpa)	Engine Speed > 70 rpm Ambient Pressure > 12 psi (83 kPa) Ambient Temp > 19°F (-7°C) Battery Voltage (before crank) > 11 Volts	0.5 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects Fuel Rail Pressure (FRP) does not build within a predetermined time while the engine is cranking.

Malfunction Indicator Lamp (MIL) Reaction

MIL may illuminate when this fault is detected during one drive cycle.

Associated Faults

SPN 94 FMI 0 (FDP); SPN 157 FMI 3, 4, 20, and 21 (FRP); and SPN 633 FMI 3, 4, and 5 (FPCV)

Fault Facts

The Piston Overflow Valve (KUEV) valve is a flow control valve that allows return fuel to lubricate the internal components of the high-pressure fuel pump when the engine is running. The Piston Overflow Valve (KUEV) valve can be serviced separately from the high-pressure fuel pump.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Fuel Rail Pressure (FRP) sensor or circuit fault
- Low fuel level
- Low-pressure fuel system leaks
- Restricted engine mounted secondary fuel filter
- Aerated fuel delivery
- Restricted low pressure fuel system
- Internal leak in high-pressure fuel system
- Leaking fuel pressure relief valve
- Leaking Piston Overflow Valve (KUEV) valve
- Stuck or sticking FPCV
- Failed low-pressure fuel pump
- Failed high-pressure fuel pump

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 0 (FDP); SPN 157 FMI 3, 4, 20, and 21 (FRP); and SPN 633 FMI 3, 4, and 5 (FPCV). Is EST DTC list free of SPN 94 FMI 0; SPN 157 FMI 3, 4, 20, and 21; and SPN 633 FMI 3, 4, and 5?	Yes: Go to step 2. No: Repair SPN 94 FMI 0; SPN 157 FMI 3, 4, 20, and 21; and SPN 633 FMI 3, 4, and 5. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
2	Check fuel level. Read fuel level using the vehicle instrument panel gauge and perform a visual inspection of fluid level in the fuel tank. Is fuel tank fluid level above 1/2 tank?	Yes: Go to step 3. No: Add fuel and prime engine. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
3	Check fuel tank, fuel lines, and fuel filter assembles for: cracks and pitting; and loose, leaking, or damaged connections. Are the fuel tank, fuel lines, and fuel filter assembles in good condition and Not leaking?	Yes: Go to step 4. No: Add fuel or repair leaks, and prime engine. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
4	Check that the engine cranks at a minimum of 130 rpm. Crank engine for maximum of 20 seconds. Does engine crank at a minimum of 130 rpm?	Yes: Go to step 5. No: Repair low cranking speed. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
5	Verify the engine starts. Crank engine for maximum of 20 seconds. If engine does not start, wait 2 minutes and try again. Does engine start and maintain idle?	Yes: Go to SPN 3055 FMI 15 (page 703). No: Go to step 6.

Step	Action	Decision
6	Check for a failed FRP sensor or circuit. Disconnect the FRP sensor electrical connector and attempt to start engine. Crank engine for maximum of 20 seconds. Does the engine start?	Yes: Diagnose FRP Sensor (page 683). After repairs are complete, retest for SPN 3055 FMI 1. No: Reconnect sensor and go to step 7.

Step	Action	Decision
7	Check for low FDP. Perform Fuel Delivery Pressure (FDP) Test (page 129). Does FDP measure > 30 psi (15 psi in ServiceMaxx™)?	Yes: Go to step 11. No: Go to step 8.

Step	Action	Decision
8	Check for leaks or restrictions in the fuel supply to the low-pressure fuel pump. Perform Fuel Dead head Test (page 130). Is fuel dead head pressure greater than 65 psi?	Yes: Go to step 11. No: Go to step 9.

Step	Action	Decision
9	Check for aeration in low-pressure fuel system. Perform Fuel Aeration Test (page 131). Is low-pressure fuel system free from aeration?	Yes: Go to step 10. No: Repair aeration in low-pressure fuel system. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
10	Check for restriction in low-pressure fuel system. Perform Fuel Restriction Test (page 133). Is low-pressure fuel system free of restrictions?	Yes: Replace low-pressure fuel pump. After repairs are complete, retest for SPN 3055 FMI 1. No: Repair restriction in low-pressure fuel system. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
11	Check for a restricted engine mounted secondary fuel filter. Perform High-pressure Pump Inlet Pressure Test (page 136). Does the fuel pressure gauge read > 30 psi?	Yes: Go to step 12. No: Replace engine mounted secondary fuel filter. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
12	Check for excessive fuel return. Perform Fuel Rail Pressure (FRP) Return Flow Test Part 1 (page 137). Is the fuel volume returned between 20-22 ml?	Yes: Go to step 15. No: Go to step 13.

Step	Action	Decision
13	Check for a failed fuel pressure relief valve. Perform Fuel Rail Pressure (FRP) Return Flow Test Part 2 (page 137). Is the line free of return fuel from fuel rail?	Yes: Go to step 14. No: Replace fuel pressure relief valve. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
14	Check for an internal leak in the high-pressure fuel system. Perform Fuel Rail Pressure (FRP) Leak Isolation (page 138). Is fuel leaking out of High Pressure Return Line Tester ZTSE4887?	Yes: Retest for SPN 3055 FMI 1. If fault is still present notify supervisor for further action. No: Replace the last capped injector, injector tube, and all HP lines removed during this test. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
15	Check for a failed Piston Overflow Valve (KUEV) valve. Perform the HP Pump Return Flow Test (page 139). Is High Pressure Return Line Tester ZTSE4887 free of fuel from the high-pressure pump return port?	Yes: Replace the high-pressure fuel pump. After repairs are complete, go to step 16. No: Replace Piston Overflow Valve (KUEV) valve. After repairs are complete, retest for SPN 3055 FMI 1.

Step	Action	Decision
16	Verify the fuel return line is free from restriction. Run HP Pump Fuel Return Pressure Test (page 139). Is pressure < 13 psi?	Yes: Retest for SPN 3055 FMI 1. If fault is still present notify supervisor for further action. No: Repair restriction in fuel return line between high-pressure fuel pump and fuel tank. After repairs are complete, retest for SPN 3055 FMI 1.

NOTE: After performing all diagnostic steps, if SPN 3055 FMI 1 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 15 - FRP Below Minimum with Maximum Command

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) governor deviation above maximum limit	Rail pressure governor error > 725 psi at 600-750 rpm	Key ON Metering unit flow > function engine speed (41,500-55,000 mm^3/s) Engine mode normal Engine speed > 0 rpm OR FRP > 13,050 psi (90,000 kpa) for more than 20 engine revolutions Metering unit flow < 327,670 mm^3/sec	10 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects Fuel Rail Pressure (FRP) is below minimum when the maximum is commanded.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 157 FMI 3, 4, 20, 21 (FRP); and SPN 633 FMI 3, 4, and 5 (FPCV)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Low fuel level
- Fuel pressure fuel system leaks
- Restricted engine mounted secondary fuel filter
- Aerated fuel delivery
- Restricted fuel supply
- Internal leak in high-pressure fuel system
- Leaking fuel pressure relief valve
- Leaking Piston Overflow Valve (KUEV) valve
- Stuck or sticking FPCV
- Failed low-pressure fuel pump
- Failed high-pressure fuel pump

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 157 FMI 3, 4, 20, and 21 (FRP) or SPN 633 FMI 3, 4, and 5 (FPCV). Is the EST DTC list free of SPN 157 FMI 3, 4, 20, and 21, and SPN 633 FMI 3, 4, and 5?	Yes: Go to step 2. No: Repair SPN 157 FMI 3, 4, 20, and 21, and SPN 633 FMI 3, 4, and 5. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
2	Check fuel level. Read fuel level using the vehicle instrument panel gauge and perform a visual inspection of fluid level in the fuel tank. Is fuel tank fluid level above 1/2 tank?	Yes: Go to step 3. No: Add fuel and prime engine. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
3	Check fuel tank, fuel lines, and fuel filter assembles for: cracks and pitting; and loose, leaking, or damaged connections. Are the fuel tank, fuel lines, and fuel filter assembles in good condition and Not leaking?	Yes: Go to step 4. No: Add fuel or repair leaks, and prime engine. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
4	Check that the engine cranks at a minimum of 130 rpm. Crank engine for maximum of 20 seconds. Does engine crank at a minimum of 130 rpm?	Yes: Go to step 5. No: Repair low cranking speed. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
5	Verify the engine starts. Crank engine for maximum of 20 seconds. If engine does not start, wait 2 minutes and try again. Does engine start and maintain idle?	Yes: Go to step 6. No: Go to SPN 3055 FMI 1 (page 699).

Step	Action	Decision
6	Check for low FDP. Perform Fuel Delivery Pressure (FDP) Test (page 167). Does FDP measure between 85 - 120 psi?	Yes: Go to step 10. No: Go to step 7.

Step	Action	Decision
7	Check for leaks or restrictions in the fuel supply to the low-pressure fuel pump. Perform Fuel Dead head Test (page 168). Is fuel dead head pressure greater than 65 psi?	Yes: Go to step 10. No: Go to step 8.

Step	Action	Decision
8	Check for aeration in low-pressure fuel system. Perform Fuel Aeration Test (page 170). Is low-pressure fuel system free from aeration?	Yes: Go to step 9. No: Repair aeration in low-pressure fuel system. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
9	Check for restriction in low-pressure fuel system. Perform Fuel Restriction Test (page 170). Is low-pressure fuel system free of restrictions?	Yes: Retest for SPN 3055 FMI 15. If fault is still present notify supervisor for further action. No: Repair restriction in low-pressure fuel system. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
10	Check for a restricted engine mounted secondary fuel filter. Perform High-pressure Pump Inlet Pressure Test (page 175). Does the fuel pressure gauge read > 30 psi?	Yes: Go to step 11. No: Replace engine mounted secondary fuel filter. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
11	Check for excessive fuel return. Perform Fuel Rail Pressure (FRP) Return Flow Test Part 1 . Is the fuel volume returned between 20-22 ml?	Yes: Go to step 14. No: Go to step 12.

Step	Action	Decision
12	Check for a failed fuel pressure relief valve. Perform Fuel Rail Pressure (FRP) Return Flow Test Part 2 . Is the line free of return fuel from fuel rail?	Yes: Go to step 13. No: Replace fuel pressure relief valve. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
13	Check for an internal leak in the high-pressure fuel system. Perform Fuel Rail Pressure (FRP) Leak Isolation (page 177). Is fuel leaking out of High Pressure Return Line Tester ZTSE4887?	Yes: Retest for SPN 3055 FMI 15. If fault is still present notify supervisor for further action. No: Replace the last capped injector, injector tube and all HP lines removed during this test. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
14	Check for a failed Piston Overflow Valve (KUEV) valve. Perform the HP Pump Return Flow Test (page 139). Is High Pressure Return Line Tester ZTSE4887 free of fuel from the high-pressure pump return port while cranking?	Yes: Replace the high-pressure fuel pump. After repairs are complete, go to step 15. No: Replace Piston Overflow Valve (KUEV) valve. After repairs are complete, retest for SPN 3055 FMI 15.

Step	Action	Decision
15	Verify the fuel return line is free from restriction. Run HP Pump Fuel Return Pressure Test (page 178). Is pressure < 13 psi?	Yes: Retest for SPN 3055 FMI 15. If fault is still present notify supervisor for further action. No: Repair restriction in fuel return line between high-pressure fuel pump and fuel tank. After repairs are complete, retest for SPN 3055 FMI 15.

NOTE: After performing all diagnostic steps, if SPN 3055 FMI 15 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3055 FMI 17 - FRP Above Maximum with Minimum Command

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Fuel Rail Pressure (FRP) governor deviation below minimum limit	FRP governor error less than 725 psi at 600-750 rpm	Key ON ECM Not in limp-home mode Metering unit flow < 327,670 mm^3/sec Engine speed > 0 rpm OR FRP > 13,053 psi (90,000 kpa) for more than 20 engine revolutions Fuel injector quantity command > 5 mg/stroke ECT1 > -40°F (-40°C) Engine Not overrunning	10 seconds

Fault Overview

Fault code sets when the Engine Control Module (ECM) detects Fuel Rail Pressure (FRP) exceeds 13,053 psi (90,000 kPa) when the Fuel Pressure Control Valve (FPCV) is commanded to minimum pressure.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 94 FMI 0 (FDP); SPN 157 FMI 3, 4, 20, 21 (FRP); and SPN 633 FMI 3, 4, and 5 (FPCV)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Restricted high-pressure pump fuel return line
- FRP sensor or circuit fault
- Fuel Pressure Control Valve (FPCV) or circuit fault

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 94 FMI 0 (FDP); SPN 157 FMI 3, 4, 20; and 21 (FRP) or SPN 633 FMI 3, 4, and 5 (FPCV). Is the EST DTC list free of SPN 94 FMI 0; SPN 157 FMI 3, 4, 20, and 21; and SPN 633 FMI 3, 4, and 5?	Yes: Go to step 2. No: Repair SPN 94 FMI 0; SPN 157 FMI 3, 4, 20, and 21; and SPN 633 FMI 3, 4, and 5. After repairs are complete, retest for SPN 3055 FMI 17.

Step	Action	Decision
2	Check for restricted fuel return line. Perform HP Pump Fuel Return Pressure Test (page 178). Is pressure < 13 psi?	Yes: Go to step 3. No: Repair restriction in fuel return line between high-pressure fuel pump and fuel tank. After repairs are complete, retest for SPN 3055 FMI 17.

Step	Action	Decision
3	Check for a failed FRP sensor or circuit. Disconnect the FRP sensor electrical connector and attempt to start engine. Crank engine for maximum of 20 seconds. Does the engine start and maintain idle?	Yes: Diagnose FRP Sensor (page 683). After repairs are complete, retest for SPN 3055 FMI 17. No: Reconnect sensor and go to step 4.

Step	Action	Decision
4	Check for a failed Fuel Pressure Control Valve (FPCV). Key OFF, connect Breakout Harness ZTSE4828 to FPCV and leave vehicle harness disconnected. Using a DMM, measure resistance between ZTSE4828 pin-1 and pin-2. Is resistance between 2.6 and 3.2 ohms?	Yes: Go to step 5. No: Replace FPCV. After repairs are complete, retest for SPN 3055 FMI 17.

Step	Action	Decision
5	Check for a sticking FPCV. Run engine at idle. Using EST, monitor the difference between the desired and actual fuel rail pressure for 5 minutes. Does the pressure difference maintain < 1160 psi (80 bar) throughout the test?	Yes: Retest for SPN 3055 FMI 17. No: Replace FPCV. After repairs are complete, retest for SPN 3055 FMI 17.

NOTE: After performing all diagnostic steps, if SPN 3055 FMI 17 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Hard Brake Monitor

SPN	FMI	Condition	Possible Causes	Actions
1810	0	Hard Brake monitor, event log, extreme	• Incorrect programmable parameter value • Hard brake event	Pinpoint Diagnostics (page 709)
1810	15	Hard Brake monitor, even log non-extreme	• Incorrect programmable parameter value • Hard brake event	Pinpoint Diagnostics (page 709)

Overview

The hard brake monitor feature determines hard vehicle speed deceleration incidents. An incident occurs when programmable parameter 89052 Hard Brake Decel Rate Threshold is set at too low of a speed change. The incident is then reported to the ECM and stored as a vehicle event.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

SPN 1810 FMI 0 - Hard Brake monitor, event log, extreme

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Parameters session and adjust parameter ID 89052 Hard Brake Decel Rate Threshold to 5-9 mph/s.
2. Program engine and retest for 1810 FMI 0.

SPN 1810 FMI 15- Hard Brake monitor, event log, non-extreme

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Parameters session and adjust parameter ID 89052 Hard Brake Decel Rate Threshold to 5-9 mph/s.
2. Program engine and retest for 1810 FMI 15.

HS (Humidity Sensor) / IAT (Inlet Air Temperature Sensor)

SPN	FMI	Condition	Possible Causes	Actions
172	2	IAT signal does not agree with other sensors	• Biased IAT sensor or circuit	Pin-Point Diagnostics (page 712)
172	3	IAT Out of Range HIGH	• IAT signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed IAT sensor	Pin-Point Diagnostics (page 711)
172	4	IAT Out of Range LOW	• IAT signal circuit short to GND • Failed IAT sensor	Pin-Point Diagnostics (page 711)
354	3	Relative Humidity signal Out of Range HIGH	• HS signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed HS sensor	Pin-Point Diagnostics (page 711)
354	4	Relative Humidity signal Out of Range LOW	• HS signal circuit short to GND • Failed HS sensor	Pin-Point Diagnostics (page 711)

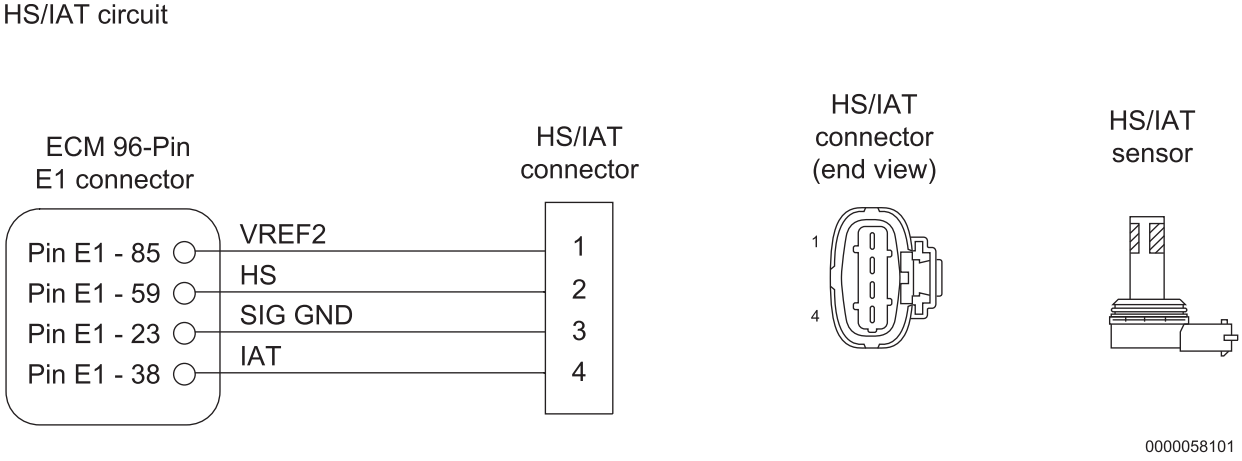


Figure 271 HS/IAT sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4830 (HS/IAT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Cold Soak Sensor Compare Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

SPN 172 FMI 2 – IAT signal does not agree with other sensors

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

NOTE: Temperature values need to be measured after 8 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Default session.
3. Compare IAT and Ambient Air Temperature (AAT). Sensor temperatures should be within 5 °C (10 °F) of each other.
   - If IAT is 5 °C (10 °F) above or below AAT, check for poor circuitry going to the IMT sensor.
   - If circuits are within specification, replace HS/IAT sensor.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4830 to HS/IAT engine harness, and leave HS/IAT sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment– < Less than, > Greater than
EST - Monitor HSv	5.0 V ± 0.5 V	If < 4.5 V check HS signal circuit for short to GND.
EST - Monitor IATv	5.0 V ± 0.5 V	If < 4.5 V check IAT signal circuit for short to GND.
EST - Monitor HSv Short pin 2 to GND	0 V	If > 0.25 V, check HS signal circuit for OPEN. Do Harness Resistance Check.
EST - Monitor HSv Short pin 2 to 3	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check.
EST - Monitor IATv Short pin 4 to GND	0 V	If > 0.25 V, check IAT signal circuit for OPEN. Do Harness Resistance Check.
EST – Monitor HSv Short 500 Ω resistor across pins 2 and 3	< 1.0 V	If > 1.0 V, check HS signal circuit for short to PWR.
EST – Monitor HSv Short 500 Ω resistor across pins 3 and 4	< 1.0 V	If > 1.0 V, check IAT signal circuit for short to PWR.

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4830 to HS/IAT engine harness, and leave HS/IAT sensor disconnected. Turn ignition ON.. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	5.0 V ± 0.5 V	If < 4.5 V, check for OPEN in VREF2 circuit.
2 to GND	5.0 V ± 0.5 V	If < 4.5 V, check for OPEN in HS circuit.
3 to B+	B+	If < B+, check for OPEN is SIG GND circuit.
4 to GND	5.0 V ± 0.5 V	If < 4.5 V, check for OPEN in IAT circuit.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4830 to HS/IAT engine harness, and leave HS/IAT sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check VREF2 circuit for short to GND.
1 to E1-85	< 5 Ω	If > 5 Ω, check VREF2 circuit for OPEN.
2 to GND	> 1k Ω	If < 1k Ω, check HS circuit for short to GND.
2 to E1-59	< 5 Ω	If > 5 Ω, check HS circuit for OPEN.
3 to GND	> 1k Ω	If < 1k Ω, check SIG GND circuit for short to GND.
3 to E1-23	< 5 Ω	If > 5 Ω, check SIG GND circuit for OPEN.
4 to GND	> 1k Ω	If < 1k Ω, check IAT circuit for short to GND.
4 to E1-38	< 5 Ω	If > 5 Ω, check IAT circuit for OPEN.

IMP (Intake Manifold Pressure)

SPN	FMI	Condition	Possible Causes	Actions
102	2	IMP signal does not agree with BARO	• Biased IMP sensor or circuit	Circuit Checks (page 717)
102	3	IMP signal Out of Range HIGH	• IMP signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed IMP sensor	Circuit Checks (page 718)
102	4	IMP signal Out of Range LOW	• IMP signal circuit short to GND • VREF2 circuit OPEN • Failed IMP sensor	Circuit Checks (page 718)
102	10	IMP Boost slow response	• Turbocharger 2 (TC2) wastegate stuck open • Restricted intake air system • Charge Air Cooler (CAC) hose leaking • CAC leak • Failed turbocharger • Exhaust leak • Restricted exhaust • Exhaust Gas Recirculation (EGR) fault	Step Based Diagnostics (page 720)

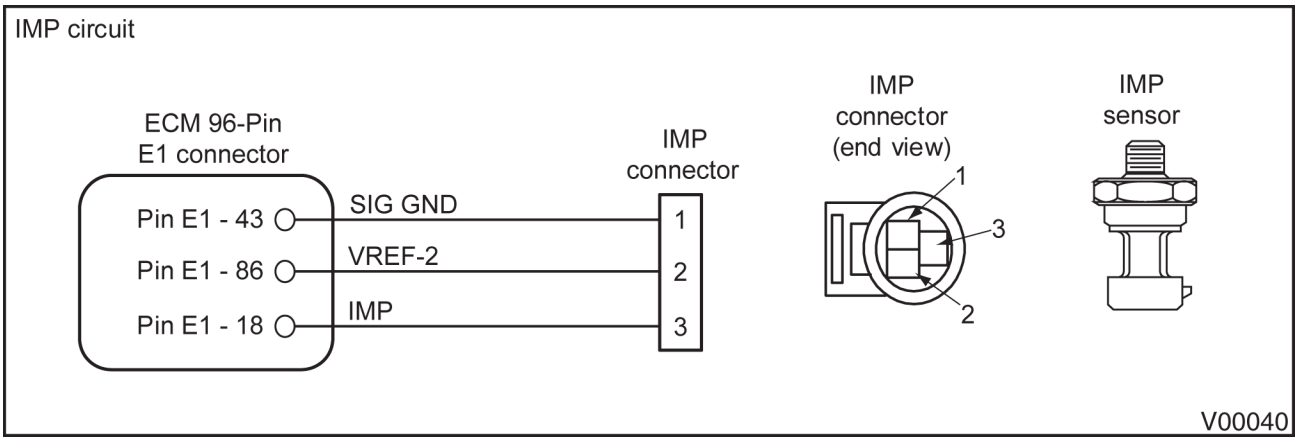


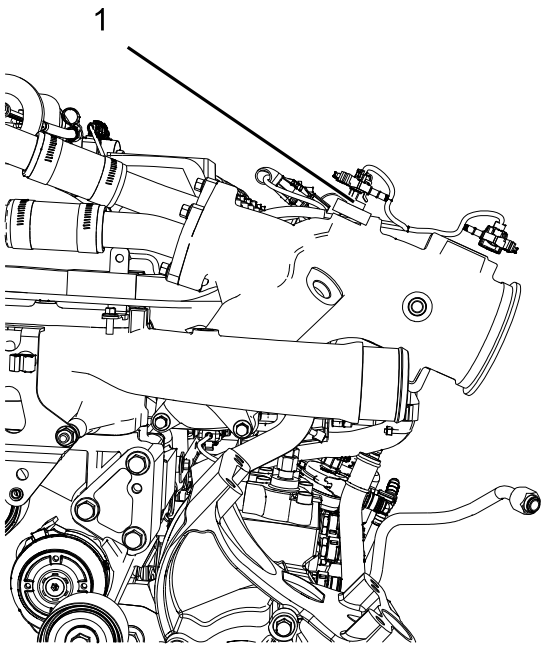
Figure 272 IMP Sensor Circuit Diagram

Overview

The IMP sensor is a variable-capacitance sensor that measures charge-air pressure entering the air intake throttle duct. As pressure increases, ceramic material moves closer to a thin metal disc (internal sensor), causing a change in capacitance that changes the voltage sent to, and interpreted by, the Engine Control Module (ECM). IMP is monitored by the ECM for Exhaust Gas Recirculation (EGR) and turbocharger wastegate control.

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4850 (IMP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device



0000038233

Figure 273 IMP Sensor Location

1. Intake Manifold Pressure (IMP) sensor

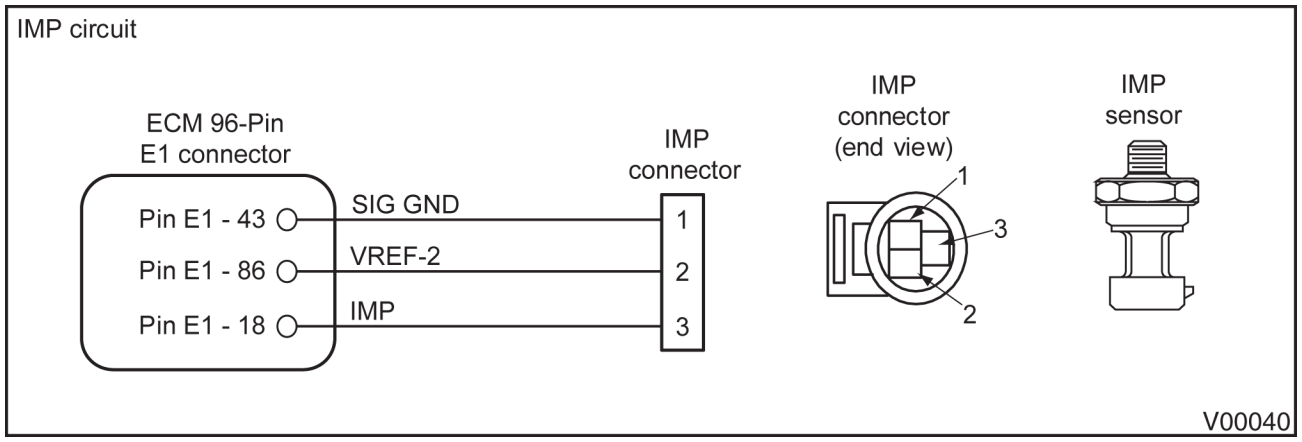


Figure 274 IMP Sensor Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Biased Sensor or Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Biased Sensor or Circuit Check

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Continuous Monitor session.
3. Verify S_IMP volts are within specification. See “APPENDIX A: PERFORMANCE SPECIFICATIONS."
   - If voltage is not within specification, go to Circuit Checks (page 718). If circuits are within specification, replace IMP sensor.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4850 to IMP engine harness, and leave IMP sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor IMPv	5.0 V ± 0.5 V	If < 4.5 V, check IMP signal circuit for short to GND. Do Harness Resistance Check (page 719).
DMM – Measure volts 2 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF2 circuit for short to PWR. If < 4.5 V, check VREF2 circuit for OPEN or short to GND. Do Harness Resistance Check (page 719).
DMM – Measure voltage 1 to 2	5.0 V ± 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 719).
EST – Monitor IMPv Short across Breakout Harness ZTSE4850 pins 1 and 3	0 V	If > 0.5 V, check IMP signal circuit for OPEN or short to PWR. Do Harness Resistance Check (page 719).
If checks are within specifications, connect sensor and clear DTCs. If active DTC remains, replace IMP sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4850 to IMP engine harness, and leave IMP sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to B+	B+	If < B+, check SIG GND circuit for OPEN or short to PWR.
2 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF2 for short to PWR. If < 4.5 V, check VREF2 for OPEN or short to GND. Do Harness Resistance Check (page 719).
3 to GND	5.0 V ± 0.5 V	If < 4.5 V, check IMP signal circuit for short to GND. Do Harness Resistance Check (page 719).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4850 to IMP engine harness, and leave IMP sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-43	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
2 to E1-86	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to E1-18	< 5 Ω	If > 5 Ω, check for OPEN circuit.

SPN 102 - FMI 10 IMP - Boost Slow Response

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Intake Manifold Pressure (IMP) accumulated deviation from boost.	Intake Manifold Pressure (IMP) does not maintain less than 80 psi (550 kPa) difference between actual and desired.	Rate of Change in Engine Speed > 100 rpms Time after Key ON > 0 seconds Battery voltage > 10.7 V Battery voltage < 15 V Engine Speed > 800 rpm Rate of Change in Injection Quantity > 50 mg Injection Quantity > 0 mg/stroke and < 500 mg/stroke	1 event

Malfunction Indicator Lamp (MIL) Reaction

When fault is active, MIL will not illuminate.

Associated Faults

SPN's 27, 51, 1189, 2791, and 3464.

Drive Cycle

See 2013 HD-OBD Diagnostic Reference Manual.

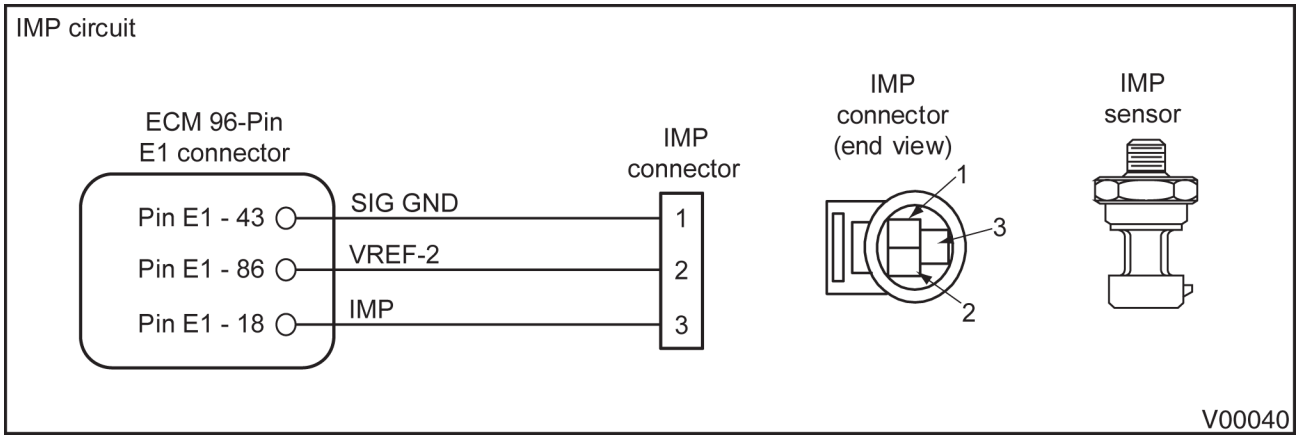


Figure 275 IMP Sensor Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 102 FMI 10 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
2	Inspect air intake system, exhaust system, and air filter for restrictions, air leaks, or physical damage. Also, inspect the fuel system from fuel tank to AFI valve for leaks or physical damage. Is air intake system, exhaust system, fuel system and air filter free of restrictions, leaks, and physical damage?	Yes: Go to step 3. No: Repair restrictions, air leaks, fuel leaks or physical damage. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
3	Determine if Intake Manifold Pressure (IMP) sensor or circuit is out of specifications. Using EST with ServiceMaxx™ software, do IMP Biased Sensor or Circuit Check (page 717). Is IMP sensor within specifications?	Yes: Go to step 4. No: Repair IMP sensor or circuit. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
4	Verify IMP changes when Turbocharger 2 Wastegate Control (TC2WC) and Exhaust Gas Recirculation (EGR) valve are commanded On. Key-On Engine-Running (KOER). Run Air Management Test while monitoring IMP sensor signal. Does IMP sensor signal change: • When TC2WC is commanded On? • When EGR valve is commanded On?	IMP signal change only when TC2WC is commanded On: Do EGR Pinpoint Diagnostics (page 622) and check for EGR issue. After repairs are complete, retest for SPN 102 FMI 10. IMP signal change only with EGR valve commanded On: Do TC2WC voltage and circuit checks (page 839). After repairs are complete, retest for SPN 102 FMI 10. Neither change IMP signal when commanded On: Go to step 5. Both change IMP signal when commanded On: Go to step 7.

Step	Action	Decision
5	Verify IMP sensor and bore are not restricted due to carbon buildup. Remove and inspect IMP sensor and bore for carbon buildup. Is IMP sensor and bore free of carbon buildup?	Yes: Go to step 6. No: Clean IMP sensor bore of carbon deposits. After repairs are complete, retest for SPN 102 FMI 10. Go to step 6 if cleaning does not resolve fault code.

Step	Action	Decision
6	Determine if Charge Air Cooler is leaking. Do Charge Air Cooler (CAC) pressure test (page 184). Was CAC free of leaks?	Yes: Go to step 7. No: Correct air leak(s). After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
7	Do a road test (100% throttle when safe to do so) while recording a snap shot of the following signals: • Diesel Particulate Filter Differential Pressure (DPFDP) = 0.5 - 0.8 psi • Turbocharger 1 Turbine Outlet Pressure (TC1TOP) = 2 – 3 psi Are DPFDP and TC1TOP within specification? **NOTE: DPFDP and TC1TOP specifications only apply with soot load < 40%.**	**Both** TC1TOP and DPFDP signals are above specification: Go to step 8. **Only** TC1TOP signal above specification: Remove Pre Diesel Oxidation Catalyst (Pre-DOC) and Diesel Oxidation Catalyst (DOC) for inspection and clean or replace as necessary. After repairs are complete, retest for SPN 102 FMI 10. **Neither** signal above specification: Go to step 9.

Step	Action	Decision
8	Using EST with ServiceMaxx software, start an Onboard Filter Cleanliness Test (OBFCT). Is OBFCT running without an Abort Message in ServiceMaxx™?	Yes: Go to step 9. No: Correct Parked Regen Inhibitors (page 319) and restart OBFCT.

<table>
<tr><th>Step</th><th colspan="3">Action</th><th>Decision</th></tr>
<tr><td rowspan="10">9</td><td colspan="3">While running OBFCT, inspect for exhaust leaks and monitor following signals during test:
Are Parked Regen Checks within specification during OBFCT?</td><td rowspan="2">If Parked Regen Checks are within specification: Go to step 7.</td></tr>
<tr><td>Parked Regen Checks</td><td>Specifications</td><td>Pass / Fail</td></tr>
<tr><td>Engine condition</td><td>Smooth, not stumbling</td><td></td><td rowspan="2">If AFTFP1 is below 110 psi: Do Fuel Delivery Pressure (FDP) Test (page 167). Repair any FDP measurements out of specification. After repairs are complete, retest for SPN 102 FMI 10.</td></tr>
<tr><td>Engine Coolant Temp (ECT)</td><td>Above 122°F (50°C) per ServiceMaxx</td><td></td></tr>
<tr><td>DOCIT</td><td>After 5 - 10 minutes above 500°F (260°C)</td><td></td><td rowspan="2">If AFTFP2 fuel pressure is below 40-70 psi at AFI opening: Clean AFI valve, housing, and bore. After cleaning procedure is complete, retest for SPN 102 FMI 10.</td></tr>
<tr><td>DOCOT</td><td>After 5 – 10 minutes above 986°F (530°C)</td><td></td></tr>
<tr><td>DPFOT</td><td>Below 1292°F (700°C)</td><td></td><td rowspan="3">If Parked Regen Checks other than AFTFP1 and AFTFP2 are out of specifications: Repair Parked Regen Check (page 321). After repairs are complete, retest for SPN 102 FMI 10.</td></tr>
<tr><td>Aftertreatment Fuel Pressure 1 (AFTFP1)</td><td>> 110 psi during test</td><td></td></tr>
<tr><td>Aftertreatment Fuel Pressure 2 (AFTFP2)</td><td>Aftertreatment Fuel Injector (pop-off valve) fuel pressure range between 40-70 psi at opening pressure.</td><td></td></tr>
</table>

Step	Action	Decision
10	After OBFCT is complete, does Diesel Particulate Filter Differential Pressure (DPFDP) signal measure below 0.5 psi at high idle?	Yes: Go to step 11.
		No: Remove DPF and inspect for restrictions. If restricted, have the DPF cleaned using the appropriate DPF cleaning equipment. After repairs are complete, retest for SPN 102 FMI 10.

Step	Action	Decision
11	Inspect turbochargers for signs of wear and correct operation. Inspect turbocharger compressor wheel and air inlet for chipping, scuffs, and rough finishes. Is the turbocharger working correctly and undamaged?	Yes: Repair or replace turbocharger as necessary. After repairs are complete, retest for SPN 102 FMI 10.
		No: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

IMT Sensor (Intake Manifold Temperature)

SPN	FMI	Condition	Possible Causes	Actions
105	2	IMT signal does not agree with other sensors	• Biased IMT sensor or circuit	Pin-Point Diagnostics (page 725)
105	3	IMT signal Out of Range HIGH	• IMT signal OPEN or short to PWR • SIG GND circuit OPEN • Failed IMT sensor	Pin-Point Diagnostics (page 725)
105	4	IMT signal Out of Range LOW	• IMT signal circuit short to GND • Failed IMT sensor	Pin-Point Diagnostics (page 725)
105	18	IMT signal not responding as expected	• IMT signal does not rise during engine warm up	Pin-Point Diagnostics (page 725)

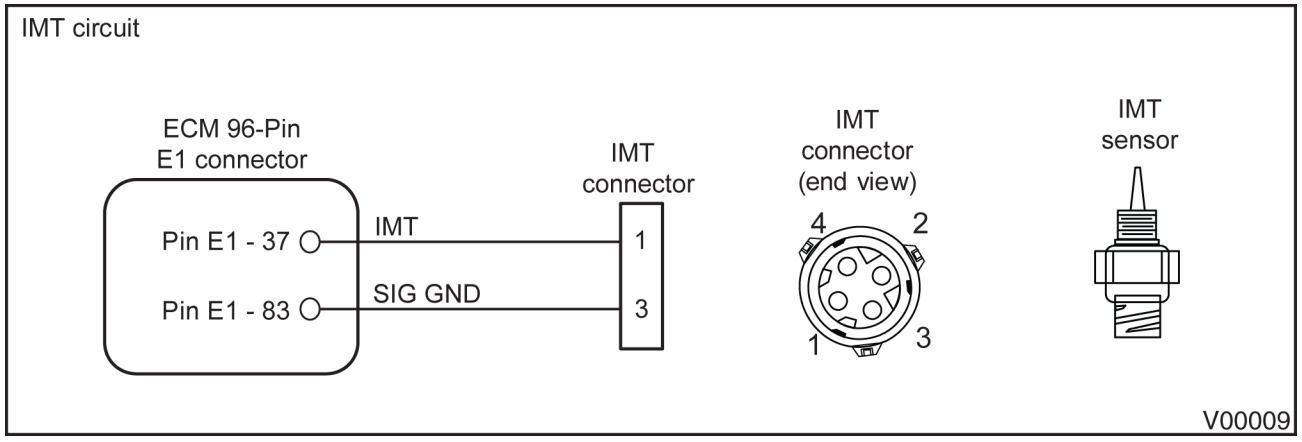


Figure 276 IMT sensor circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE4883 (IMT)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.

2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Cold Soak Sensor Compare Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

Cold Soak Sensor Compare Check With ServiceMaxx™ Software

SPN 105 FMI 2 – IMT signal does not agree with other sensors

DTC sets after cold soak and IMT signal does not compare with other air temperature sensors.

SPN 105 FMI 18 – IMT signal not responding as expected

DTC sets if IMT signal does not rise 10 °C (50 °F) after a cold soak, when engine is started and run above 1400 rpm for 45 seconds.

NOTE: Temperature values need to be measured after 8 hours of cold soak.

1. Turn ignition switch ON, engine OFF.
2. Using ServiceMaxx™ software, open the Default session.
3. Compare IMT, Ambient Air Temperature (AAT), and Air Intake Temperature (IAT). Sensor temperatures should be within 5 °C (10 °F) of each other.
   - If IMT is 5 °C (10 °F) above or below AAT, IAT, or IMT, check for poor circuitry going to the IMT sensor.
   - If circuits are within specification, replace IMT sensor.
4. Start engine while monitoring IMT signal.
   - If IMT signal does not raise 10 °C (50 °F), check for poor circuitry going to the sensor.
   - If circuits are within specification, replace sensor.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE4883 to IMT engine harness, and leave IMT sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment– < Less than, > Greater than
EST – Monitor IMTv	5.0 V ± 0.5 V	If <4.5 V, check IMT signal circuit for short to GND.
EST – Monitor IMTv Short pin 1 to GND	0 V	If > 0.25 V, check IMT signal circuit for OPEN. Do Harness Resistance Check.
EST – Monitor IMTv Short pin 1 to 3	0 V	If > 0.25 V, check SIG GND circuit for OPEN. Do Harness Resistance Check.
EST – Monitor IMTv Short 500 Ω resistor across pins 1 and 3	< 1.0 V	If > 1.0 V, check IMT signal circuit for short to PWR.
If checks are within specification, connect sensor and clear DTCs. If active code remains, replace IMT sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4883 to IMT engine harness, and leave IMT sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	4.5 V to 5 V	If < 4.5 V, check for short to GND.
3 to B+	B+	If < B+, check for short to PWR.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and sensor Breakout Harness ZTSE4883. Leave ECM and sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
1 to E1-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to E1-83	< 5 Ω	If > 5 Ω, check for OPEN circuit.

INJ (Injector) Circuits

SPN	FMI	Condition	Possible Causes	Actions
651	4	Injector 1 short circuit	• INJ1 H circuit shorted to INJ1 L circuit • INJ1 H circuit short to GND • INJ1 L circuit short to GND • Fuel injector 1 shorted to engine brake housing • Failed fuel injector 1	Step-Based Diagnostics (page 734)
651	5	Injector 1 open load/circuit	• INJ1 H circuit Open or high resistance • INJ1 L circuit Open or high resistance • Failed fuel injector 1 (Open coil)	Step-Based Diagnostics (page 738)
652	4	Injector 2 short circuit	• INJ2 H circuit shorted to INJ2 L circuit • INJ2 H circuit short to GND • INJ2 L circuit short to GND • Fuel injector shorted to engine brake housing • Failed fuel injector 2	Step-Based Diagnostics (page 742)
652	5	Injector 2 open load/circuit	• INJ2 H circuit Open or high resistance • INJ2 L circuit Open or high resistance • Failed fuel injector 2 (Open coil)	Step-Based Diagnostics (page 746)

653	4	Injector 3 short circuit	• INJ3 H circuit shorted to INJ3 L circuit • INJ3 H circuit short to GND • INJ3 L circuit short to GND • Fuel injector shorted to engine brake housing • Failed fuel injector 3	Step-Based Diagnostics (page 750)
653	5	Injector 3 open load/circuit	• INJ3 H circuit Open or high resistance • INJ3 L circuit Open or high resistance • Failed fuel injector 3 (Open coil)	Step-Based Diagnostics (page 754)
654	4	Injector 4 short circuit	• INJ4 H circuit shorted to INJ4 L circuit • INJ4 H circuit short to GND • INJ4 L circuit short to GND • Fuel injector shorted to engine brake housing • Failed fuel injector 4	Step-Based Diagnostics (page 758)
654	5	Injector 4 open load/circuit	• INJ4 H circuit Open or high resistance • INJ4 L circuit Open or high resistance • Failed fuel injector 4 (Open coil)	Step-Based Diagnostics (page 762)

655	4	Injector 5 short circuit	•	INJ5 H circuit shorted to INJ5 L circuit	Step-Based Diagnostics (page 766)
			•	INJ5 H circuit short to GND	
			•	INJ5 L circuit short to GND	
			•	Fuel injector shorted to engine brake housing	
			•	Failed fuel injector 5	
655	5	Injector 5 open load/circuit	•	INJ5 H circuit Open or high resistance	Step-Based Diagnostics (page 770)
			•	INJ5 L circuit Open or high resistance	
			•	Failed fuel injector 5 (Open coil)	
656	4	Injector 6 short circuit	•	INJ6 H circuit shorted to INJ6 L circuit	Step-Based Diagnostics (page 774)
			•	INJ6 H circuit short to GND	
			•	INJ6 L circuit short to GND	
			•	Fuel injector shorted to engine brake housing	
			•	Failed fuel injector 6	
656	5	Injector 6 open load/circuit	•	INJ6 H circuit Open or high resistance	Step-Based Diagnostics (page 778)
			•	INJ6 L circuit Open or high resistance	
			•	Failed fuel injector 6 (Open coil)	

2797	11	INJ Control Group 1 short circuit (INJ 1, 3, 5)	• INJ1 H circuit short to PWR • INJ1 H circuit short to GND • INJ1 H short to INJ1 L • INJ1 L circuit short to PWR • INJ1 L circuit short to GND • Fuel injector 1 shorted to engine brake housing • Failed fuel injector 1 • INJ3 H circuit short to PWR • INJ3 H circuit short to GND • INJ3 H short to INJ3 L • INJ3 L circuit short to PWR • INJ3 L circuit short to GND • Fuel injector 3 shorted to engine brake housing • Failed fuel injector 3 • INJ5 H circuit short to PWR • INJ5 H circuit short to GND • INJ5 H short to INJ6 L • INJ5 L circuit short to PWR • INJ5 L circuit short to GND • Fuel injector 5 shorted to engine brake housing • Failed fuel injector 5	Step-Based Diagnostics (page 782)

2798	11	INJ Control Group 2 short circuit (INJ 2, 4, 6)	• INJ2 H circuit short to PWR • INJ2 H circuit short to GND • INJ2 H short to INJ2 L • INJ2 L circuit short to PWR • INJ2 L circuit short to GND • Fuel injector 2 shorted to engine brake housing • Failed fuel injector 2 • INJ4 H circuit short to PWR • INJ4 H circuit short to GND • INJ4 H short to INJ4 L • INJ4 L circuit short to PWR • INJ4 L circuit short to GND • Fuel injector 4 shorted to engine brake housing • Failed fuel injector 4 • INJ6 H circuit short to PWR • INJ6 H circuit short to GND • INJ6 H short to INJ6 L • INJ6 L circuit short to PWR • INJ6 L circuit short to GND • Fuel injector 6 shorted to engine brake housing • Failed fuel injector 6	Step-Based Diagnostics (page 792)

Fuel Injector circuits

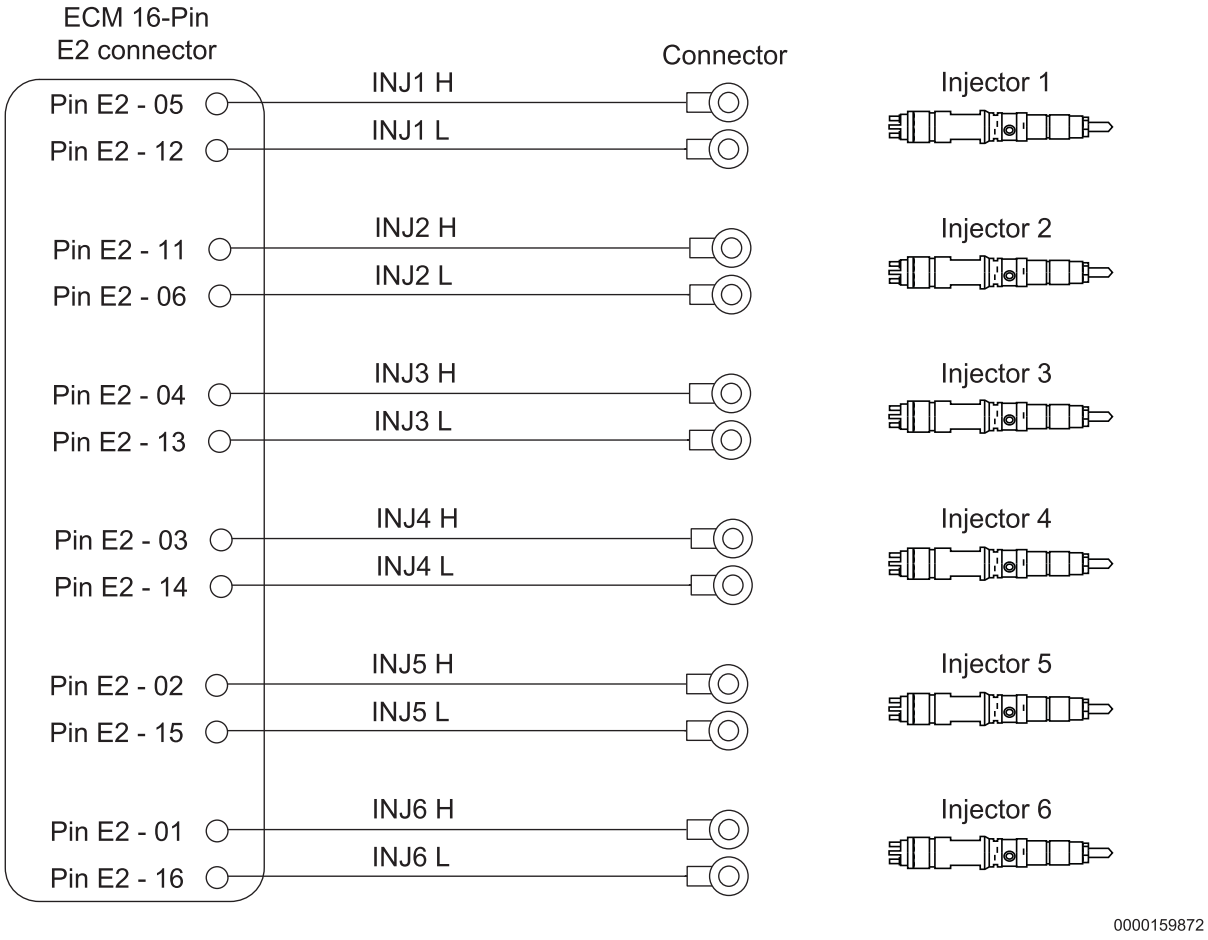


Figure 277 Fuel Injector circuit diagram

NOTE: See latest version of Maxxforce 11 / 13 Engine and Aftertreatment Wiring Schematic Form 0000002941 for additional circuit information.

Overview

When the Engine Control Module (ECM) determines fueling is required to a cylinder, voltage is supplied to the fuel injector. The fuel injector has a magnetic coil, which lifts a needle inside the injector. The needle moving upward uncovers the spray holes directing fuel into the cylinder. When the ECM determines injection should end, voltage to the magnetic coil is removed.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- Breakout Harness 00-01468-00
- 500 Ohm Resistor Harness ZTSE4497
- Big Bore Terminal Test Probe Kit ZTSE4899
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

SPN 651 FMI 4- Injector 1 short circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short to GND detected in fuel injector 1 circuit	INJ1 circuit resistance to ground < 0.5 ohms	Engine Control Module (ECM) commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 1 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

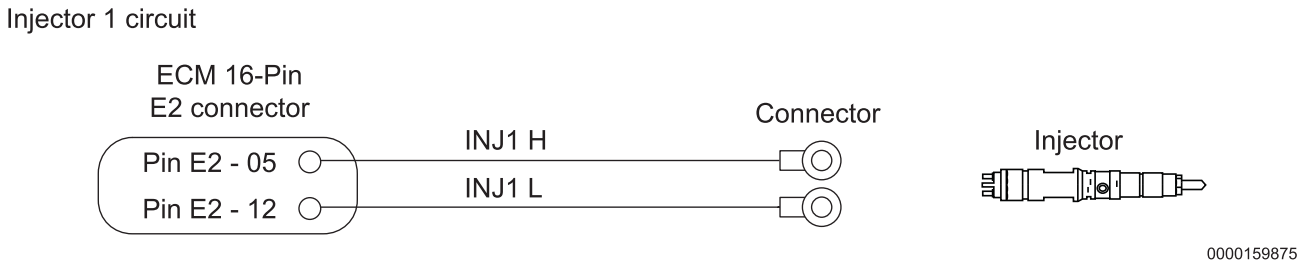


Figure 278 Injector 1 circuit diagram

Possible Causes

- INJ1 H circuit shorted to INJ1 L circuit
- INJ1 H circuit short to GND
- INJ1 L circuit short to GND
- Fuel injector shorted to engine brake housing
- Failed fuel injector 1

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

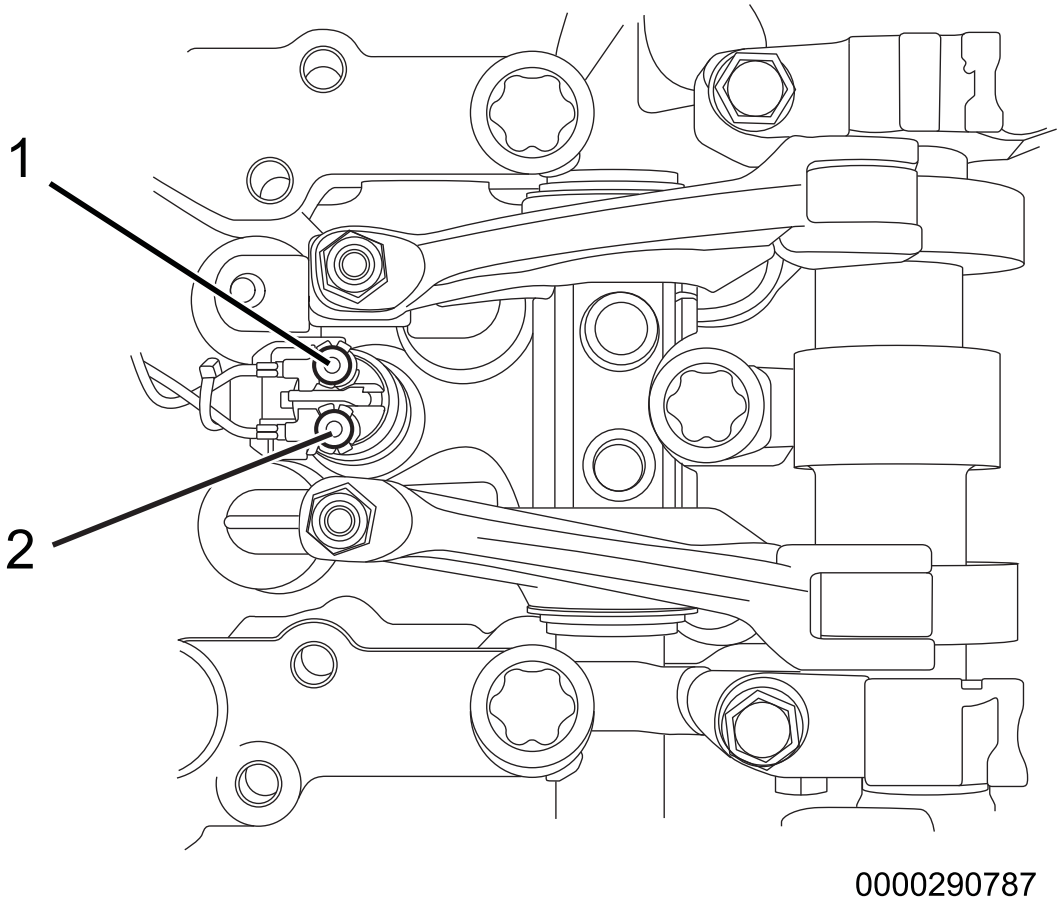


Figure 279 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Verify proper fuel injector and terminal orientation. Remove upper valve cover and engine brake housing (see Engine Service Manual). Verify fuel injector terminals are installed parallel to avoid a short to ground on the engine brake housings. Are fuel injector 1 terminals oriented correctly and Not contacting the engine brake housing?	Yes: Go to step 2. No: Adjust connections so fuel injector 1 and injector terminals will not contact the engine brake housing. After repairs are complete, retest for SPN 651 FMI 4.

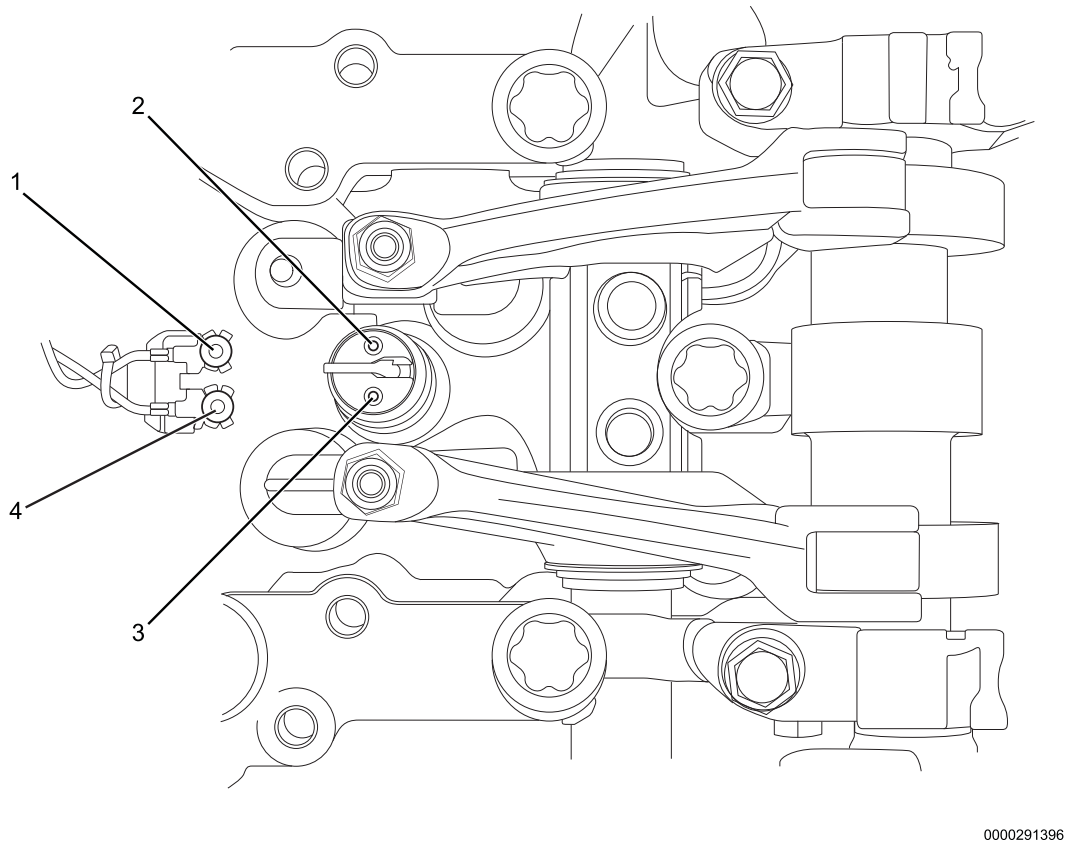


Figure 280 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
2	Check for a shorted fuel injector 1 coil. Key OFF, disconnect the connectors from fuel injector 1. Using a DMM, check resistance across fuel injector 1 terminals. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 1. After repairs are complete, retest for SPN 651 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM) E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 651 FMI 4.

Step	Action	Decision
4	Check for fuel injector 1 high side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 1, use a DMM to test resistance between high side terminal and a known good GND. Is resistances greater than 1000 ohms?	Yes: Go to step 5. No: Replace fuel injector 1. After repairs are complete, retest for SPN 651 FMI 4.

Step	Action	Decision
5	Check for fuel injector 1 low side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 1, use a DMM to test resistance between low side terminal and a known good GND. Is resistances greater than 1000 ohms?	Yes: Go to step 6. No: Replace fuel injector 1. After repairs are complete, retest for SPN 651 FMI 4.

Step	Action	Decision
6	Check for INJ1 H short to INJ1 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 1 disconnected. measure resistance between Breakout Box pins E2-05 and E2-12 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 7. No: Repair short between INJ1 H circuit and INJ1 L circuit. After repairs are complete, retest for SPN 651 FMI 4.

Step	Action	Decision
7	Check INJ 1 H circuit for short to GND. Key OFF, connect 180-pin breakout box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 1 disconnected, measure resistance between Breakout Box pin E2-05 and known good GND (wiggle test may be required). Is resistance greater than 1000 Ohms?	Yes: Repair short to GND between E2-12 and fuel injector 1. After repairs are complete, retest for SPN 651 FMI 4. No: Repair short to GND between E2-05 and fuel injector 1. After repairs are complete, retest for SPN 651 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 651 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 651 FMI 5- Injector 1 Open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Open detected in fuel injector 1 circuit.	INJ1 circuit > 30 ohms	Engine Control Module (ECM) commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 1 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

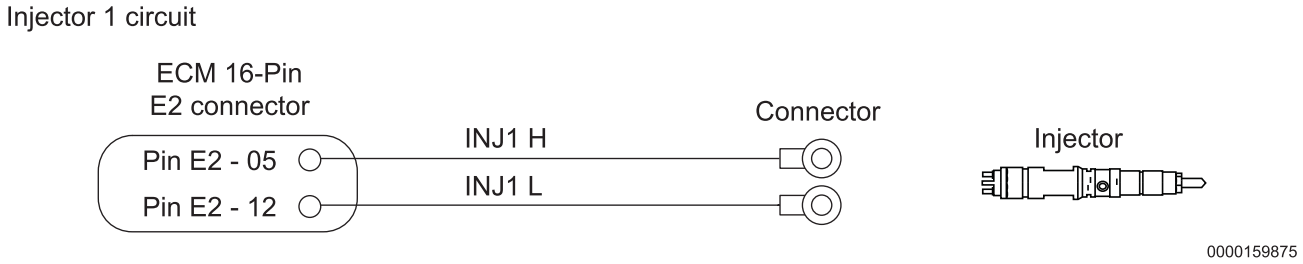


Figure 281 Injector 1 circuit diagram

Possible Causes

- INJ1 H circuit Open or high resistance
- INJ1 L circuit Open or high resistance
- Failed fuel injector 1 (Open coil)

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

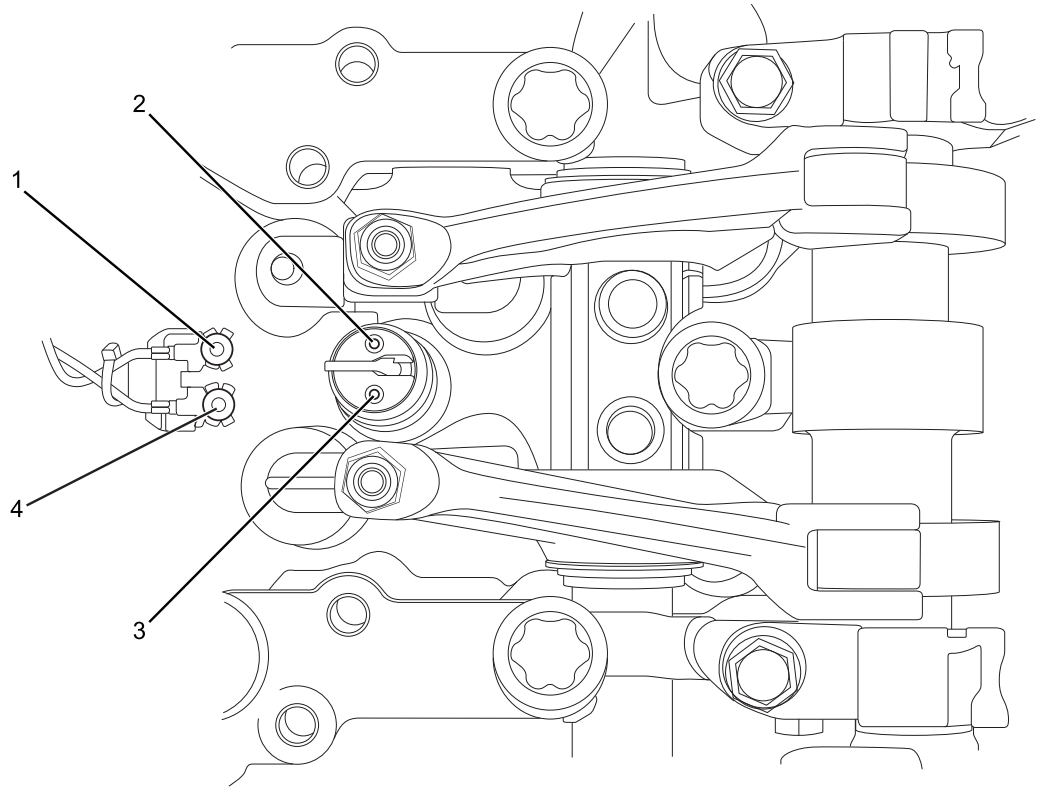


Figure 282 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Inspect connections at fuel injector 1. Remove upper valve cover and engine brake housing (see Engine Service Manual). Check fuel injector 1 connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the fuel injector 1 connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 651 FMI 5.

Step	Action	Decision
2	Check for a failed fuel injector 1 (Open coil). Key OFF, disconnect the connectors from fuel injector 1. Using a DMM, measure resistance between fuel injector 1 H and L terminals. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 1. After repairs are complete, retest for SPN 651 FMI 5.

Step	Action	Decision
3	Inspect connections at ECM E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 651 FMI 5.

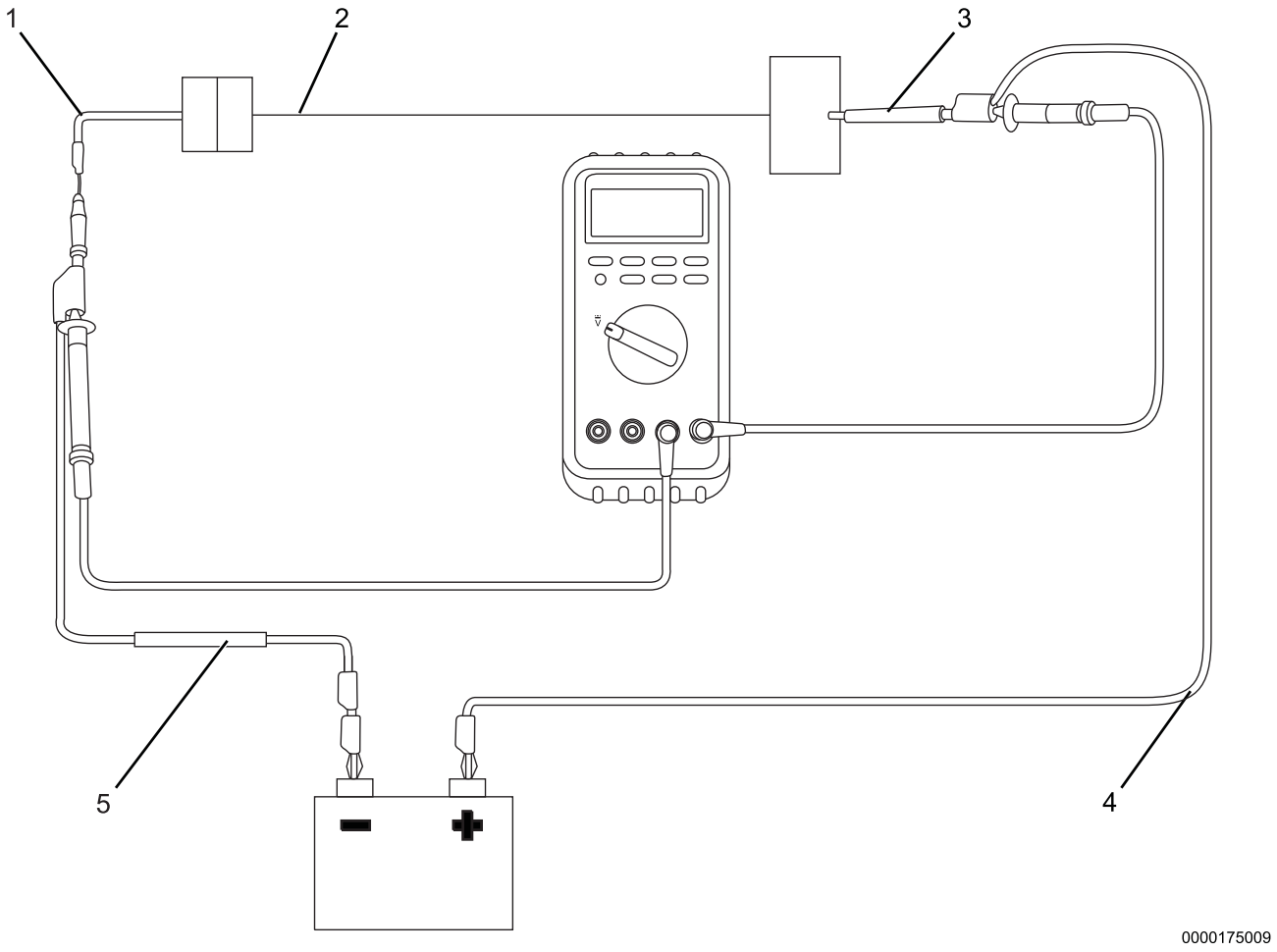


Figure 283 Voltage drop test (typical)

1. Breakout harness
2. Circuit under test
3. Terminal from ZTSE4435C
4. Jumper wire
5. 500 Ohm Resistor Jumper Harness ZTSE4497

Step	Action	Decision
4	Check INJ1 H circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect fuel injector 1 and ECM E2 connector. 2. Using Engine Terminal Test Kit ZTSE4435C, insert proper terminal into ECM pin E2-05. 3. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal in E2-05, and connect the other end of 500 Ohm Resistor Jumper Harness to PWR (use a jumper wire if needed). 4. Connect INJ1 H ring terminal to a known good GND (use a jumper wire if needed) 5. Using a DMM, measure voltage between fuel injector 1 INJ 1 H ring terminal and terminal in ECM pin E2-05. Is voltage less than 0.3V?	Yes: Repair Open or high resistance between fuel injector 1 INJ1 L ring terminal and ECM pin E2-12. After repairs are complete, retest for SPN 651 FMI 5. No: Repair Open or high resistance between fuel injector 1 INJ1 H ring terminal and ECM pin E2-05. After repairs are complete, retest for SPN 651 FMI 5.

NOTE: After performing all diagnostic steps, if SPN 651 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 652 FMI 4- Injector 2 short circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short to GND detected in fuel injector 2 circuit	INJ2 circuit resistance to ground < 0.5 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 2 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

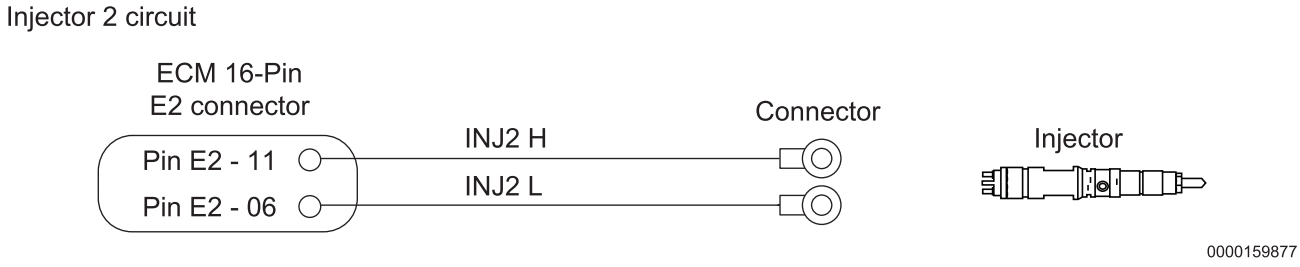


Figure 284 Injector 2 circuit diagram

Possible Causes

- INJ2 H circuit shorted to INJ2 L circuit
- INJ2 H circuit short to GND
- INJ2 L circuit short to GND
- Fuel injector shorted to engine brake housing
- Failed fuel injector 2

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

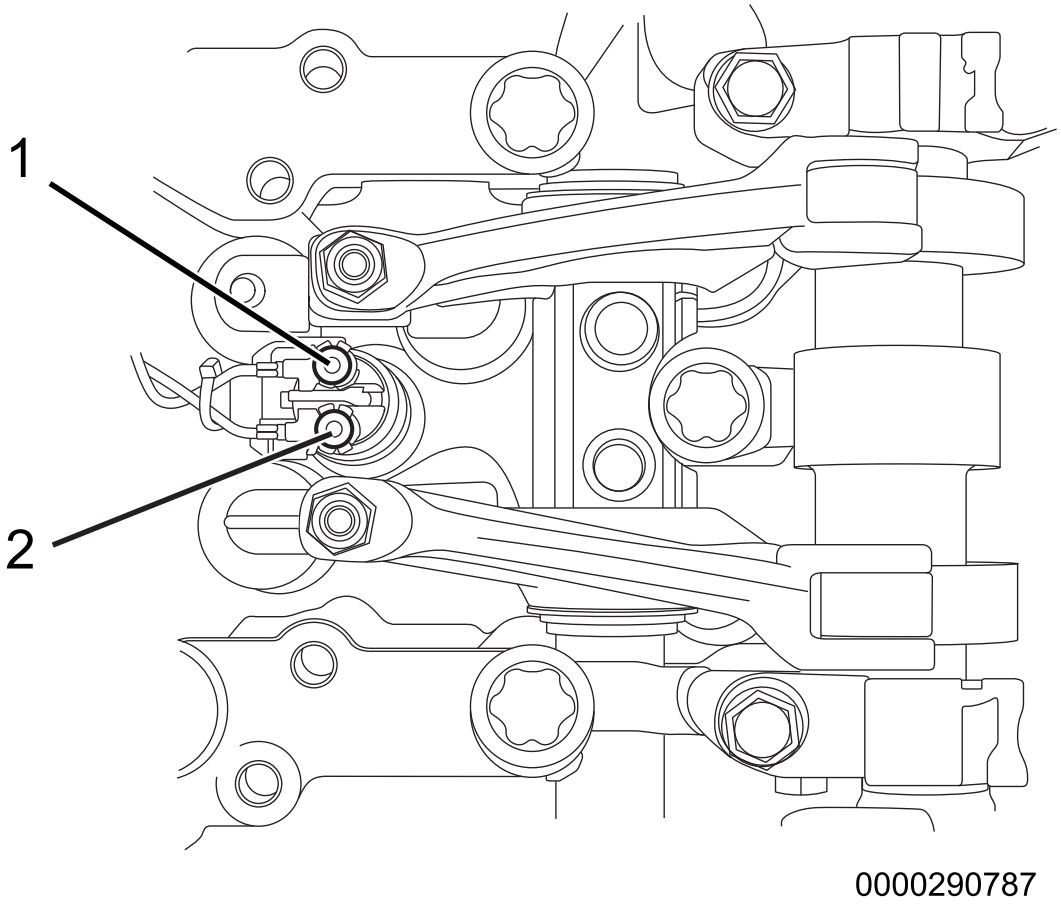


Figure 285 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Verify proper fuel injector and terminal orientation. Remove upper valve cover and engine brake housing (see Engine Service Manual). Verify fuel injector terminals are installed parallel to avoid a short to ground on the engine brake housings. Are fuel injector 2 terminals oriented correctly and Not contacting the engine brake housing?	Yes: Go to step 2. No: Adjust connections so fuel injector 2 and injector terminals will not contact the engine brake housing. After repairs are complete, retest for SPN 652 FMI 4.

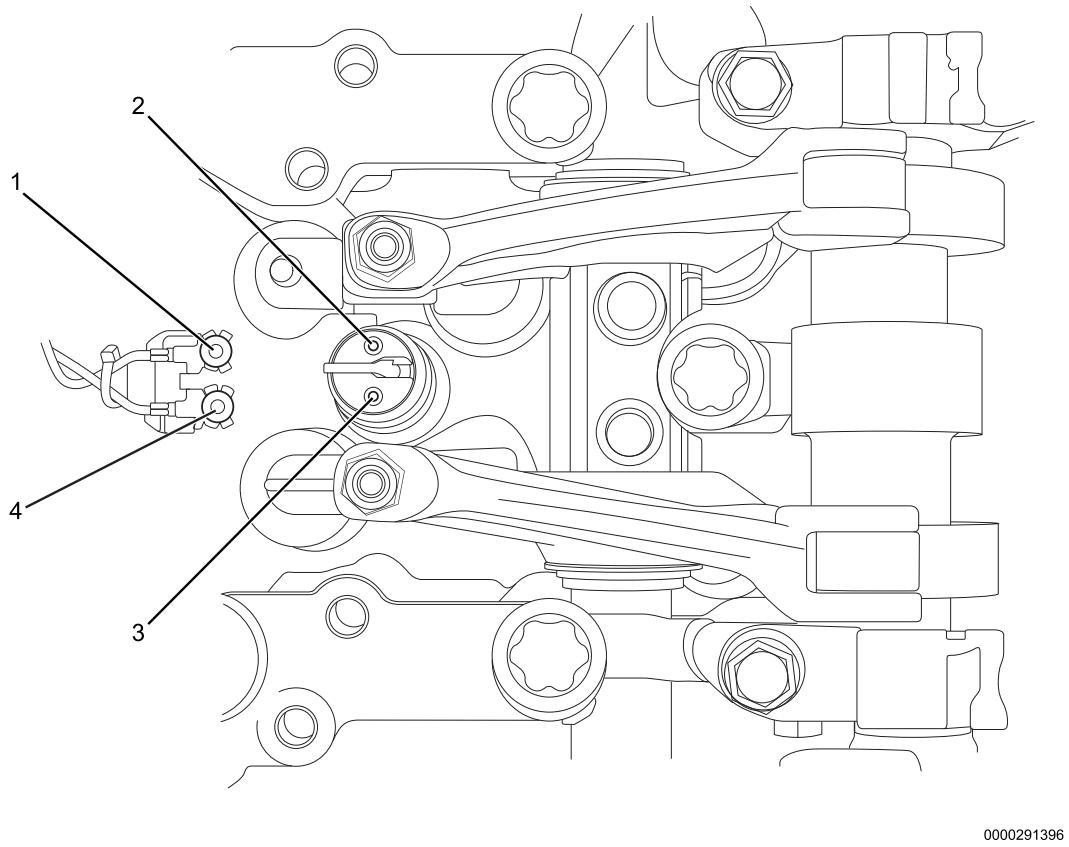


Figure 286 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
2	Check for a shorted fuel injector 2 coil. Key OFF, disconnect the wiring terminals from fuel injector 2. Using a DMM, check resistance across fuel injector 2 terminals. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 2. After repairs are complete, retest for SPN 652 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM) E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 652 FMI 4.

Step	Action	Decision
4	Check for fuel injector 2 high side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 2, use a DMM to test resistance between high side terminal and a known good GND. Is resistances greater than 1000 ohms?	Yes: Go to step 5. No: Replace fuel injector 2. After repairs are complete, retest for SPN 652 FMI 4.

Step	Action	Decision
5	Check for fuel injector 2 low side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 2, use a DMM to test resistance between low side terminal and a known good GND. Is resistances greater than 1000 ohms?	Yes: Go to step 6. No: Replace fuel injector 2. After repairs are complete, retest for SPN 652 FMI 4.

Step	Action	Decision
6	Check for INJ2 H short to INJ2 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 2 disconnected. measure resistance between Breakout Box pins E2-06 and E2-11 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 7. No: Repair short between INJ2 H circuit and INJ2 L circuit. After repairs are complete, retest for SPN 652 FMI 4.

Step	Action	Decision
7	Check INJ2 H circuit for short to GND. Key OFF, connect 180-pin breakout box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 2 disconnected, measure resistance between Breakout Box pin E2-06 and known good GND (wiggle test may be required). Is resistance greater than 1000 Ohms?	Yes: Repair short to GND between E2-11 and fuel injector 2. After repairs are complete, retest for SPN 652 FMI 4. No: Repair short to GND between E2-06 and fuel injector 2. After repairs are complete, retest for SPN 652 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 652 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 652 FMI 5- Injector 2 Open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Open detected in fuel injector 2 circuit.	INJ2 circuit > 30 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 2 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

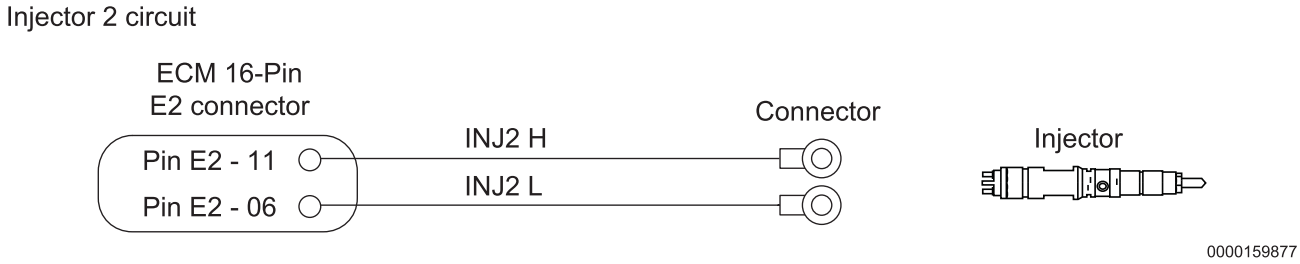


Figure 287 Injector 2 circuit diagram

Possible Causes

- INJ2 H circuit Open or high resistance
- INJ2 L circuit Open or high resistance
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

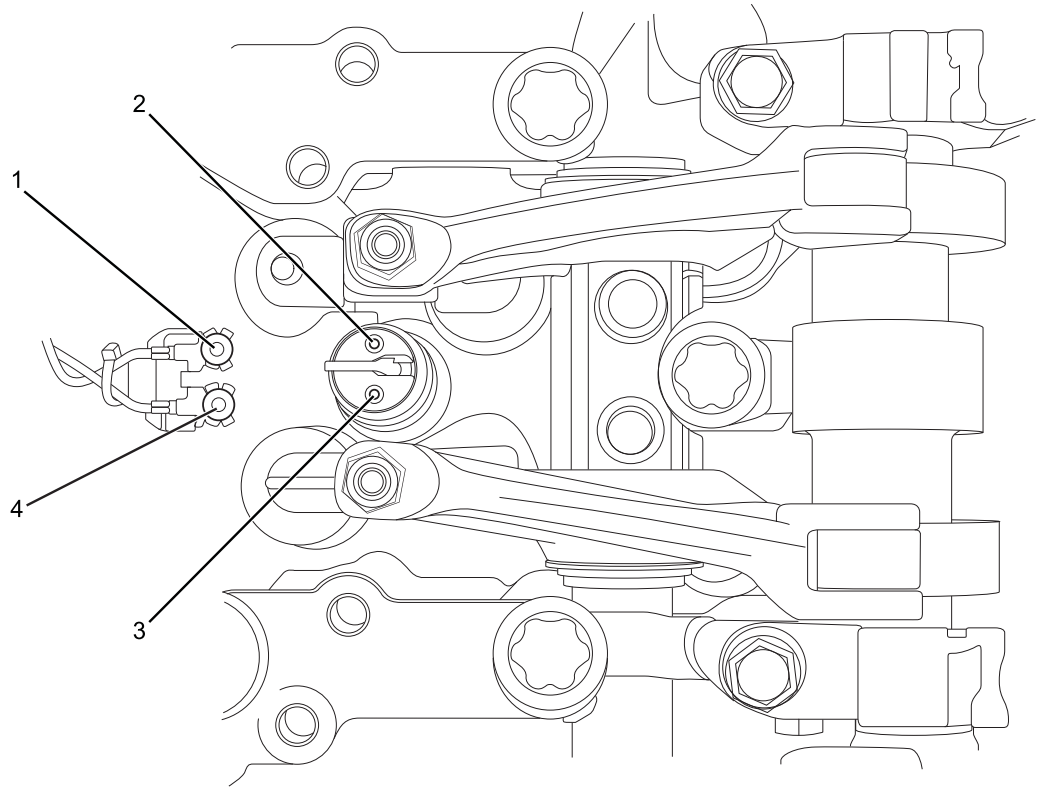


Figure 288 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Inspect connections at fuel injector 2. Remove upper valve cover and engine brake housing (see Engine Service Manual). Check fuel injector 2 connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the fuel injector 2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 652 FMI 5.

Step	Action	Decision
2	Check for a failed fuel injector 2 (Open coil). Key OFF, disconnect the connectors from fuel injector 2. Measure resistance between fuel injector 2 H and L terminals. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 2. After repairs are complete, retest for SPN 652 FMI 5.

Step	Action	Decision
3	Inspect connections at ECM E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 652 FMI 5.

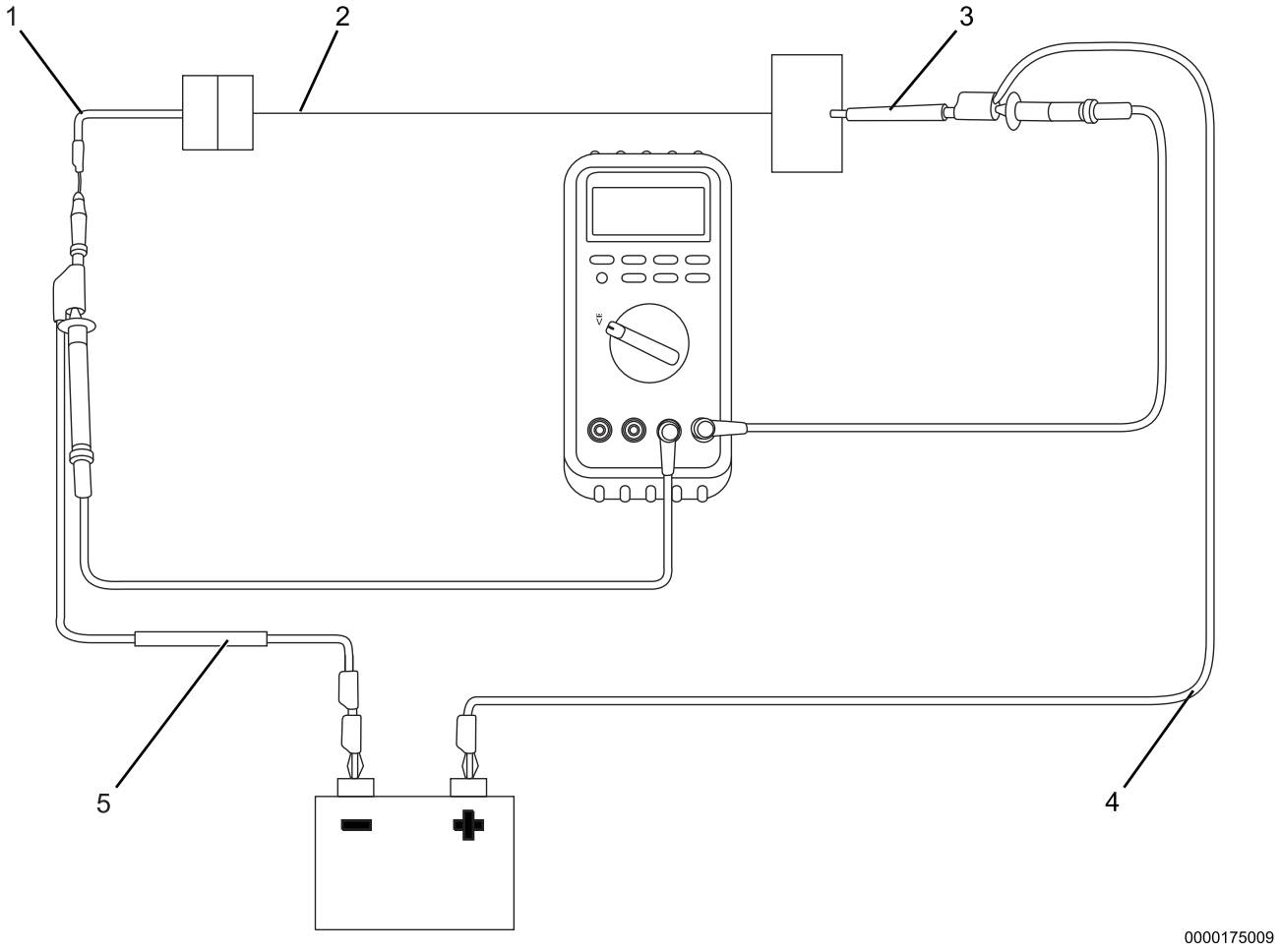


Figure 289 Voltage drop test (typical)

1. Breakout harness
2. Circuit under test
3. Terminal from ZTSE4435C
4. Jumper wire
5. 500 Ohm Resistor Jumper Harness ZTSE4497

Step	Action	Decision
4	Check INJ1 H circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect fuel injector 2 and ECM E2 connector. 2. Using Engine Terminal Test Kit ZTSE4435C, insert proper terminal into ECM pin E2-06. 3. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal in E2-06, and the other end of 500 Ohm Resistor Jumper Harness to PWR (use a jumper wire if needed). 4. Connect INJ2 H ring terminal to a known good GND (use a jumper wire if needed) 5. Using a DMM, measure voltage between fuel injector 2 INJ 2 H ring terminal and terminal in ECM pin E2-06. Is voltage less than 0.3V?	Yes: Repair Open or high resistance between fuel injector 1 INJ2 L ring terminal and ECM pin E2-11. After repairs are complete, retest for SPN 652 FMI 5. No: Repair Open or high resistance between fuel injector 1 INJ2 H ring terminal and ECM pin E2-06. After repairs are complete, retest for SPN 652 FMI 5.

NOTE: After performing all diagnostic steps, if SPN 652 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 653 FMI 4- Injector 3 short circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short to GND detected in fuel injector 3 circuit	INJ3 circuit resistance to ground < 0.5 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 3 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

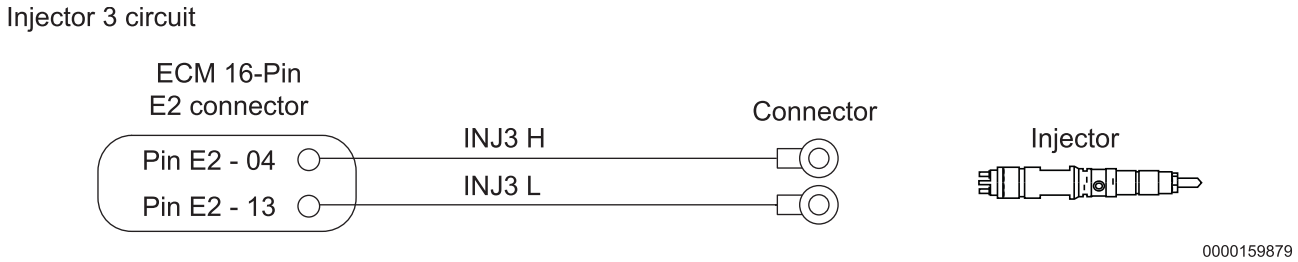


Figure 290 Injector 3 circuit diagram

Possible Causes

- INJ3 H circuit shorted to INJ3 L circuit
- INJ3 H circuit short to GND
- INJ3 L circuit short to GND
- Fuel injector shorted to engine brake housing
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

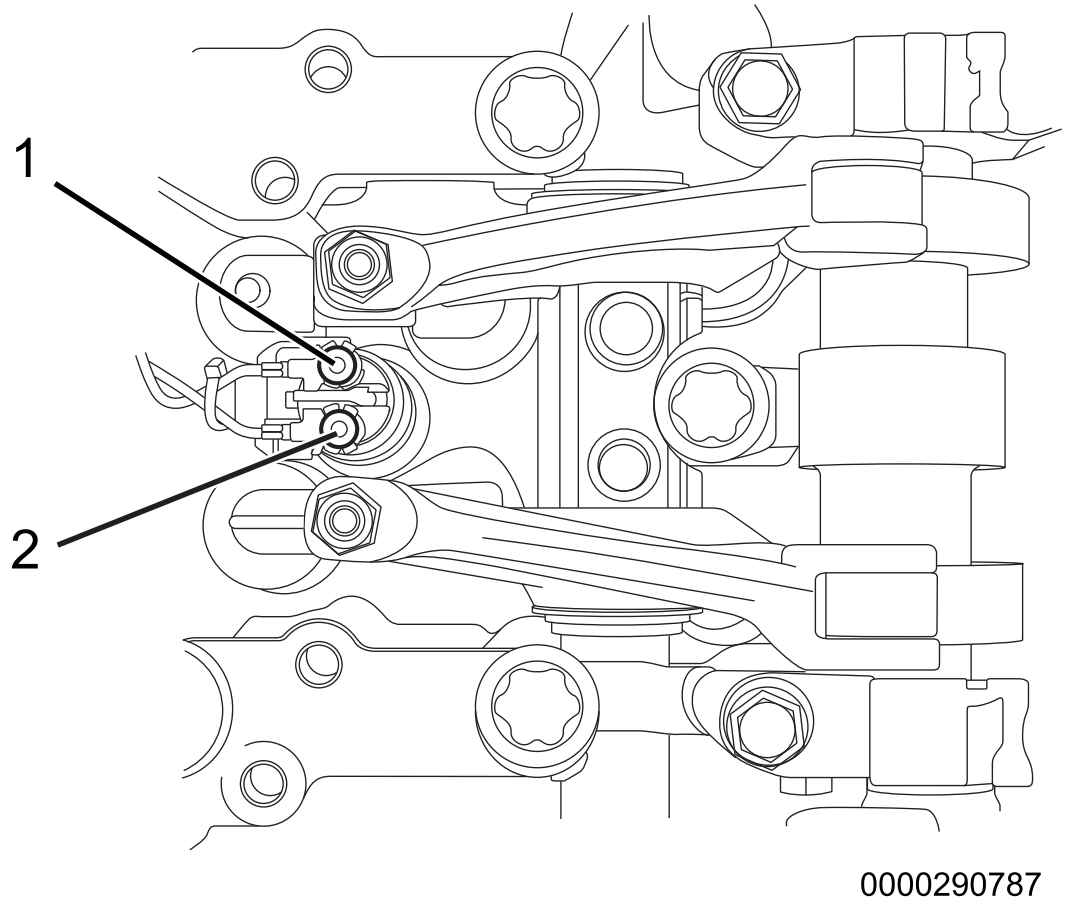


Figure 291 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Verify proper fuel injector and terminal orientation. Remove upper valve cover and engine brake housing (see Engine Service Manual). Verify fuel injector terminals are installed parallel to avoid a short to ground on the engine brake housings. Are fuel injector 3 terminals oriented correctly and Not contacting the engine brake housing?	Yes: Go to step 2. No: Adjust connections so fuel injector 3 and injector terminals will not contact the engine brake housing. After repairs are complete, retest for SPN 653 FMI 4.

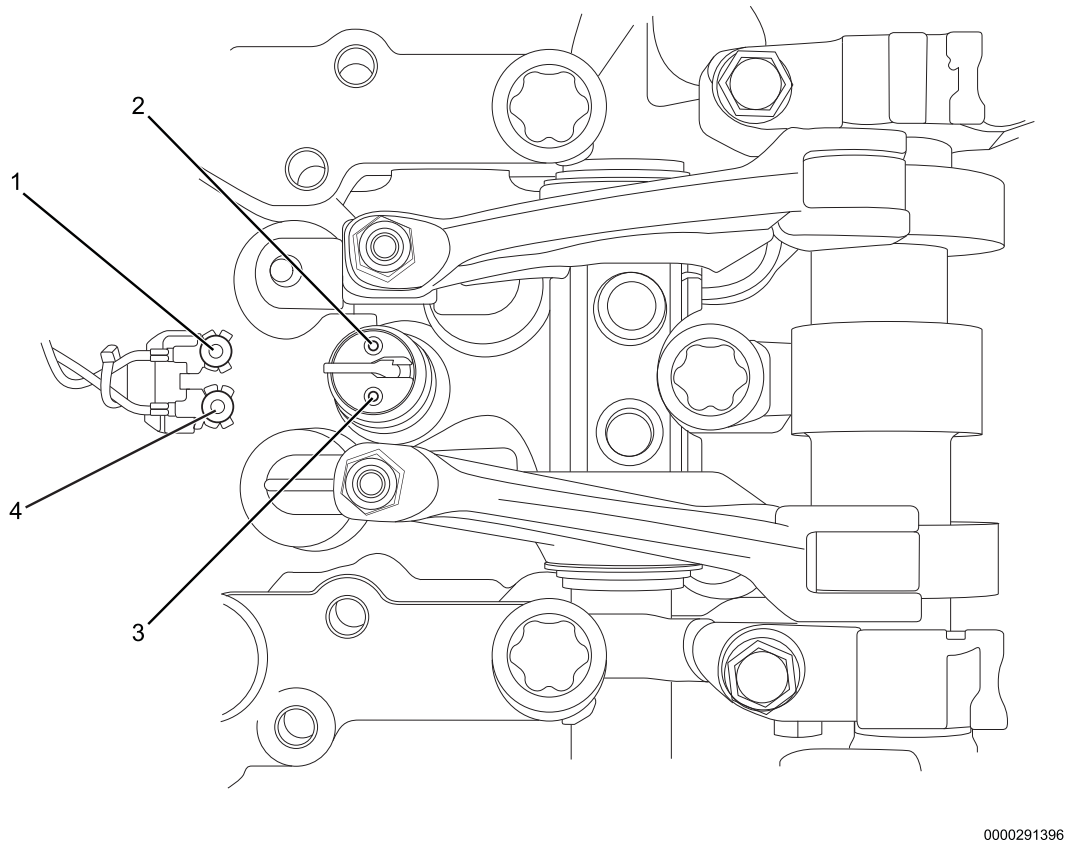


Figure 292 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
2	Check for a shorted fuel injector 3 coil. Key OFF, disconnect the connectors from fuel injector 3. Using a DMM, check resistance across fuel injector 3 terminals. Is resistance between 0.2 to 0.6 Ohms?	Yes: Go to step 3. No: Replace fuel injector 3. After repairs are complete, retest for SPN 653 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM) E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 653 FMI 4.

Step	Action	Decision
4	Check for fuel injector 3 high side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 3, use a DMM to test resistance between high side terminal and a known good GND. Is resistances greater than 1000 ohms?	Yes: Go to step 5. No: Replace fuel injector 3. After repairs are complete, retest for SPN 653 FMI 4.

Step	Action	Decision
5	Check for fuel injector 3 low side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 3, use a DMM to test resistance between low side terminal and a known good GND. Is resistances greater than 1000 ohms?	Yes: Go to step 6. No: Replace fuel injector 3. After repairs are complete, retest for SPN 653 FMI 4.

Step	Action	Decision
6	Check for INJ3 H short to INJ3 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 3 disconnected. measure resistance between Breakout Box pins E2-04 and E2-13 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 7. No: Repair short between INJ3 H circuit and INJ3 L circuit. After repairs are complete, retest for SPN 653 FMI 4.

Step	Action	Decision
7	Check INJ3 H circuit for short to GND. Key OFF, connect 180-pin breakout box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 3 disconnected, measure resistance between Breakout Box pin E2-04 and known good GND (wiggle test may be required). Is resistance greater than 1000 Ohms?	Yes: Repair short to GND between E2-13 and fuel injector 3. After repairs are complete, retest for SPN 653 FMI 4. No: Repair short to GND between E2-04 and fuel injector 3. After repairs are complete, retest for SPN 653 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 653 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 653 FMI 5- Injector 3 Open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Open detected in fuel injector 3 circuit.	INJ3 circuit > 30 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 3 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

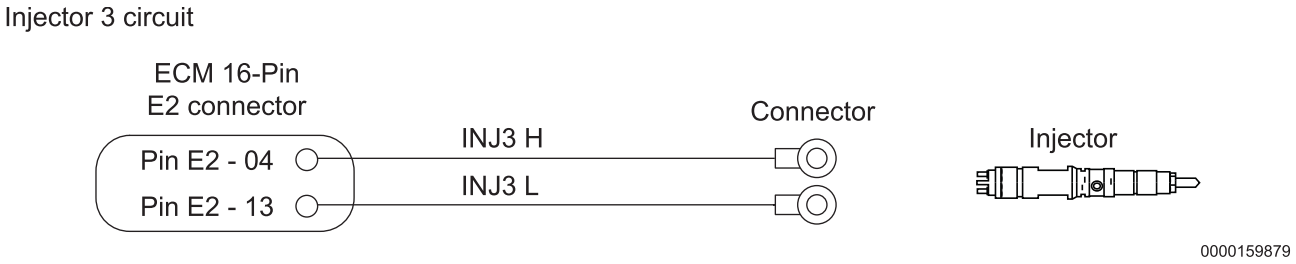


Figure 293 Injector 3 circuit diagram

Possible Causes

- INJ3 H circuit Open or high resistance
- INJ3 L circuit Open or high resistance
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

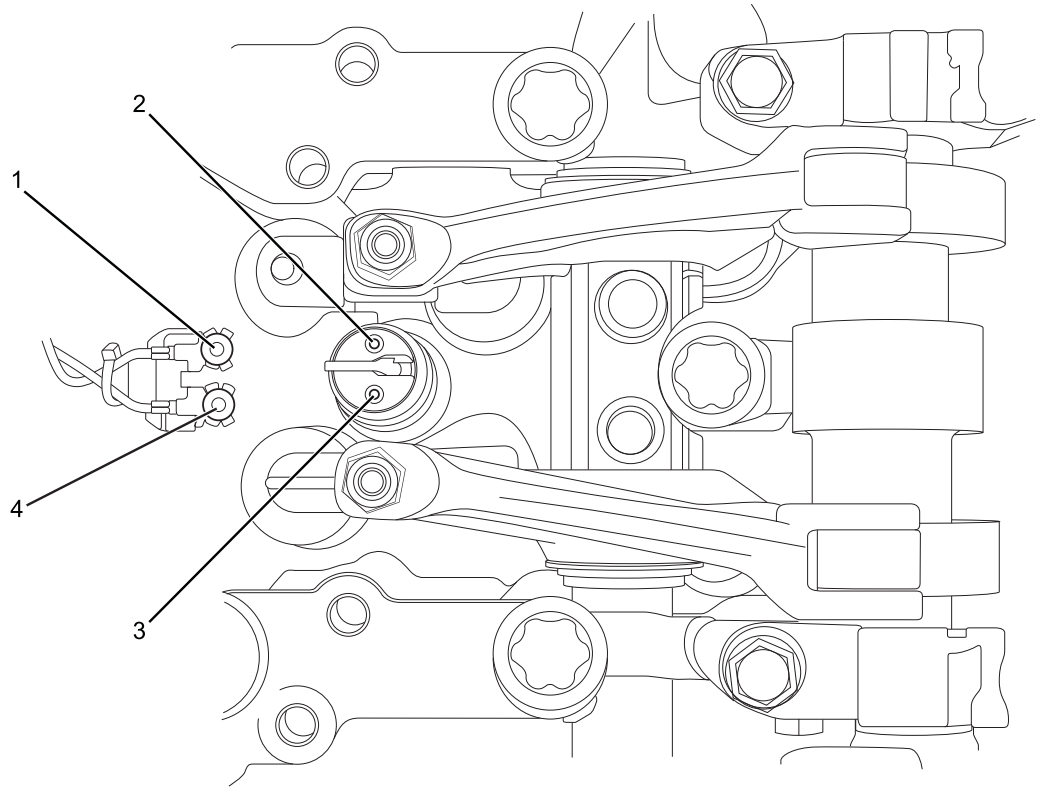


Figure 294 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Inspect connections at fuel injector 3. Remove upper valve cover and engine brake housing (see Engine Service Manual). Check fuel injector 3 connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the fuel injector 3 connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 653 FMI 5.

Step	Action	Decision
2	Check for a Open fuel injector 3 coil. Disconnect the connectors from fuel injector 3. Check resistance across fuel injector 3. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 3. After repairs are complete, retest for SPN 653 FMI 5.

Step	Action	Decision
3	Inspect connections at ECM E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 653 FMI 5.

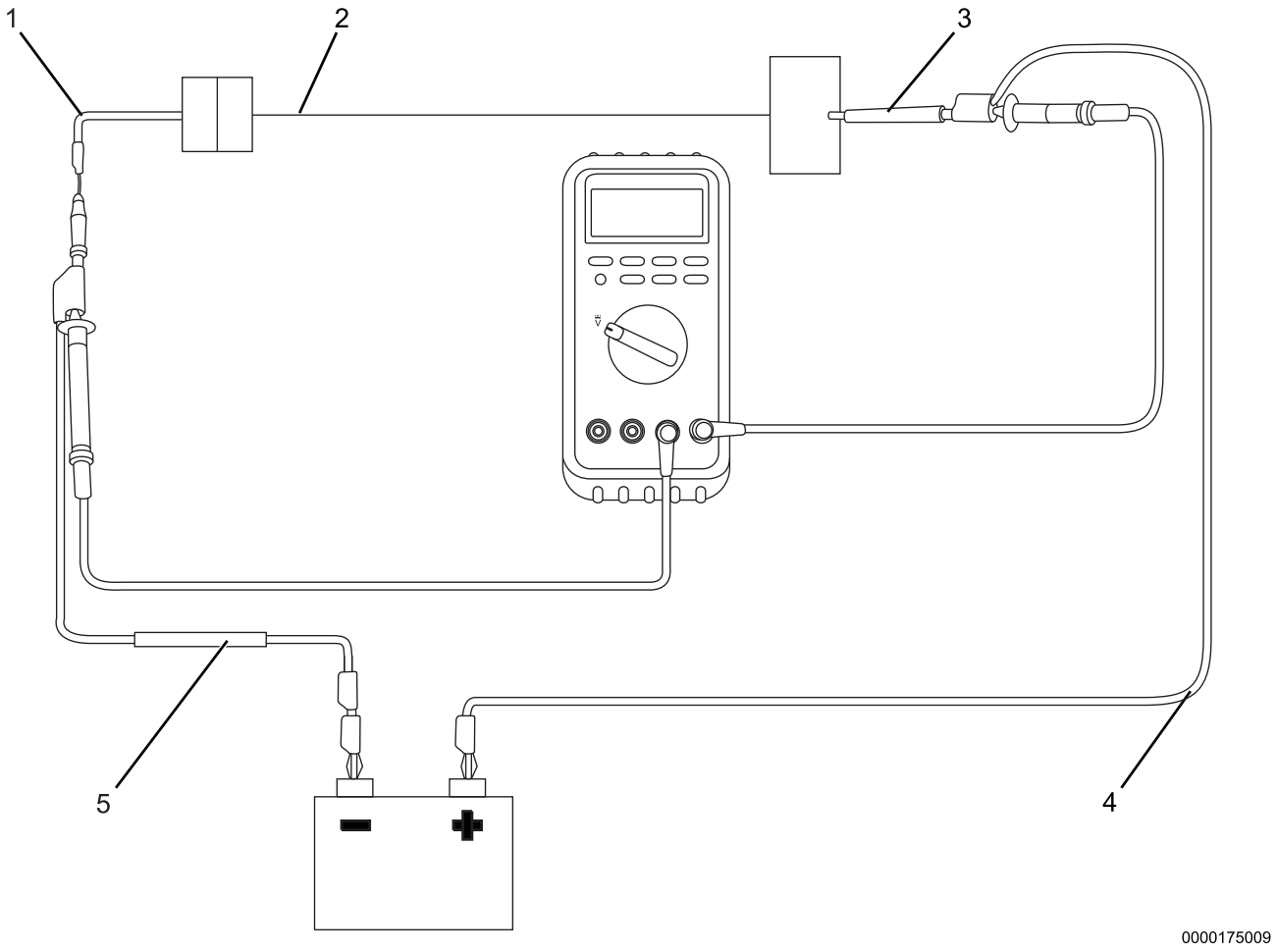


Figure 295 Voltage drop test (typical)

1. Breakout harness
2. Circuit under test
3. Terminal from ZTSE4435C
4. Jumper wire
5. 500 Ohm Resistor Jumper Harness ZTSE4497

Step	Action	Decision
4	Check INJ3 H circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect fuel injector 3 and ECM E2 connector. 2. Using Engine Terminal Test Kit ZTSE4435C, insert proper terminal into ECM pin E2-04. 3. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal in E2-04, and the other end of 500 Ohm Resistor Jumper Harness to PWR (use a jumper wire if needed). 4. Connect INJ3 H ring terminal to a known good GND (use a jumper wire if needed) 5. Using a DMM, measure voltage between fuel injector 3 INJ 3 H ring terminal and terminal in ECM pin E2-04. Is voltage less than 0.3V	Yes: Repair INJ3 L circuit between fuel injector 3 and pin E2-13. After repairs are complete, retest for SPN 653 FMI 5. No: Repair INJ3 H circuit between fuel injector 3 and pin E2-04. After repairs are complete, retest for SPN 653 FMI 5.

NOTE: After performing all diagnostic steps, if SPN 653 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 654 FMI 4- Injector 4 short circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short to GND detected in fuel injector 4 circuit	INJ3 circuit resistance to ground < 0.5 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 4 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

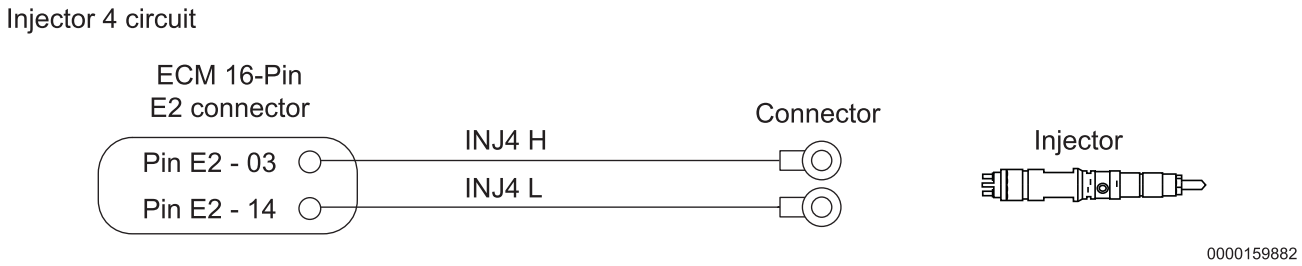


Figure 296 Injector 4 circuit diagram

Possible Causes

- INJ4 H circuit shorted to INJ4 L circuit
- INJ4 H circuit short to GND
- INJ4 L circuit short to GND
- Fuel injector shorted to engine brake housing
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

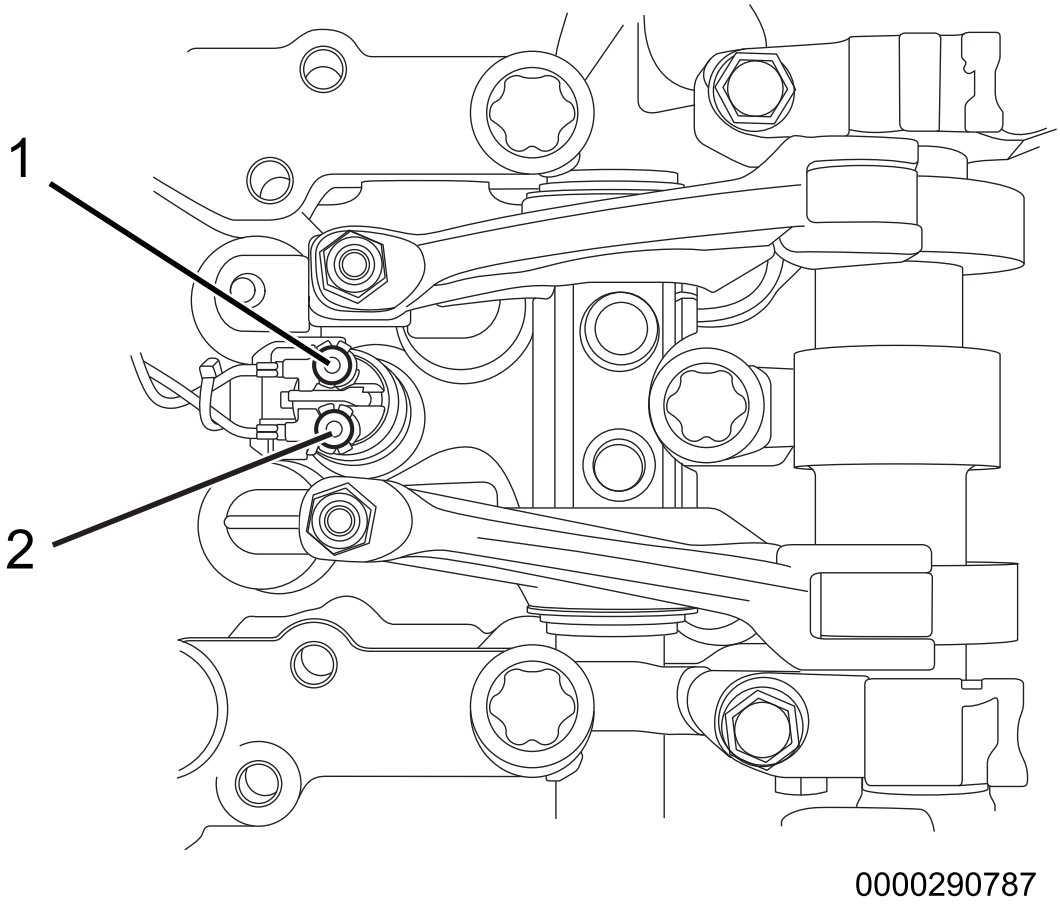


Figure 297 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Verify proper fuel injector and terminal orientation. Remove upper valve cover and engine brake housing (see Engine Service Manual). Verify fuel injector terminals are installed parallel to avoid a short to ground on the engine brake housings. Are fuel injector 4 terminals oriented correctly and Not contacting the engine brake housing?	Yes: Go to step 2. No: Adjust connections so fuel injector 4 and injector terminals will not contact the engine brake housing. After repairs are complete, retest for SPN 654 FMI 4.

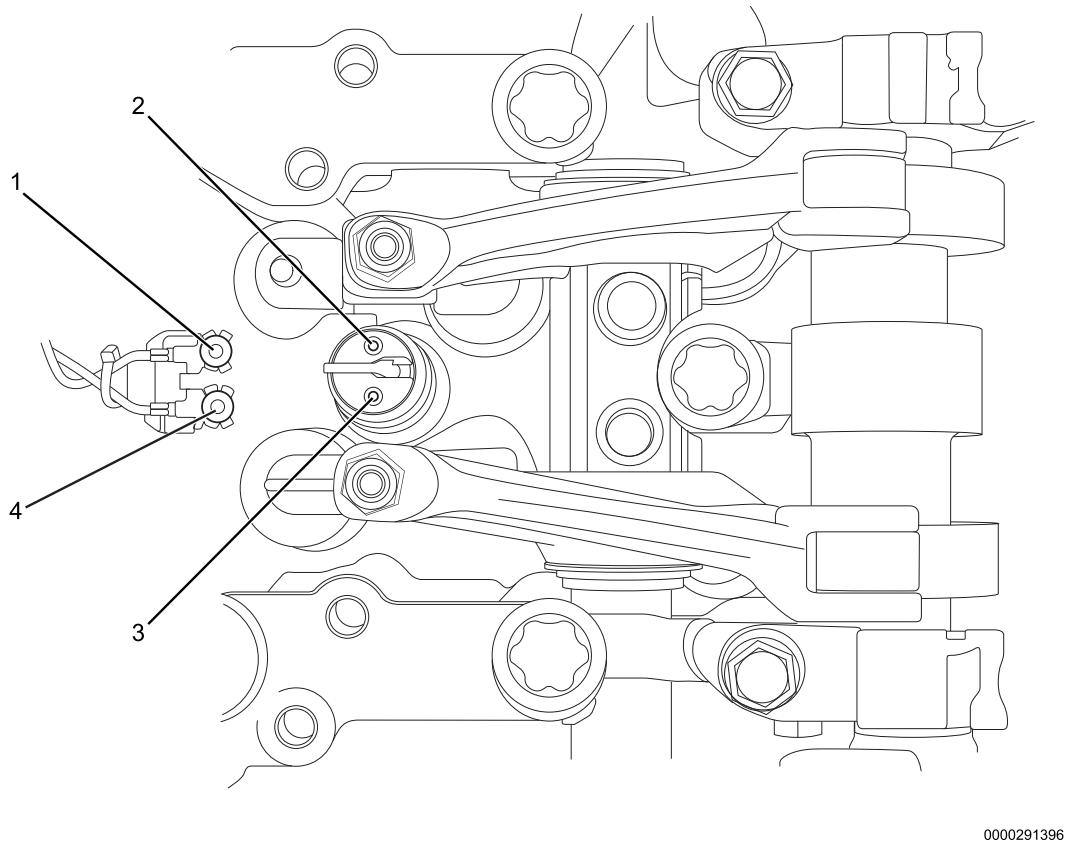


Figure 298 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
2	Check for a shorted fuel injector 4 coil. Key OFF, disconnect the connectors from fuel injector 4. Using a DMM, check resistance across fuel injector 4 terminals. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 4. After repairs are complete, retest for SPN 654 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM) E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 654 FMI 4.

Step	Action	Decision
4	Check for fuel injector 4 high side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 4, use a DMM to test resistance between high side terminal and a known good GND. Is resistances greater than 1000 ohms?	Yes: Go to step 5. No: Replace fuel injector 4. After repairs are complete, retest for SPN 654 FMI 4.

Step	Action	Decision
5	Check for fuel injector 4 low side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 4, use a DMM to test resistance between low side terminal and a known good GND. Is resistances greater than 1000 ohms?	Yes: Go to step 6. No: Replace fuel injector 4. After repairs are complete, retest for SPN 654 FMI 4.

Step	Action	Decision
6	Check for INJ4 H short to INJ4 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 4 disconnected. measure resistance between Breakout Box pins E2-03 and E2-14 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 7. No: Repair short between INJ4 H circuit and INJ4 L circuit. After repairs are complete, retest for SPN 654 FMI 4.

Step	Action	Decision
7	Check INJ4 H circuit for short to GND. Key OFF, connect 180-pin breakout box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 4 disconnected, measure resistance between Breakout Box pin E2-03 and known good GND (wiggle test may be required). Is resistance greater than 1000 Ohms?	Yes: Repair short to GND between E2-14 and fuel injector 4. After repairs are complete, retest for SPN 654 FMI 4. No: Repair short to GND between E2-03 and fuel injector 4. After repairs are complete, retest for SPN 654 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 654 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 654 FMI 5- Injector 4 Open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Open detected in fuel injector 4 circuit.	INJ4 circuit > 30 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 4 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

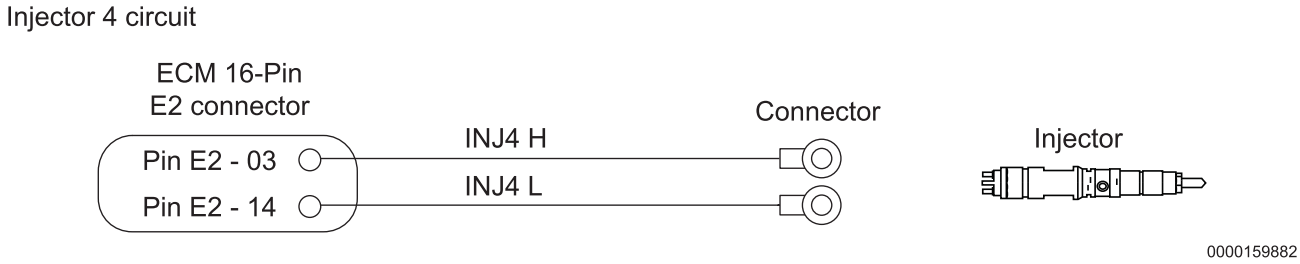


Figure 299 Injector 4 circuit diagram

Possible Causes

- INJ4 H circuit Open or high resistance
- INJ4 L circuit Open or high resistance
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

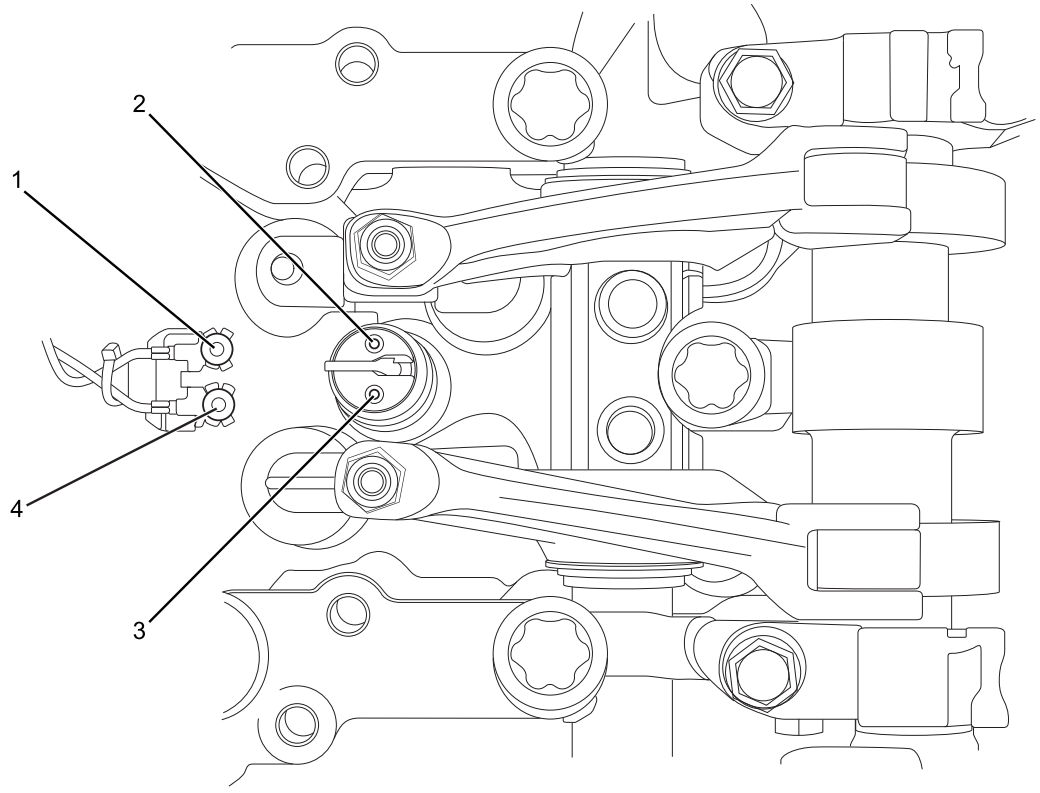


Figure 300 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Inspect connections at fuel injector 4. Remove valve cover and engine brake housing (see Engine Service Manual). Check fuel injector 4 connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the fuel injector 4 connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 654 FMI 5.

Step	Action	Decision
2	Check for a Open fuel injector 4 coil. Disconnect the connectors from fuel injector 4. Check resistance across fuel injector 4. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 4. After repairs are complete, retest for SPN 654 FMI 5.

Step	Action	Decision
3	Inspect connections at ECM E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 654 FMI 5.

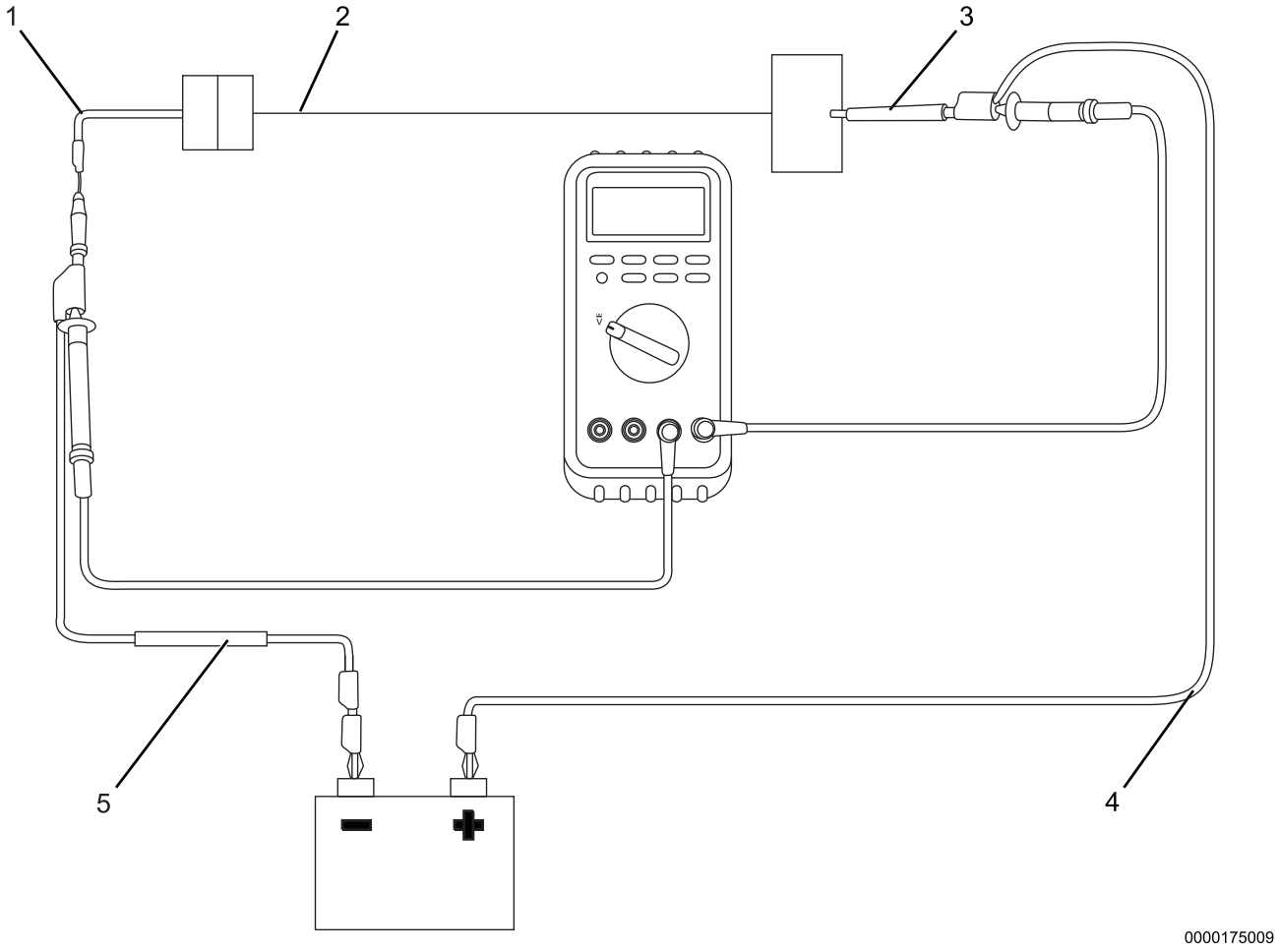


Figure 301 Voltage drop test (typical)

1. Breakout harness
2. Circuit under test
3. Terminal from ZTSE4435C
4. Jumper wire
5. 500 Ohm Resistor Jumper Harness ZTSE4497

Step	Action	Decision
4	Check INJ4 H circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect fuel injector 4 and ECM E2 connector. 2. Using Engine Terminal Test Kit ZTSE4435C, insert proper terminal into ECM pin E2-03. 3. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal in E2-03, and the other end of 500 Ohm Resistor Jumper Harness to PWR (use a jumper wire if needed). 4. Connect INJ4 H ring terminal to a known good GND (use a jumper wire if needed) 5. Using a DMM, measure voltage between fuel injector 4 INJ 4 H ring terminal and terminal in ECM pin E2-03. Is voltage less than 0.3V	Yes: Repair INJ4 L circuit between fuel injector 4 and pin E2-14. After repairs are complete, retest for SPN 654 FMI 5. No: Repair INJ4 H circuit between fuel injector 4 and pin E2-03. After repairs are complete, retest for SPN 654 FMI 5.

NOTE: After performing all diagnostic steps, if SPN 654 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 655 FMI 4- Injector 5 short circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short to GND detected in fuel injector 5 circuit	INJ5 circuit resistance to ground < 0.5 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 5 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

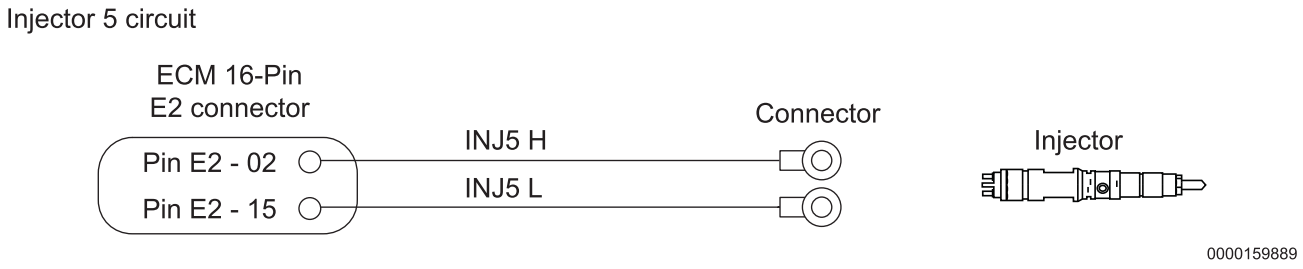


Figure 302 Injector 5 circuit diagram

Possible Causes

- INJ5 H circuit shorted to INJ5 L circuit
- INJ5 H circuit short to GND
- INJ5 L circuit short to GND
- Fuel injector shorted to engine brake housing
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

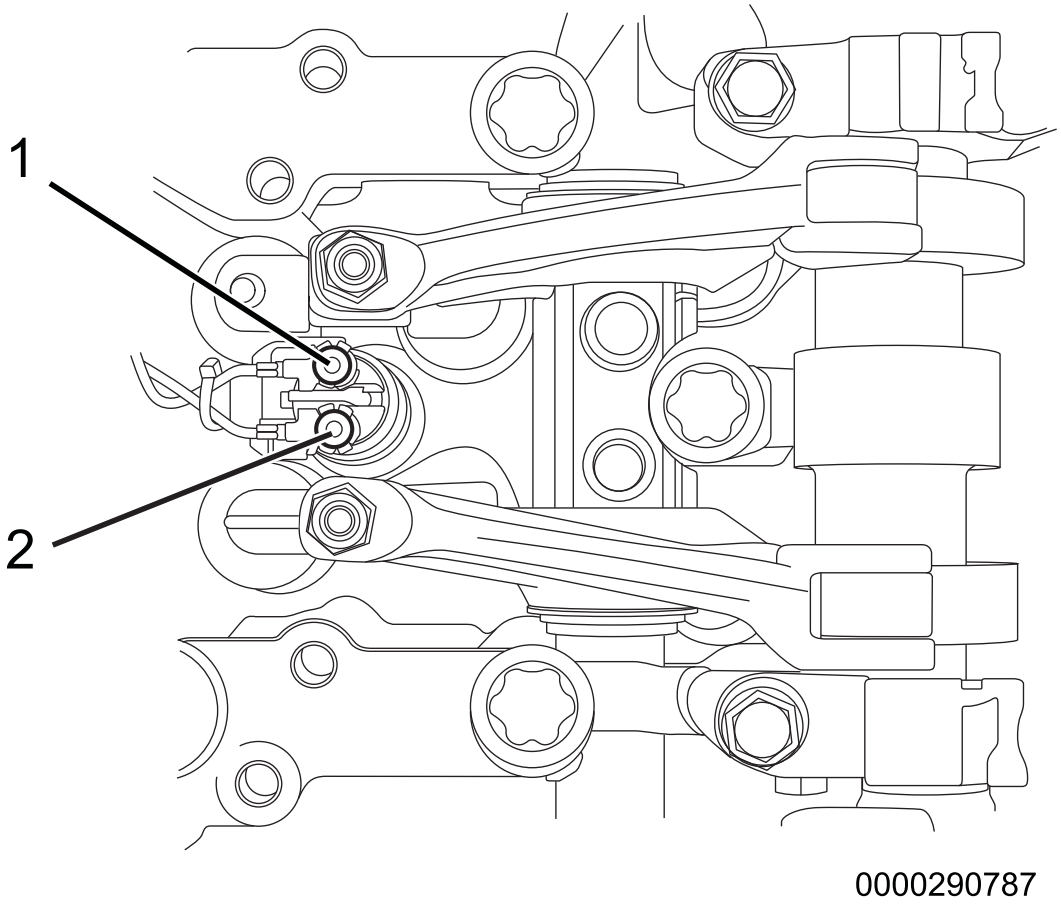


Figure 303 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Verify proper fuel injector and terminal orientation. Remove upper valve cover and engine brake housing (see Engine Service Manual). Verify fuel injector terminals are installed parallel to avoid a short to ground on the engine brake housings. Are fuel injector 5 terminals oriented correctly and Not contacting the engine brake housing?	Yes: Go to step 2. No: Adjust connections so fuel injector 5 and injector terminals will not contact the engine brake housing. After repairs are complete, retest for SPN 655 FMI 4.

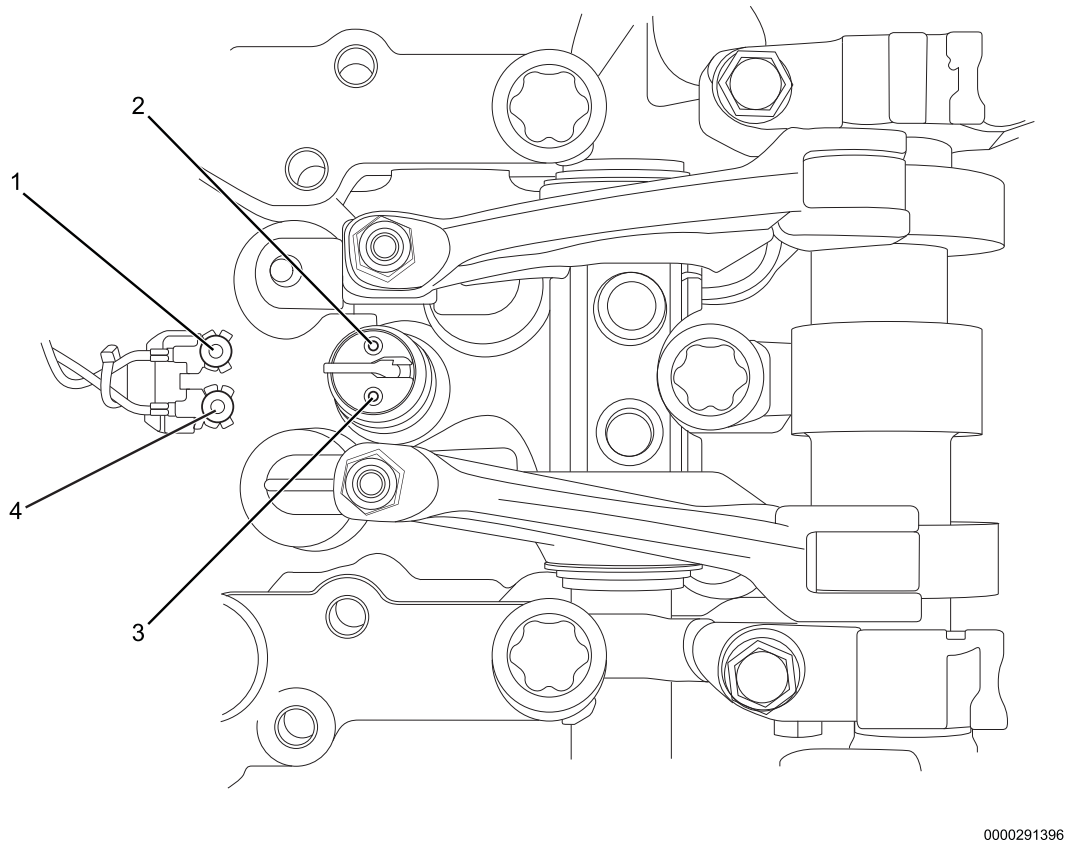


Figure 304 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
2	Check for a shorted fuel injector 5 coil. Key OFF, disconnect the connectors from fuel injector 5. Using a DMM, check resistance across fuel injector 5 terminals. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 5. After repairs are complete, retest for SPN 655 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM) E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 655 FMI 4.

Step	Action	Decision
4	Check for fuel injector 5 high side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 5, use a DMM to test resistance between high side terminal and a known good GND. Is resistance greater than 1000 ohms?	Yes: Go to step 5. No: Replace fuel injector 5. After repairs are complete, retest for SPN 655 FMI 4.

Step	Action	Decision
5	Check for fuel injector 5 low side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 5, use a DMM to test resistance between low side terminal and a known good GND. Is resistance greater than 1000 ohms?	Yes: Go to step 6. No: Replace fuel injector 5. After repairs are complete, retest for SPN 655 FMI 4.

Step	Action	Decision
6	Check for INJ5 H short to INJ5 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 5 disconnected. measure resistance between Breakout Box pins E2-02 and E2-15 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 7. No: Repair short between INJ5 H circuit and INJ5 L circuit. After repairs are complete, retest for SPN 655 FMI 4.

Step	Action	Decision
7	Check INJ5 H circuit for short to GND. Key OFF, connect 180-pin breakout box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 5 disconnected, measure resistance between Breakout Box pin E2-02 and known good GND (wiggle test may be required). Is resistance greater than 1000 Ohms?	Yes: Repair short to GND between E2-15 and fuel injector 5. After repairs are complete, retest for SPN 655 FMI 4. No: Repair short to GND between E2-02 and fuel injector 5. After repairs are complete, retest for SPN 655 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 655 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 655 FMI 5- Injector 5 Open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Open detected in fuel injector 5 circuit.	INJ5 circuit > 30 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 5 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

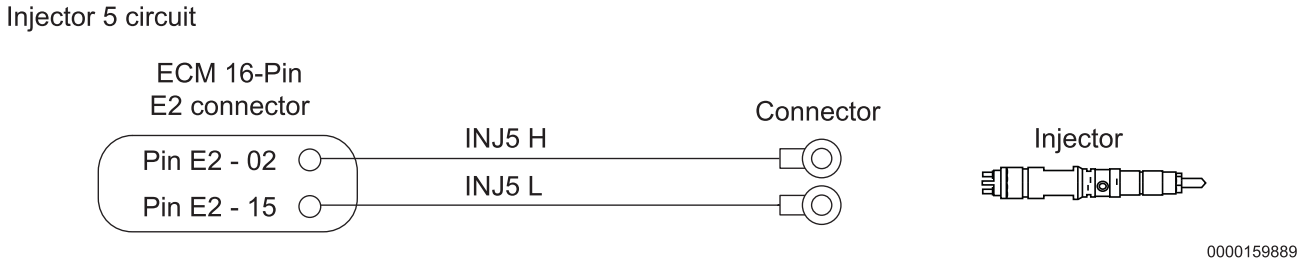


Figure 305 Injector 5 circuit diagram

Possible Causes

- INJ5 H circuit Open or high resistance
- INJ5 L circuit Open or high resistance
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

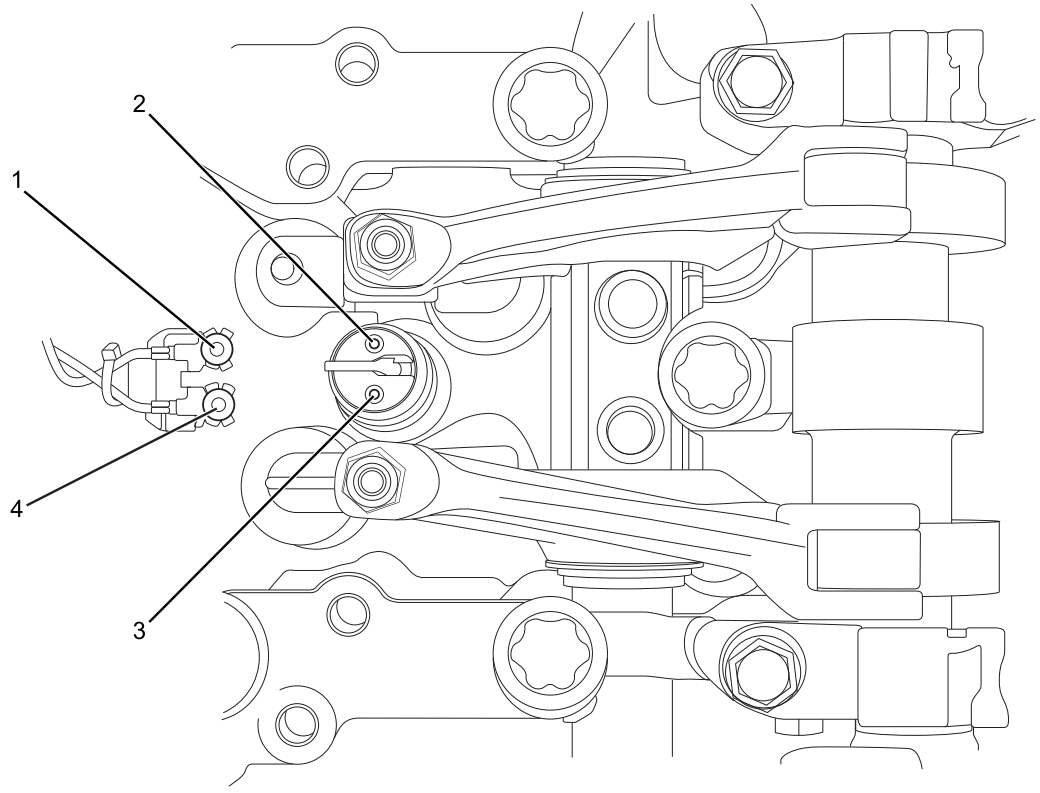


Figure 306 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Inspect connections at fuel injector 5. Remove upper valve cover and engine brake housing (see Engine Service Manual). Check fuel injector 5 connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the fuel injector 5 connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 655 FMI 5.

Step	Action	Decision
2	Check for a Open fuel injector 5 coil. Disconnect the connectors from fuel injector 5. Check resistance across fuel injector 5 terminals. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 5. After repairs are complete, retest for SPN 655 FMI 5.

Step	Action	Decision
3	Inspect connections at ECM E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 655 FMI 5.

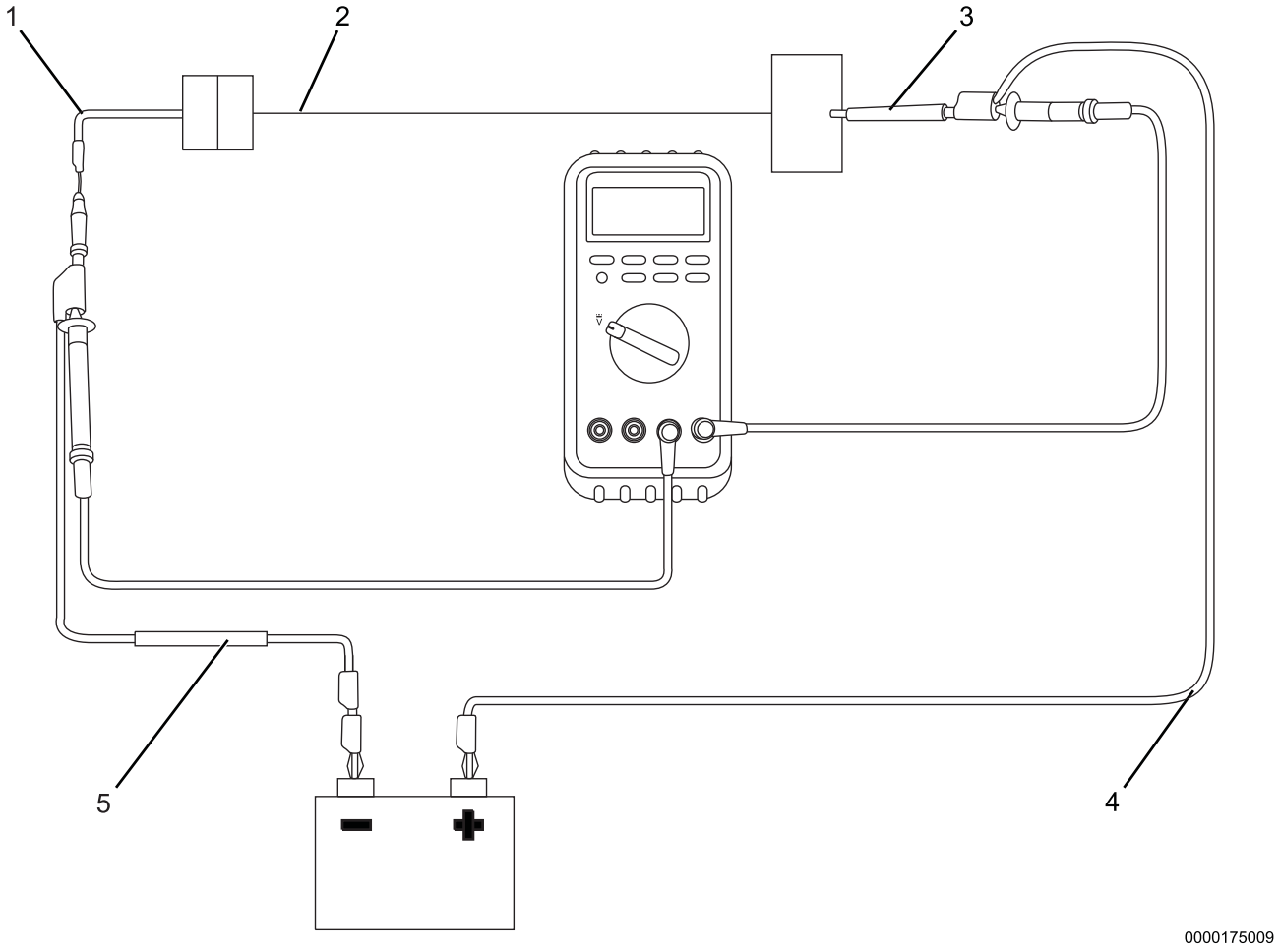


Figure 307 Voltage drop test (typical)

1. Breakout harness
2. Circuit under test
3. Terminal from ZTSE4435C
4. Jumper wire
5. 500 Ohm Resistor Jumper Harness ZTSE4497

Step	Action	Decision
4	Check INJ5 H circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect fuel injector 5 and ECM E2 connector. 2. Using Engine Terminal Test Kit ZTSE4435C, insert proper terminal into ECM pin E2-02. 3. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal in E2-02, and the other end of 500 Ohm Resistor Jumper Harness to PWR (use a jumper wire if needed). 4. Connect INJ5 H ring terminal to a known good GND (use a jumper wire if needed) 5. Using a DMM, measure voltage between fuel injector 5 INJ 5 H ring terminal and terminal in ECM pin E2-02. Is voltage less than 0.3V	Yes: Repair INJ5 L circuit between fuel injector 5 and pin E2-15. After repairs are complete, retest for SPN 655 FMI 5. No: Repair INJ5 H circuit between fuel injector 5 and pin E2-02. After repairs are complete, retest for SPN 655 FMI 5.

NOTE: After performing all diagnostic steps, if SPN 655 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 656 FMI 4- Injector 6 short circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short to GND detected in fuel injector 6 circuit	INJ6 circuit resistance to ground < 0.5 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 6 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

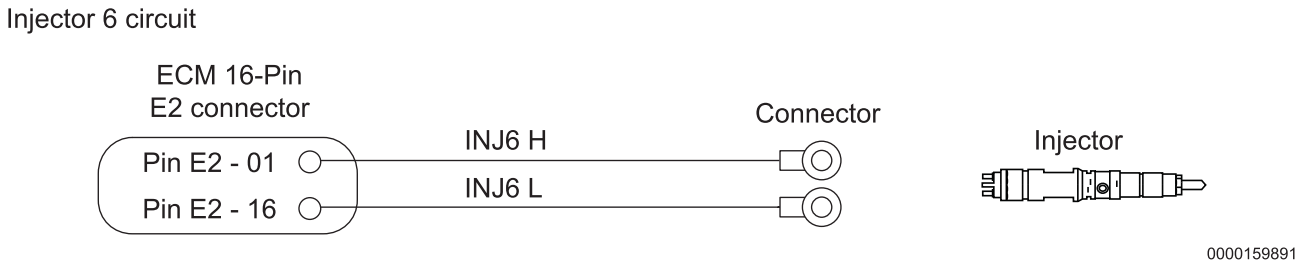


Figure 308 Injector 5 circuit diagram

Possible Causes

- INJ6 H circuit shorted to INJ6 L circuit
- INJ6 H circuit short to GND
- INJ6 L circuit short to GND
- Fuel injector shorted to engine brake housing
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

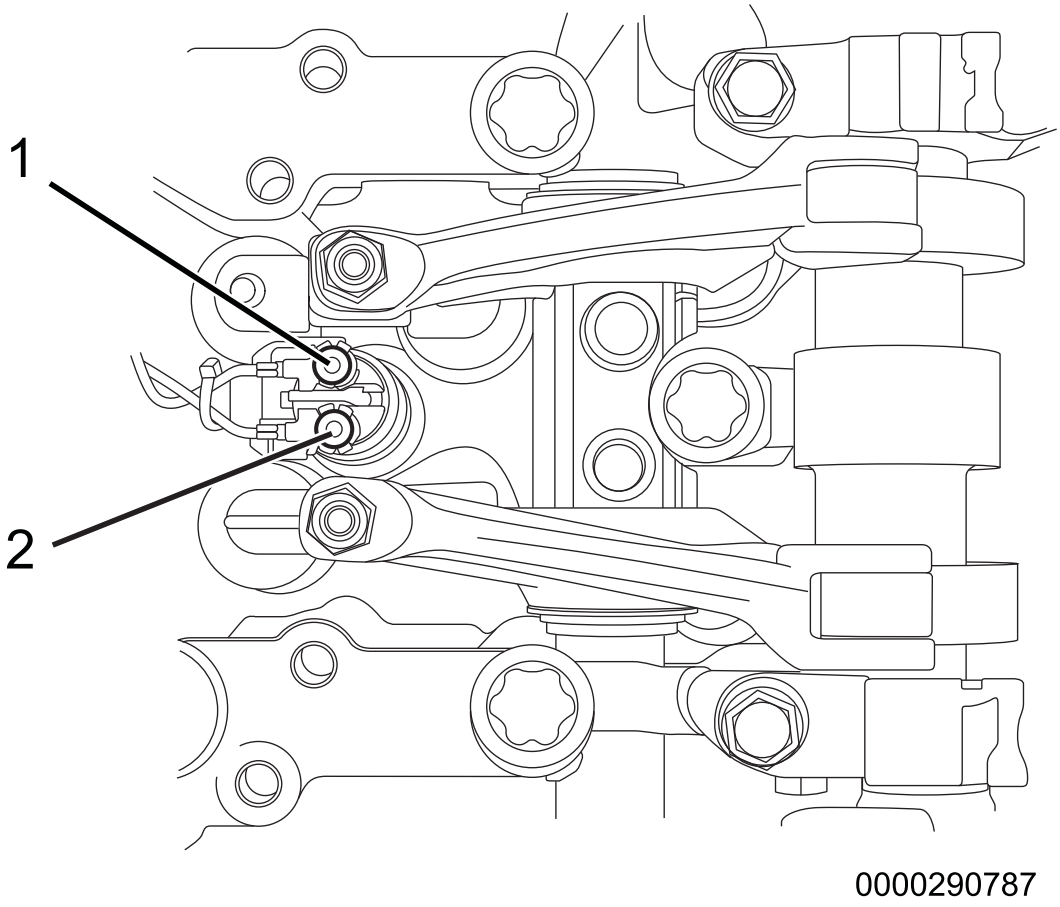


Figure 309 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Verify proper fuel injector and terminal orientation. Remove upper valve cover and engine brake housing (see Engine Service Manual). Verify fuel injector terminals are installed parallel to avoid a short to ground on the engine brake housings. Are fuel injector 6 terminals oriented correctly and Not contacting the engine brake housing?	Yes: Go to step 2. No: Adjust connections so fuel injector 6 and injector terminals will not contact the engine brake housing. After repairs are complete, retest for SPN 656 FMI 4.

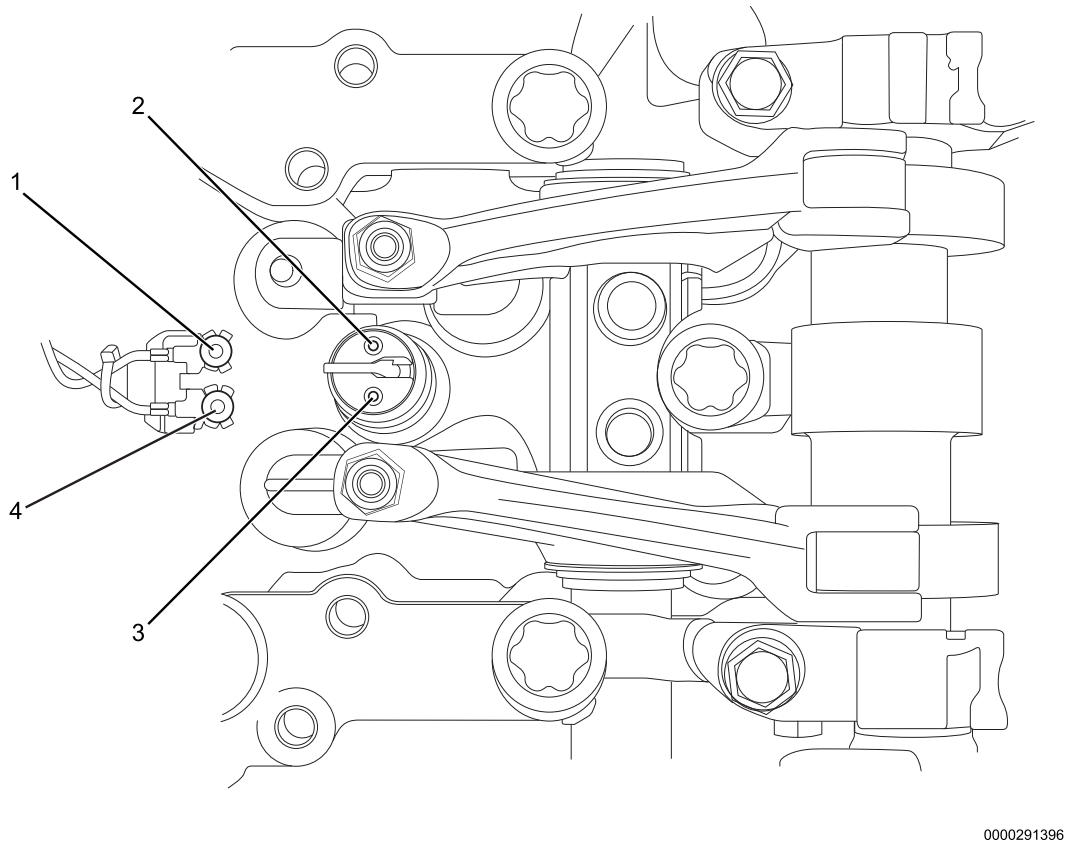


Figure 310 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
2	Check for a shorted fuel injector 6 coil. Key OFF, disconnect the connectors from fuel injector 6. Using a DMM, check resistance across fuel injector 6 terminals. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 6. After repairs are complete, retest for SPN 656 FMI 4.

Step	Action	Decision
3	Inspect connections at Engine Control Module (ECM) E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 656 FMI 4.

Step	Action	Decision
4	Check for fuel injector 6 high side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 6, use a DMM to test resistance between high side terminal and a known good GND. Is resistance greater than 1000 ohms?	Yes: Go to step 5. No: Replace fuel injector 6. After repairs are complete, retest for SPN 655 FMI 4.

Step	Action	Decision
5	Check for fuel injector 6 low side terminal short to ground. Key OFF, with ECM E2 connector disconnected and wiring terminals disconnected from fuel injector 6, use a DMM to test resistance between low side terminal and a known good GND. Is resistance greater than 1000 ohms?	Yes: Go to step 6. No: Replace fuel injector 6. After repairs are complete, retest for SPN 656 FMI 4.

Step	Action	Decision
6	Check for INJ6 H short to INJ6 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 6 disconnected. measure resistance between Breakout Box pins E2-01 and E2-16 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 7. No: Repair short between INJ6 H circuit and INJ6 L circuit. After repairs are complete, retest for SPN 656 FMI 4.

Step	Action	Decision
7	Check INJ6 H circuit for short to GND. Key OFF, connect 180-pin breakout box with Breakout Harness 00-01468-00 to ECM E2 connector, leave ECM disconnected. Using a DMM with fuel injector 6 disconnected, measure resistance between Breakout Box pin E2-01 and known good GND (wiggle test may be required). Is resistance greater than 1000 Ohms?	Yes: Repair short to GND between E2-16 and fuel injector 6. After repairs are complete, retest for SPN 656 FMI 4. No: Repair short to GND between E2-01 and fuel injector 6. After repairs are complete, retest for SPN 656 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 656 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 656 FMI 5- Injector 6 Open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Open detected in fuel injector 6 circuit.	INJ6 circuit > 30 ohms	ECM commands injector firing	3 events

Fault Overview

Fault code sets when a short to GND is detected in Fuel Injector 6 circuit.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

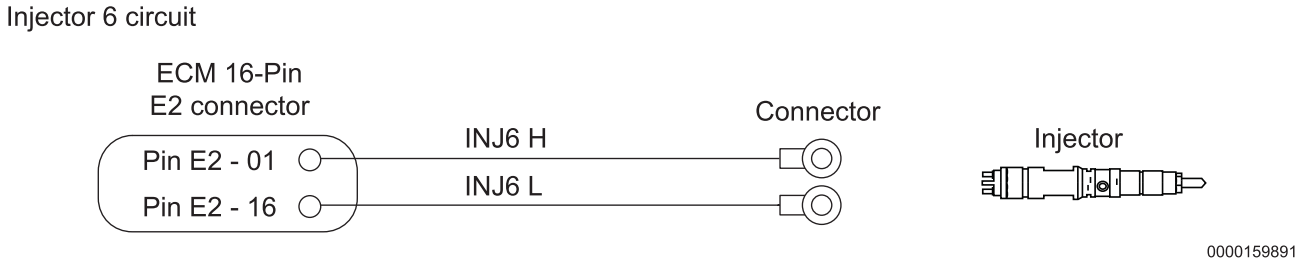


Figure 311 Injector 6 circuit diagram

Possible Causes

- INJ6 H circuit Open or high resistance
- INJ6 L circuit Open or high resistance
- Failed fuel injector

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

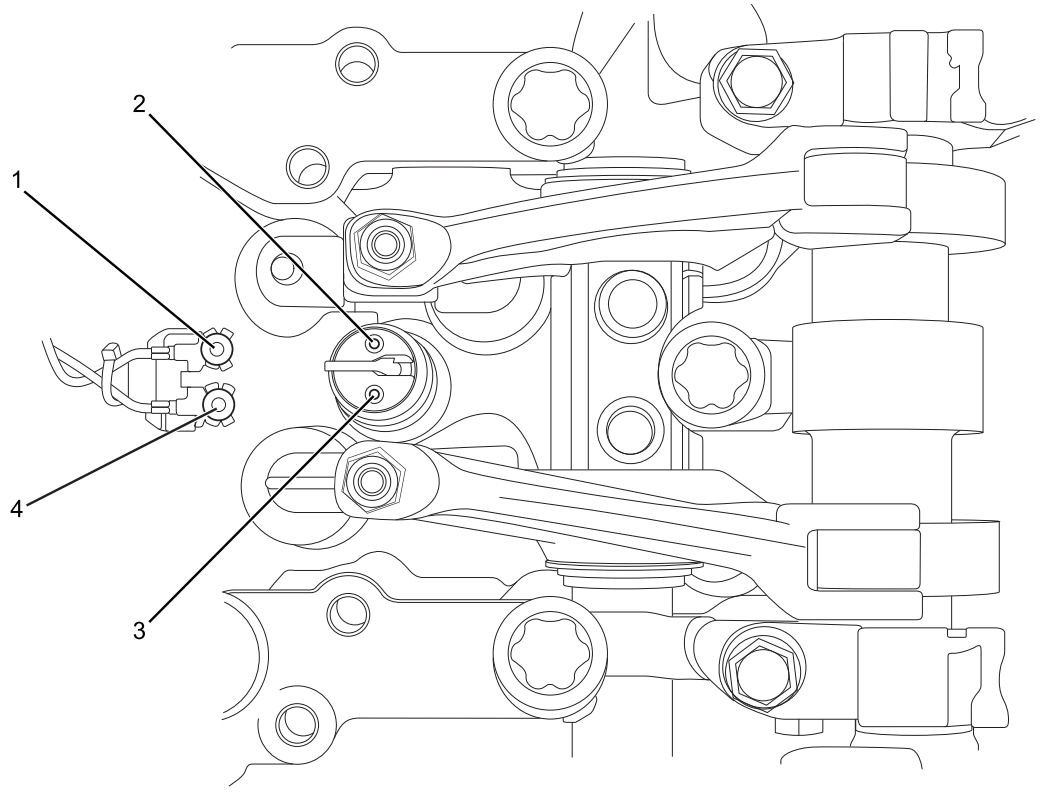


Figure 312 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
1	Inspect connections at fuel injector 6. Remove upper valve cover and engine brake housing (see Engine Service Manual). Check fuel injector 6 connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the fuel injector 6 connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 656 FMI 5.

Step	Action	Decision
2	Check for a Open fuel injector 6 coil. Disconnect the connectors from fuel injector 6. Check resistance across fuel injector 6. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 3. No: Replace fuel injector 6. After repairs are complete, retest for SPN 656 FMI 5.

Step	Action	Decision
3	Inspect connections at ECM E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 656 FMI 5.

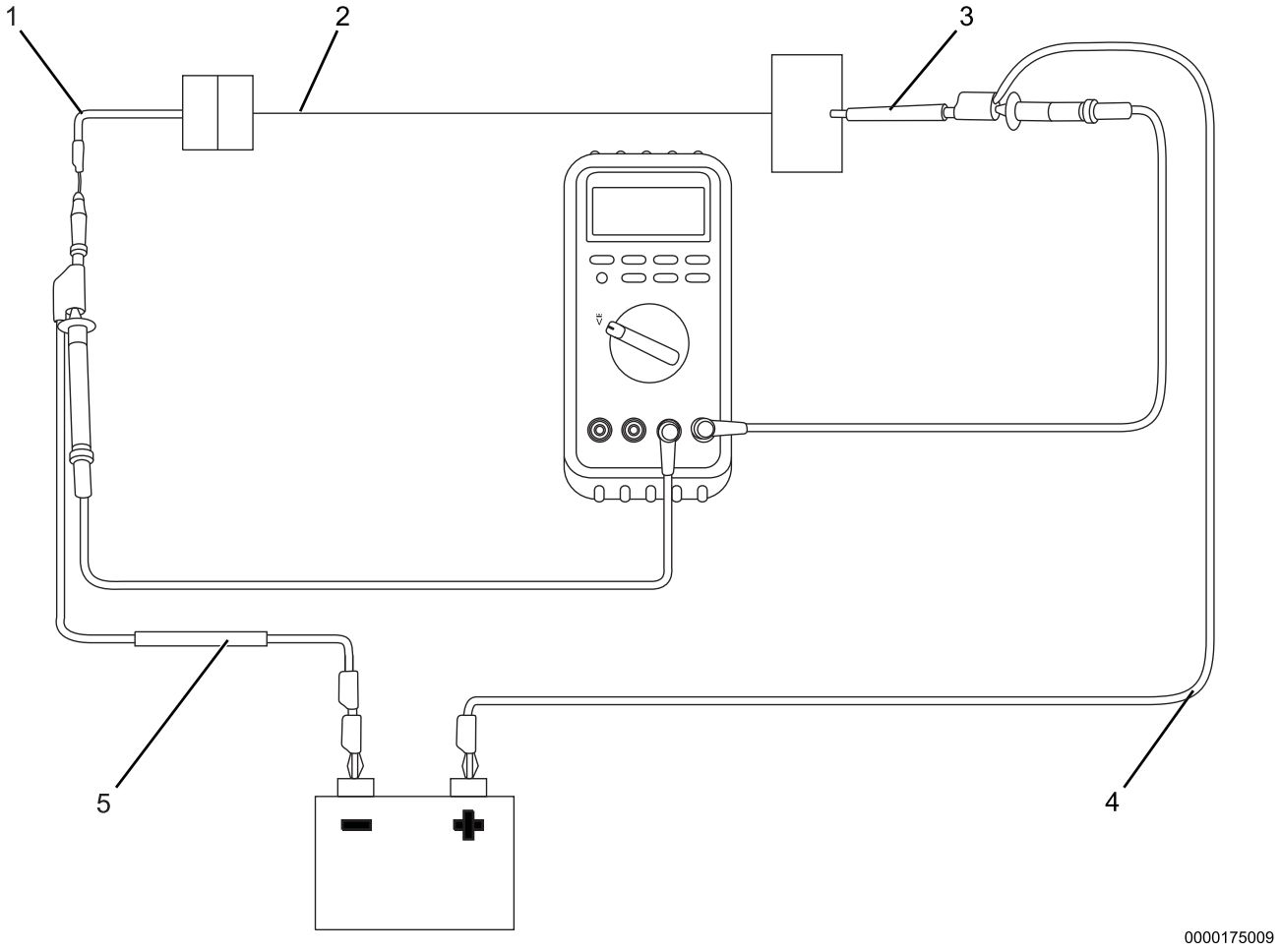


Figure 313 Voltage drop test (typical)

1. Breakout harness
2. Circuit under test
3. Terminal from ZTSE4435C
4. Jumper wire
5. 500 Ohm Resistor Jumper Harness ZTSE4497

Step	Action	Decision
4	Check INJ6 H circuit for Open or high resistance (voltage drop). 1. Key OFF, disconnect fuel injector 6 and ECM E2 connector. 2. Using Engine Terminal Test Kit ZTSE4435C, insert proper terminal into ECM pin E2-01. 3. Connect one end of the 500 Ohm Resistor Jumper Harness ZTSE4497 to terminal in E2-01, and the other end of 500 Ohm Resistor Jumper Harness to PWR (use a jumper wire if needed). 4. Connect INJ6 H ring terminal to a known good GND (use a jumper wire if needed) 5. Using a DMM, measure voltage between fuel injector 6 INJ 6 H ring terminal and terminal in ECM pin E2-01. Is voltage less than 0.3V	Yes: Repair INJ6 L circuit between fuel injector 5 and pin E2-16. After repairs are complete, retest for SPN 656 FMI 5. No: Repair INJ6 H circuit between fuel injector 5 and pin E2-01. After repairs are complete, retest for SPN 656 FMI 5.

NOTE: After performing all diagnostic steps, if SPN 656 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2797 FMI 11 - Injector Control Group 1 short circuit (INJ 1, 3, 5)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short detected in fuel injector 1, 3, or 5 circuits	High side circuit short to PWR impedance < 0.5 Ohms High side circuit short to GND impedance < 1 Ohms Low side circuit short to PWR impedance < 2 Ohms Low side circuit short to GND impedance < 2 Ohms	Engine Speed > 0 rpm Crankshaft angle between 25 deg BTDC and 23 deg ATDC Battery Voltage > 7 Volts	5 firing events

Fault Overview

Fault codes sets when a short circuit is detected in fuel injector 1, 3, or 5.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 651 FMI 4 and 5 (INJ); SPN 653 FMI 4 and 5 (INJ); SPN 655 FMI 4 and 5 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

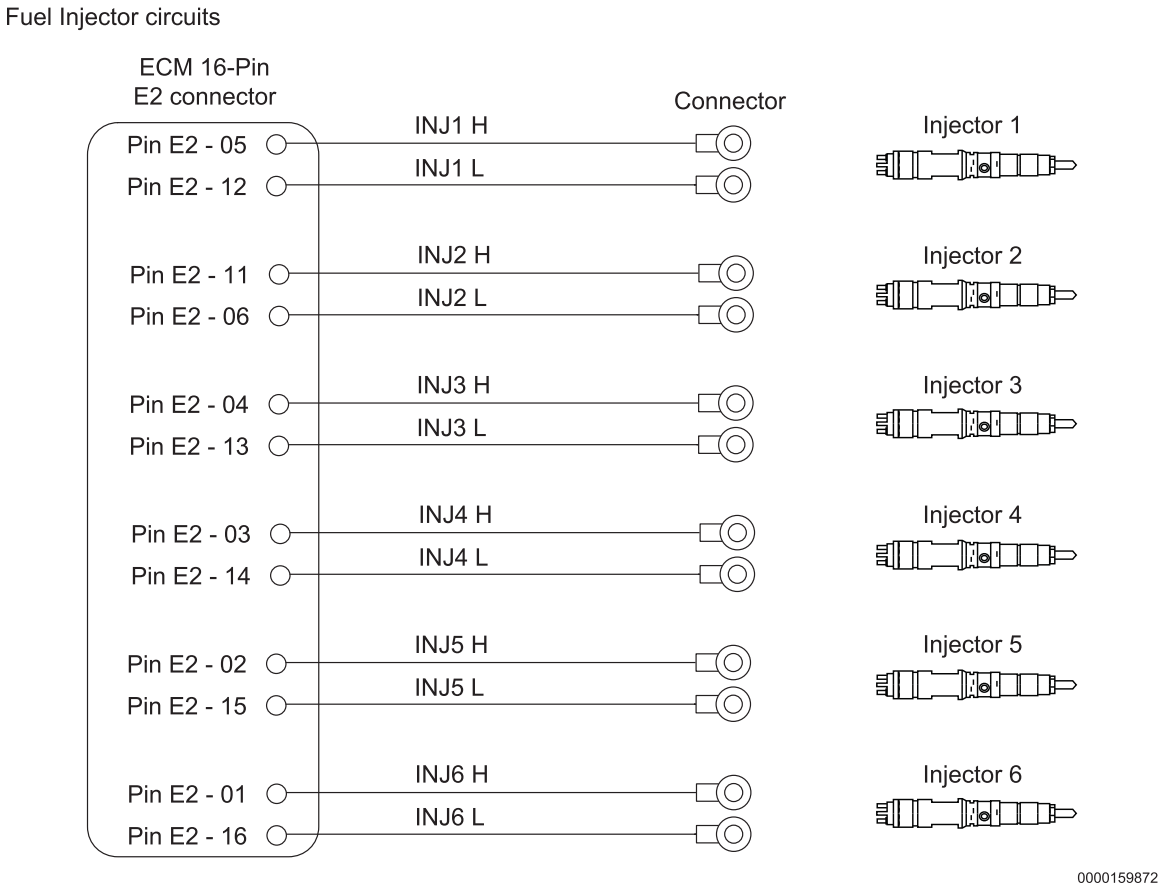


Figure 314 Fuel Injector circuit diagram

Possible Causes

- INJ1 H circuit short to PWR
- INJ1 H circuit short to GND
- INJ1 H short to INJ1 L
- INJ1 L circuit short to PWR
- INJ1 L circuit short to GND
- Fuel injector 1 wiring terminals shorted to engine brake housing
- Failed fuel injector 1
- INJ3 H circuit short to PWR
- INJ3 H circuit short to GND
- INJ3 H short to INJ3 L
- INJ3 L circuit short to PWR
- INJ3 L circuit short to GND
- Fuel injector 3 wiring terminals shorted to engine brake housing
- Failed fuel injector 3
- INJ5 H circuit short to PWR
- INJ5 H circuit short to GND
- INJ5 H short to INJ6 L
- INJ5 L circuit short to PWR
- INJ5 L circuit short to GND
- Fuel injector 5 wiring terminals shorted to engine brake housing
- Failed fuel injector 5

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 651 FMI 4 and 5 (INJ); SPN 653 FMI 4 and 5 (INJ); SPN 655 FMI 4 and 5 (INJ). Is EST DTC list free of SPN 651 FMI 4 and 5; SPN 653 FMI 4 and 5; SPN 655 FMI 4 and 5?	Yes: Go to step 2. No: Repair SPN 651 FMI 4 and 5; SPN 653 FMI 4 and 5; SPN 655 FMI 4 and 5. After repairs are complete, retest for SPN 2797 FMI 11.

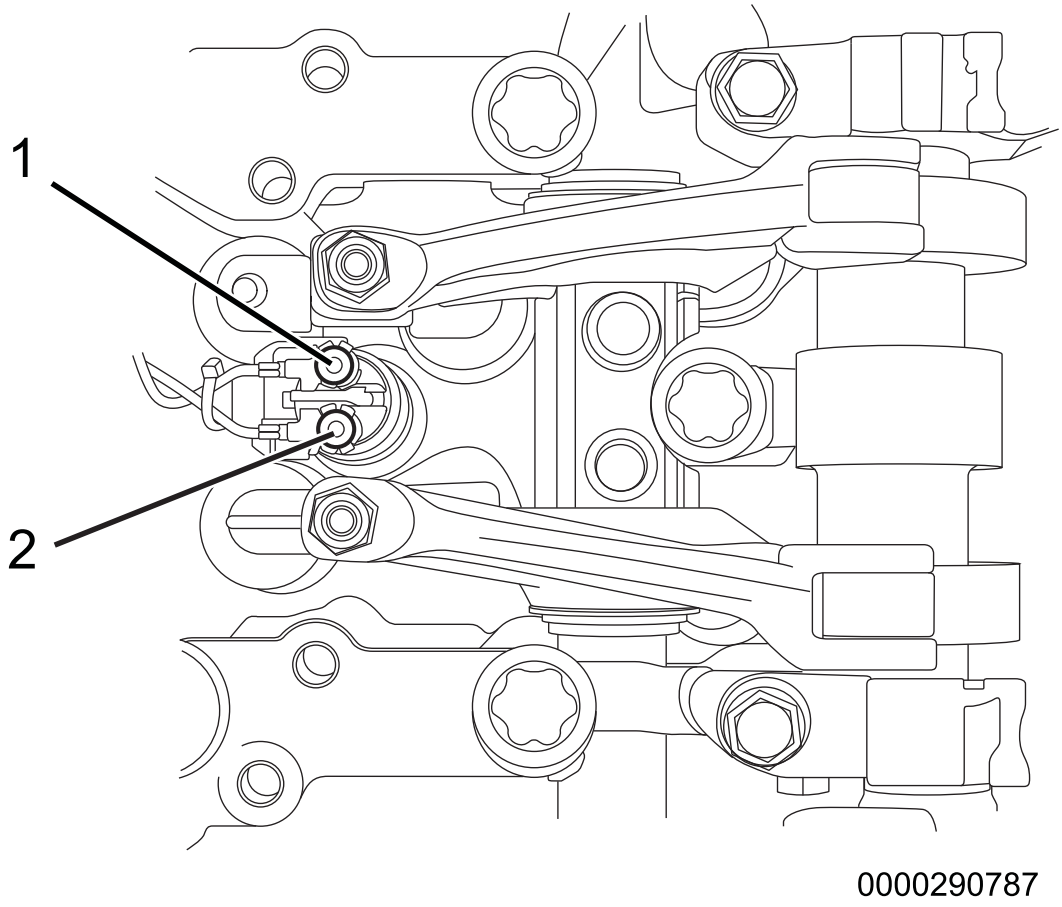


Figure 315 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
2	Verify proper fuel injector wire terminal orientation. Remove upper valve cover and engine brake housing (see Engine Service Manual). Verify fuel injector terminals are installed parallel so they do not short to ground on the engine brake housings or other components. Are fuel injector wire terminals oriented correctly and Not contacting the engine brake housing?	Yes: Go to step 3. No: Adjust connections so fuel injectors wire terminals will not contact the engine brake housing. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
3	Check for a shorted fuel injector 1 coil. Disconnect wiring terminals from fuel injector 1. Check resistance across fuel injector 1. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 4. No: Replace fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
4	Check for a shorted fuel injector 3 coil. Disconnect wiring terminals from fuel injector 3. Check resistance across fuel injector 3. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 5. No: Replace fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
5	Check for a shorted fuel injector 5 coil. Disconnect wiring terminals from fuel injector 5. Check resistance across fuel injector 5. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 6. No: Replace fuel injector 5. After repairs are complete, retest for SPN 2797 FMI 11.

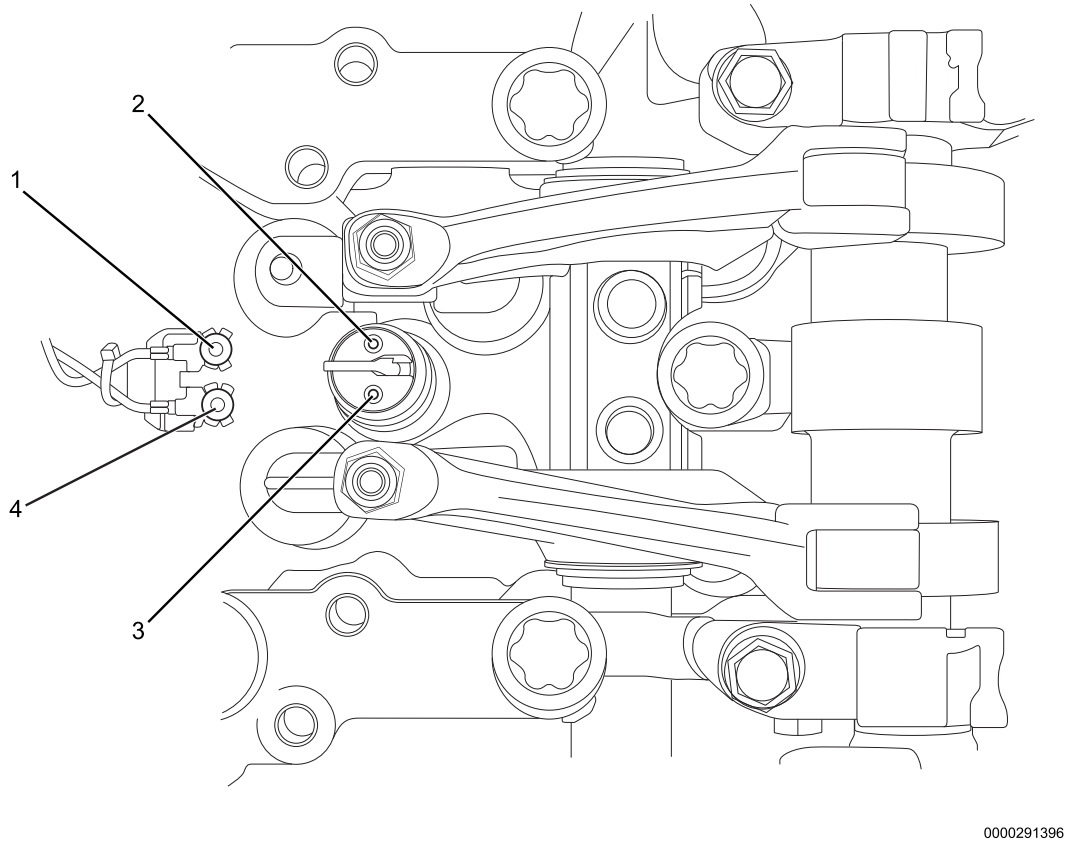


Figure 316 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
6	Check fuel injector 1 H terminal for short to GND. Key OFF with fuel injector 1 disconnected, use a DMM to measure resistance between fuel injector 1 H terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 7. No: Replace fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
7	Check fuel injector 1 L terminal for short to GND. Key OFF with fuel injector 1 disconnected, use a DMM to measure resistance between fuel injector 1 L terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 8. No: Replace fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
8	Check fuel injector 3 H terminal for short to GND. Key OFF with fuel injector 3 disconnected, use a DMM to measure resistance between fuel injector 3 H terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 9. No: Replace fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
9	Check fuel injector 3 L terminal for short to GND. Key OFF with fuel injector 3 disconnected, use a DMM to measure resistance between fuel injector 3 L terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 10. No: Replace fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
10	Check fuel injector 5 H terminal for short to GND. Key OFF with fuel injector 5 disconnected, use a DMM to measure resistance between fuel injector 5 H terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 11. No: Replace fuel injector 5. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
11	Check fuel injector 5 L terminal for short to GND. Key OFF with fuel injector 5 disconnected, use a DMM to measure resistance between fuel injector 5 L terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 12. No: Replace fuel injector 5. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
12	Inspect connections at ECM E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 13.
		No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
13	Check for INJ1 H short to INJ1 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, leave ECM E2 disconnected. Using a DMM, with fuel injector 1 disconnected measure resistance between Breakout Box pins E2-05 and E2-12 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 14.
		No: Repair INJ1 H short to INJ1 L. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
14	Check for INJ3 H short to INJ3 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 injector harness, leave ECM E2 disconnected. Using a DMM, with fuel injector 3 disconnected measure resistance between Breakout Box pins E2-04 and E2-13 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 15.
		No: Repair INJ3 H short to INJ3 L. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
15	Check for INJ5 H short to INJ5 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 injector harness, leave ECM E2 disconnected. Using a DMM, with fuel injector 5 disconnected measure resistance between Breakout Box pins E2-02 and E2-15 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 16.
		No: Repair INJ5 H short to INJ5 L. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
16.	Check INJ1 H circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 1 disconnected, measure resistance between Breakout Box pin E2-05 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 17.
		No: Repair short to GND between ECM pin E2-05 and fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
17	Check INJ1 L circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 1 disconnected, measure resistance between Breakout Box pin E2-12 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 18. No: Repair short to GND between ECM pin E2-12 and fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
18	Check INJ3 H circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 3 disconnected, measure resistance between Breakout Box pin E2-04 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 19. No: Repair short to GND between ECM pin E2-04 and fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
19	Check INJ3 L circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 3 disconnected, measure resistance between Breakout Box pin E2-13 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 20. No: Repair short to GND between ECM pin E2-13 and fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
20	Check INJ5 H circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 5 disconnected, measure resistance between Breakout Box pin E2-02 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 21. No: Repair short to GND between ECM pin E2-02 and fuel injector 5. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
21	Check INJ5 L circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 5 disconnected, measure resistance between Breakout Box pin E2-15 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 22. No: Repair short to GND between ECM pin E2-15 and fuel injector 5. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
22	Check INJ1 H circuit for short to PWR. Key-On Engine-Off (KOEO), connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 1 disconnected, measure voltage between Breakout Box pin E2-05 and a known good GND (wiggle test may be required). Is voltage less than 0.5 volts?	Yes: Go to step 23. No: Repair short to PWR between ECM pin E2-05 and fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
23	Check INJ1 L circuit for short to PWR. KOEO, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 1 disconnected, measure voltage between Breakout Box pin E2-12 and known good GND (wiggle test may be required). Is voltage less than 0.5 Volts?	Yes: Go to step 24. No: Repair short to PWR between ECM pin E2-12 and fuel injector 1. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
24	Check INJ3 H circuit for short to PWR. KOEO, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 3 disconnected, measure voltage between Breakout Box pin E2-04 and known good GND (wiggle test may be required). Is voltage less than 0.5 volts?	Yes: Go to step 25. No: Repair short to PWR between ECM pin E2-04 and fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
25	Check INJ3 L circuit for short to PWR. KOEO, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 3 disconnected, measure voltage between Breakout Box pin E2-13 and known good GND (wiggle test may be required). Is voltage less than 0.5 volts?	Yes: Go to step 26. No: Repair short to PWR between ECM pin E2-13 and fuel injector 3. After repairs are complete, retest for SPN 2797 FMI 11.

Step	Action	Decision
26	Check INJ5 H circuit for short to PWR. KOEO, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 5 disconnected, measure voltage between Breakout Box pin E2-02 and known good GND (wiggle test may be required). Is voltage less than 0.5 volts?	Yes: Repair short to PWR between ECM pin E2-15 and fuel injector 5. After repairs are complete, retest for SPN 2797 FMI 11. No: Repair short to PWR between ECM pin E2-02 and fuel injector 5. After repairs are complete, retest for SPN 2797 FMI 11.

NOTE: After performing all diagnostic steps, if SPN 2797 FMI 11 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 2798 FMI 11 - Injector Control Group 2 short circuit (INJ 2, 4, 6)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Short detected in fuel injector 2, 4, or 6 circuits	High side circuit short to PWR impedance < 0.5 Ohms High side circuit short to GND impedance < 1 Ohms Low side circuit short to PWR impedance < 2 Ohms Low side circuit short to GND impedance < 2 Ohms	Engine Speed >0 rpm Crankshaft angle between 25 deg BTDC and 23 deg ATDC Battery Voltage > 7 Volts	5 firing events

Fault Overview

Fault codes sets when a short circuit is detected in fuel injector 2, 4, or 6.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 652 FMI 4 and 5 (INJ); SPN 654 FMI 4 and 5 (INJ); SPN 656 FMI 4 and 5 (INJ)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

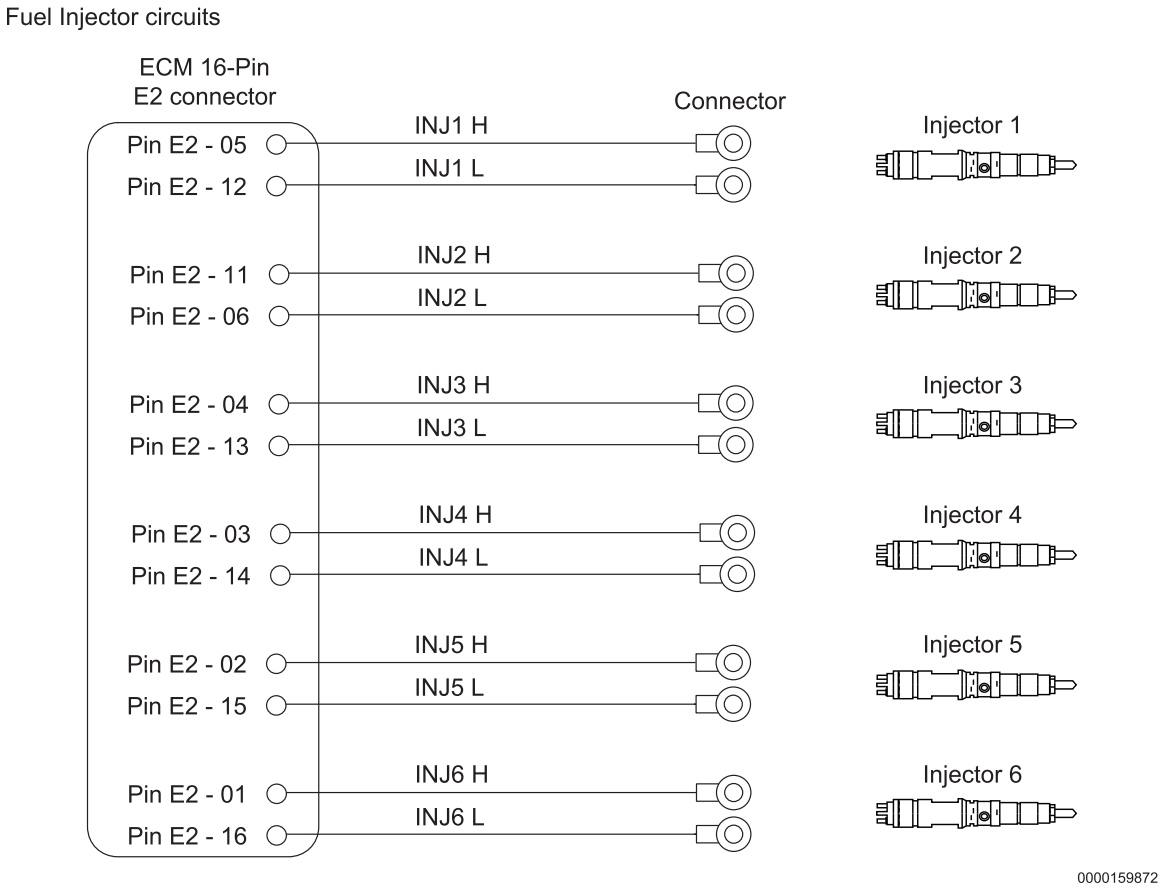


Figure 317 Fuel Injector circuit diagram

Possible Causes

- INJ2 H circuit short to PWR
- INJ2 H circuit short to GND
- INJ2 H short to INJ2 L
- INJ2 L circuit short to PWR
- INJ2 L circuit short to GND
- Fuel injector 2 shorted to engine brake housing
- Failed fuel injector 2
- INJ4 H circuit short to PWR
- INJ4 H circuit short to GND
- INJ4 H short to INJ4 L
- INJ4 L circuit short to PWR
- INJ4 L circuit short to GND
- Fuel injector 4 shorted to engine brake housing
- Failed fuel injector 4
- INJ6 H circuit short to PWR
- INJ6 H circuit short to GND
- INJ6 H short to INJ6 L
- INJ6 L circuit short to PWR
- INJ6 L circuit short to GND
- Fuel injector 6 shorted to engine brake housing
- Failed fuel injector 6

WARNING: To prevent personal injury or death, shut engine down before doing voltage checks for injector solenoids. When the engine is running, injector circuits have high voltage and amperage.

CAUTION: To avoid engine damage, turn the ignition switch to OFF before disconnecting connectors. Failure to turn ignition switch to OFF will cause a voltage spike and damage to electrical components.

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 652 FMI 4 and 5 (INJ); SPN 654 FMI 4 and 5 (INJ); SPN 656 FMI 4 and 5 (INJ). Is EST DTC list free of SPN 652 FMI 4 and 5; SPN 654 FMI 4 and 5; SPN 656 FMI 4 and 5?	Yes: Go to step 2. No: Repair SPN 652 FMI 4 and 5; SPN 654 FMI 4 and 5; SPN 656 FMI 4 and 5. After repairs are complete, retest for SPN 2798 FMI 11.

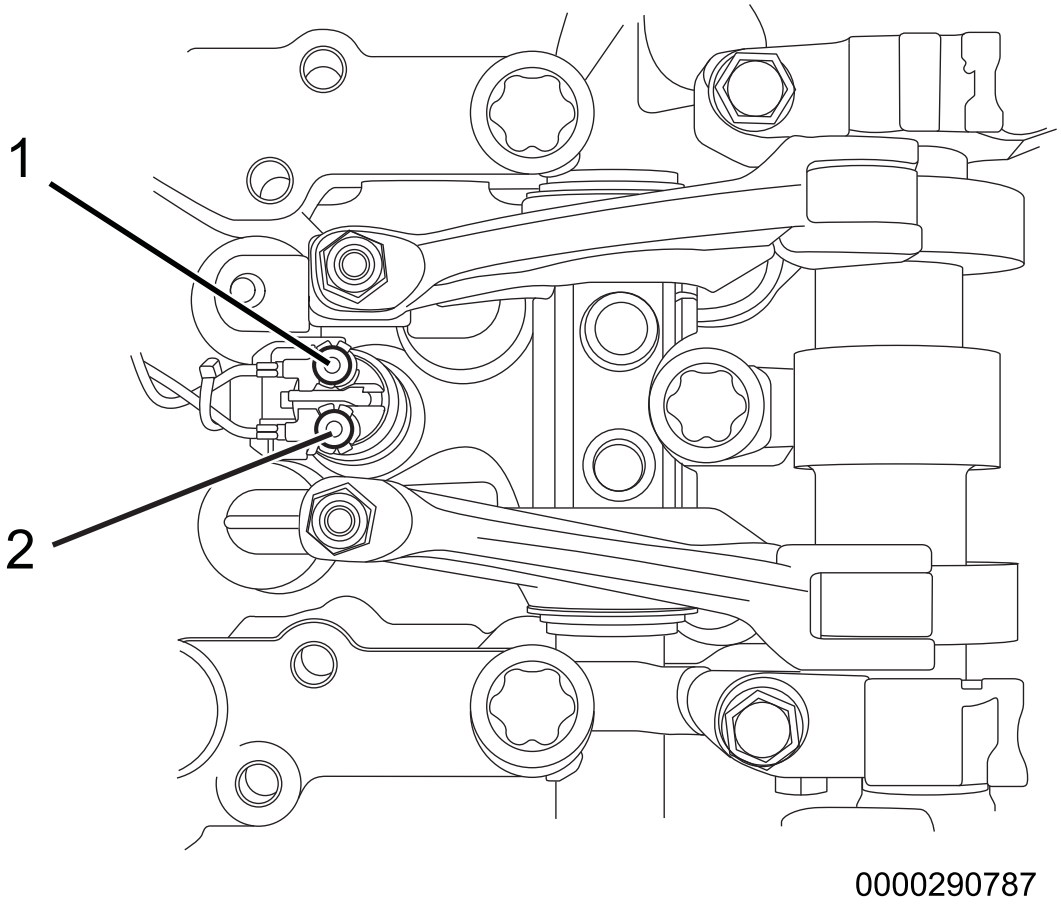


Figure 318 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
2	Verify proper fuel injector wire terminal orientation. Remove upper valve cover and engine brake housing (see Engine Service Manual). Verify fuel injector terminals are installed parallel so they do not short to ground on the engine brake housings or other components. Are fuel injector wire terminals oriented correctly and Not contacting the engine brake housing?	Yes: Go to step 3. No: Adjust connections so fuel injectors wire terminals will not contact the engine brake housing. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
3	Check for a shorted fuel injector 2 coil. Disconnect wiring terminals from fuel injector 2. Check resistance across fuel injector 2. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 4. No: Replace fuel injector 2. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
4	Check for a shorted fuel injector 4 coil. Disconnect wiring terminals from fuel injector 3. Check resistance across fuel injector 4. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 5. No: Replace fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
5	Check for a shorted fuel injector 6 coil. Disconnect wiring terminals from fuel injector 5. Check resistance across fuel injector 6. Is resistance between 0.2 to 0.8 Ohms?	Yes: Go to step 6. No: Replace fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 11.

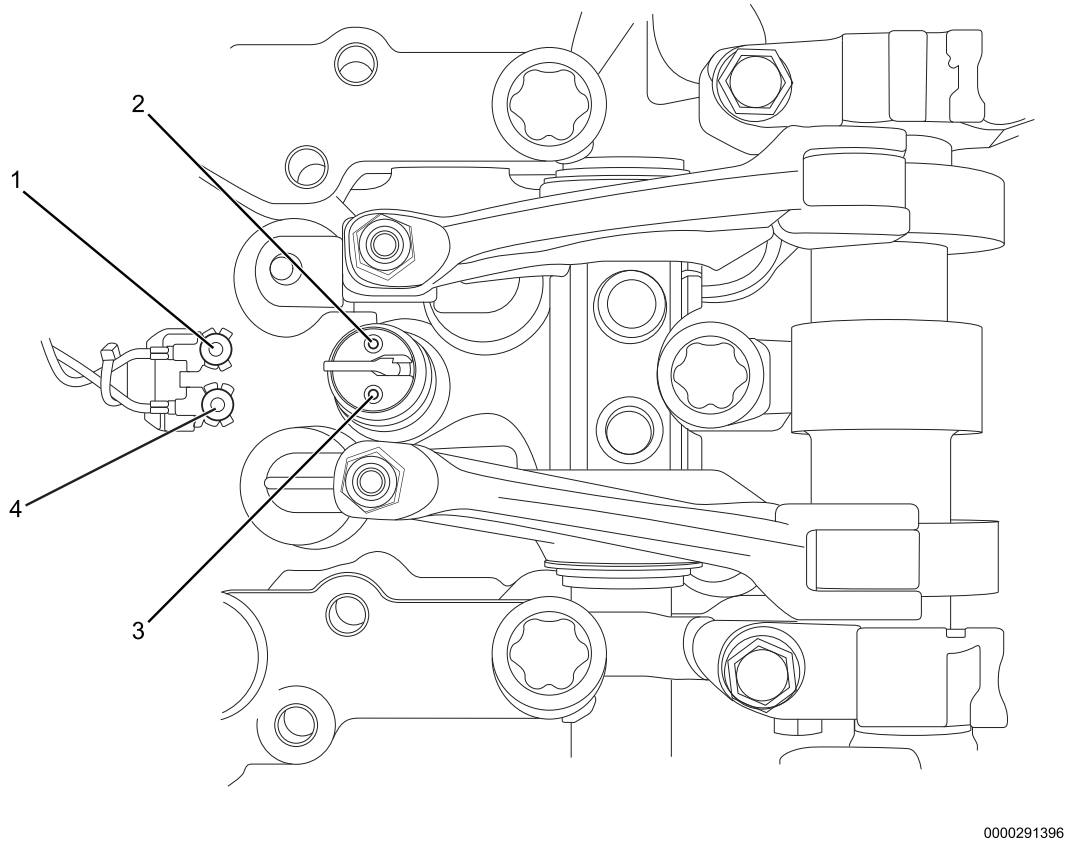


Figure 319 Fuel Injector Wiring Terminal Orientation

1. Fuel injector H wiring terminal
2. Fuel injector H terminal
3. Fuel injector L terminal
4. Fuel injector L wiring terminal (brown wire color [typical])

Step	Action	Decision
6	Check fuel injector 2 H terminal for short to GND. Key OFF with fuel injector 2 disconnected, use a DMM to measure resistance between fuel injector 2 H terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 7. No: Replace fuel injector 2. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
7	Check fuel injector 2 L terminal for short to GND. Key OFF with fuel injector 2 disconnected, use a DMM to measure resistance between fuel injector 2 L terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 8. No: Replace fuel injector 2. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
8	Check fuel injector 4 H terminal for short to GND. Key OFF with fuel injector 4 disconnected, use a DMM to measure resistance between fuel injector 4 H terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 9. No: Replace fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
9	Check fuel injector 4 L terminal for short to GND. Key OFF with fuel injector 4 disconnected, use a DMM to measure resistance between fuel injector 4 L terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 10. No: Replace fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
10	Check fuel injector 6 H terminal for short to GND. Key OFF with fuel injector 6 disconnected, use a DMM to measure resistance between fuel injector 6 H terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 11. No: Replace fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
11	Check fuel injector 6 L terminal for short to GND. Key OFF with fuel injector 6 disconnected, use a DMM to measure resistance between fuel injector 6 L terminal and GND. Is resistance greater than 1000 ohms?	Yes: Go to step 12. No: Replace fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
12	Inspect connections at ECM E2 connector. Key OFF, disconnect ECM E2 connector. Check ECM E2 connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E2 connector, harness, and terminals clean and undamaged?	Yes: Go to step 13. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
13	Check for INJ2 H short to INJ2 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, leave ECM E2 disconnected. Using a DMM, with fuel injector 2 disconnected measure resistance between Breakout Box pins E2-11 and E2-06 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 14. No: Repair INJ2 H short to INJ2 L. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
14	Check for INJ4 H short to INJ4 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 injector harness, leave ECM E2 disconnected. Using a DMM, with fuel injector 4 disconnected measure resistance between Breakout Box pins E2-03 and E2-14 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 15. No: Repair INJ4 H short to INJ4 L. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
15	Check for INJ6 H short to INJ6 L. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 injector harness, leave ECM E2 disconnected. Using a DMM, with fuel injector 6 disconnected measure resistance between Breakout Box pins E2-01 and E2-16 (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 16. No: Repair INJ6 H short to INJ6 L. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
16.	Check INJ2 H circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 2 disconnected, measure resistance between Breakout Box pin E2-11 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 17. No: Repair short to GND between ECM pin E2-11 and fuel injector 2. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
17	Check INJ2 L circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 2 disconnected, measure resistance between Breakout Box pin E2-06 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 18. No: Repair short to GND between ECM pin E2-06 and fuel injector 2. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
18	Check INJ4 H circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 4 disconnected, measure resistance between Breakout Box pin E2-03 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 19. No: Repair short to GND between ECM pin E2-03 and fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
19	Check INJ4 L circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 4 disconnected, measure resistance between Breakout Box pin E2-14 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 20. No: Repair short to GND between ECM pin E2-14 and fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
20	Check INJ6 H circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 6 disconnected, measure resistance between Breakout Box pin E2-01 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 21. No: Repair short to GND between ECM pin E2-01 and fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
21	Check INJ6 L circuit for short to GND. Key OFF, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 6 disconnected, measure resistance between Breakout Box pin E2-16 and a known good GND (wiggle test may be required). Is resistance greater than 1000 ohms?	Yes: Go to step 22. No: Repair short to GND between ECM pin E2-16 and fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
22	Check INJ2 H circuit for short to PWR. Key-On Engine-Off (KOEO), connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 2 disconnected, measure voltage between Breakout Box pin E2-11 and a known good GND (wiggle test may be required). Is voltage less than 0.5 volts?	Yes: Go to step 23. No: Repair short to PWR between ECM pin E2-11 and fuel injector 2. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
23	Check INJ2 L circuit for short to PWR. KOEO, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 2 disconnected, measure voltage between Breakout Box pin E2-06 and known good GND (wiggle test may be required). Is voltage less than 0.5 Volts?	Yes: Go to step 24. No: Repair short to PWR between ECM pin E2-06 and fuel injector 2. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
24	Check INJ4 H circuit for short to PWR. KOEO, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 4 disconnected, measure voltage between Breakout Box pin E2-03 and known good GND (wiggle test may be required). Is voltage less than 0.5 volts?	Yes: Go to step 25. No: Repair short to PWR between ECM pin E2-03 and fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
25	Check INJ4 L circuit for short to PWR. KOEO, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 4 disconnected, measure voltage between Breakout Box pin E2-14 and known good GND (wiggle test may be required). Is voltage less than 0.5 volts?	Yes: Go to step 26. No: Repair short to PWR between ECM pin E2-14 and fuel injector 4. After repairs are complete, retest for SPN 2798 FMI 11.

Step	Action	Decision
26	Check INJ6 H circuit for short to PWR. KOEO, connect 180-pin Breakout Box with Breakout Harness 00-01468-00 to vehicle harness, and leave ECM disconnected. Using a DMM with fuel injector 6 disconnected, measure voltage between Breakout Box pin E2-01 and known good GND (wiggle test may be required). Is voltage less than 0.5 volts?	Yes: Repair short to PWR between ECM pin E2-16 and fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 11. No: Repair short to PWR between ECM pin E2-01 and fuel injector 6. After repairs are complete, retest for SPN 2798 FMI 11.

NOTE: After performing all diagnostic steps, if SPN 2798 FMI 11 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

IST (Idle Shutdown Timer) System (Clean Low Idle)

IST (Clean Low Idle)

The Idle Shutdown Timer (IST) ("Clean Low Idle") allows the ECM to shut down the engine during extended idle. When parking brake is set, the idle time can be programmed up to 5 minutes. When parking brake is released, the idle time can be programmed up to 15 minutes. During service, the idle time can be programmed up to 60 minutes. The ECM deactivates the IST when the PTO is active.

Thirty seconds before engine shutdown, the IST engine lamp illuminates. This continues until the engine shuts down or the low idle shutdown timer is reset. Idle time is measured from the last clutch or APP. The engine must be out of gear for the IST to work. Engine shutdown time resets for one or more of the following conditions:

- Engine speed is not at idle speed.
- Vehicle movement or a Vehicle Speed Sensor (VSS) fault is detected.
- DPF Regeneration is enabled (Any REGEN State).
- Accelerator pedal movement or an Accelerator Pedal Position (APP) fault is detected.
- Engine coolant operating temperature is below 16 °C (60 °F).
- Brake pedal movement or a brake switch fault is detected.
- Parking brake transition is detected.
- Clutch pedal is pressed or clutch pedal switch fault is detected (manual transmissions, if equipped with a clutch switch).
- Shift selector is moved from neutral (automatic transmissions).
- If the IST is enabled, the CAP will not function.

IST (Idle Shutdown Timer) System (Federal - Optional)

IST (Federal - Optional) Sensor Circuit Operation

The optional Idle Shutdown Timer (IST) allows the ECM to shut down the engine during extended idle. Idle time can be programmed from 5 to 120 minutes. The ECM can be programmed to deactivate the IST when the Power Takeoff (PTO) is active.

- Engine speed is not at idle speed (600 rpm).
- Vehicle movement or a Vehicle Speed Sensor (VSS) fault is detected.
- Manual DPF Regeneration is enabled.
- Accelerator pedal movement or an Accelerator Pedal Position (APP) fault is detected.
- Engine coolant operating temperature is below 60 °C (140 °F).
- Ambient temperature below 16° C (60 °F) or above 44 °C (110 °F).
- Brake pedal movement or a brake switch fault is detected.
- Parking brake transition is detected.
- Clutch pedal is pressed or clutch pedal switch fault is detected (manual transmissions, if equipped with a clutch switch).
- Shift selector is moved from neutral (automatic transmissions).
- If the IST is enabled, the CAP will not function.

J1939 Data Link Communications

SPN	FMI	Condition	Possible Causes	Actions
560	19	Transmission Driveline Engaged not detected on J1939	• Transmission driveline engaged switch or circuit fault	See *Electrical System Troubleshooting Guide* for troubleshooting the switch
639	14	J1939 Data Link Error (ECM unable to transmit)	• J1939 Data link circuit fault • Failed ECM	Circuit Checks (page 805)
639	19	J1939 Data Link Error (ECM unable to transmit or receive)	• J1939 Data link circuit fault • Failed ECM	Circuit Checks (page 805)
1590	19	Adaptive Cruise Control not detected on J1939	• Incorrect programmable parameter • J1939 Data link circuit fault	Pinpoint Diagnostics (page 806)

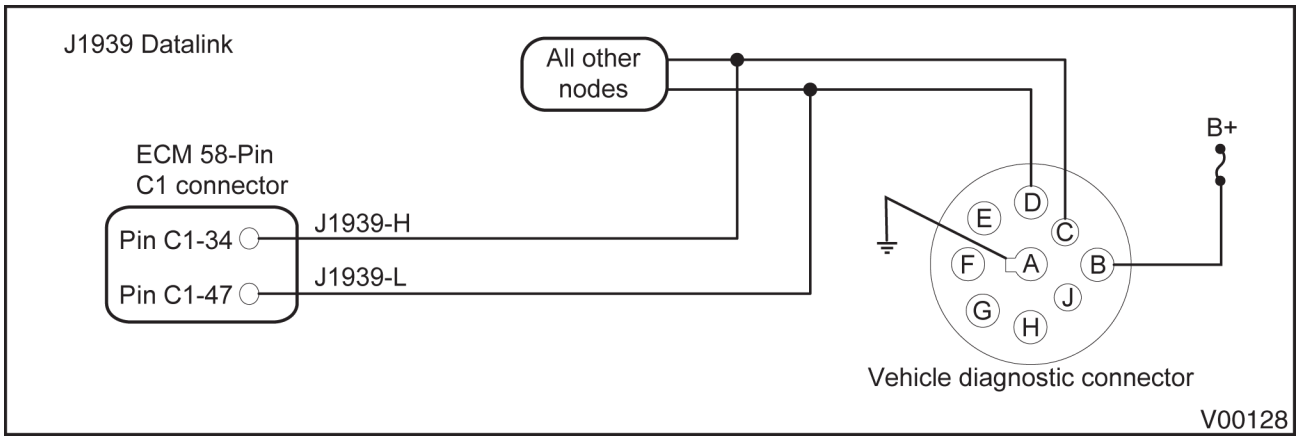


Figure 320 J1939 data link circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Vehicle Diagnostic Connector Voltage Check

Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
B to GND	B+	If < B+, check B+ circuit to vehicle diagnostic connector for OPEN or short to GND, or blown fuse.
B to A	B+	If < B+, check GND circuit to vehicle diagnostic connector for OPEN.
C to GND	1 V to 4 V	The sum of C to GND and D to GND should = 4 V to 5 V.
D to GND	1 V to 4 V	The sum of C to GND and D to GND should = 4 V to 5 V.

EST Communication Check

Turn ignition switch to ON. Connect EST to vehicle diagnostic connector. If the EST is unable to communicate with the ECM, disconnect each module connected to the J1939 data link individually, until communication can be established.

NOTE:

- **If communication to ECM is established, check J1939 circuits to disconnected node for correct wiring. See truck *Electrical System Troubleshooting Guide*.**
- **If communication to ECM is not established, go to next test point.**

Test Point	Comment
Disconnect TCM	See note.
Disconnect Body Controller	See note.
Disconnect instrument cluster	See note.
Disconnect other nodes	See note.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C to D	approximately 60 Ω	If not within specification, measure individual CAN terminating resistors.
Terminating Resistor Terminals	approximately 120 Ω	If not within specification, replace faulty terminating resistor(s).
C to C1-34	< 5 Ω	If > 5 Ω, check J1939-H for OPEN in circuit.
C to GND	> 1k Ω	If < 1k Ω, check J1939-H for short to GND.
D to C1-47	< 5 Ω	If > 5 Ω, check J1939-L for OPEN in circuit.
D to GND	> 1k Ω	If < 1k Ω, check J1939-L for short to GND.
A to GND	< 5 Ω	If > 5 Ω, check GND for OPEN in circuit.

Pinpoint Diagnostics With ServiceMaxx™ Software

SPN 1590 FMI 19 - Adaptive Cruise Control not detected on J1939

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Parameters session Verify the correct Adaptive Cruise Control (ACC) system is selected under parameter ID 76102 Adaptive Cruise Control Enable (disable, Vorad, Wingman, or Wabco).

   Is the correct ACC system selected under parameter ID 76102?

   - Yes: Go to J1939 datalink circuit checks (page 805).
   - No: Correct parameter ID 76102 and program engine. Retest for SPN 1590 FMI 19.

MAF Sensor (Mass Air Flow)

SPN	FMI	Condition	Possible Causes
None			

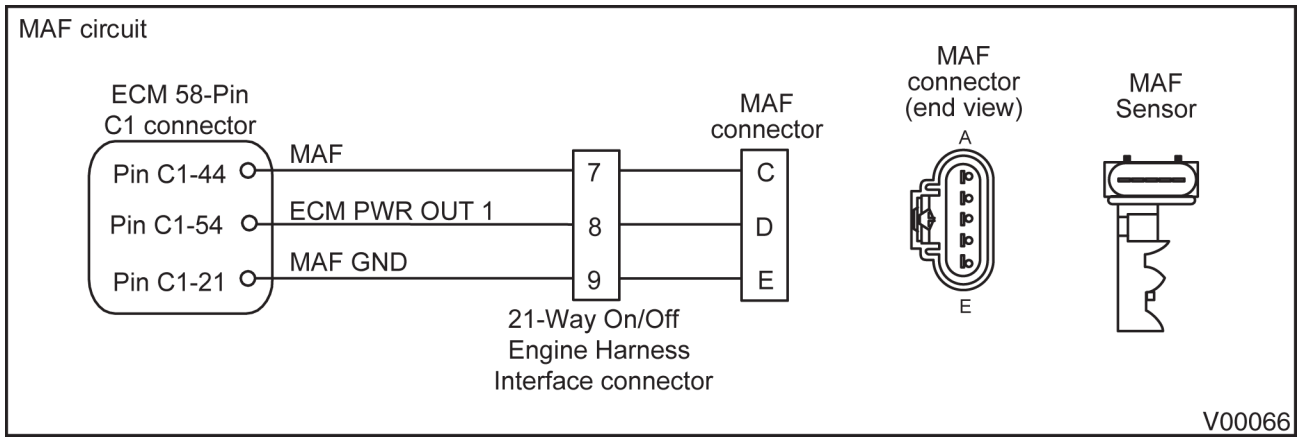


Figure 321 MAF sensor circuit diagram

Function

The MAF sensor is connected to the engine, but is disabled in ECM software. This sensor should never be replaced.

MIL (Malfunction Indicator Lamp)

SPN	FMI	Condition	Possible Causes	Actions
1213	3	MIL circuit short to PWR	• MIL circuit short to PWR	Circuit Checks (page 809)
1213	4	MIL circuit short to GND	• MIL circuit shorted to GND • Failed MIL	Circuit Checks (page 809)
1213	5	MIL open load/circuit	• MIL circuit OPEN • Failed MIL	Circuit Checks (page 809)

Overview

The Malfunction Indicator Lamp (MIL) illuminates when the Heavy-Duty On-Board Diagnostics (HD-OBD) system detects a malfunction related to the emissions control system. The illuminated MIL indicates the vehicle needs to be serviced at the first convenient opportunity. Lamp may remain active after repair until system operation confirms repair.

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- Digital Multimeter (DMM)

MIL Connector Voltage Check Without ServiceMaxx™ Software

Turn ignition OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness between ECM C1 and C2 connectors and ECM. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
MIL circuit not activated	0.1 V to 0.3 V	If no voltage is present, check for OPEN or short to GND.
C1–57 to GND		If > 0.3 V, check for short to PWR.
MIL circuit activated	B+	If no voltage is present, check for OPEN or short to GND.
C1–57 to GND		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C1–57 to 1–H	< 5 Ω	If > 5 Ω, check for OPEN circuit.
C1–24 to 2–C	< 5 Ω	If > 5 Ω, check for OPEN circuit.

O_2S (Oxygen Sensor)

SPN	FMI	Condition	Possible Causes	Actions
724	2	O_2S Slow response detecting fueling to non-fueling	• Failed O_2S • Replace sensor and run Oxygen Sensor (O_2S) calibration	Pin-Point Diagnostics (page 814)
724	3	O_2S circuit Fault: Open or short to PWR	• O_2 circuit short to PWR • Failed O_2S	Pin-Point Diagnostics (page 814)
724	4	O_2S circuit Fault: Short to GND	• O_2 circuit short to GND • Failed O_2S	Pin-Point Diagnostics (page 814)
724	5	O_2S circuit fault: Open circuit	• O_2S Open circuit • Failed O_2S	Pin-Point Diagnostics (page 814)
724	20	O_2S adaptation above maximum limit	• Oxygen sensor contamination • Failed oxygen sensor • Faulty TC1TOP signal	Step-based Diagnostics (page 816)
724	21	O_2S adaptation below minimum limit	• Biased TC1TOP sensor or circuit • Intermittent TC1TOP circuit fault • Restricted EBPV tube • Failed O_2S or circuit	Circuit Checks (page 819)
3223	0	O_2S heater temperature above maximum	• O_2 heater circuit short to GND • Failed O_2S	Step-based Diagnostics (page 820)
3223	1	O_2S heater temperature below minimum	• Charging System fault (Low B+ when O_2 Heater was commanded on) • O_2S or circuit fault	Pin-Point Diagnostics (page 825)
3223	3	O_2S heater short to PWR	• O_2 heater circuit short to PWR • Failed O_2S	Pin-Point Diagnostics (page 814)

3223	4	O_2S heater short to GND	• O_2 heater circuit short to GND • Failed O_2S	Pin-Point Diagnostics (page 814)
3223	5	O_2S heater open load/circuit	• HTR CTL circuit short to GND • ECM PWR OUT 1 circuit Open or high resistance • HTR CTL circuit Open or high resistance • Failed O_2S	Step-Based Diagnostics (page 822)
3223	17	O_2S heater temperature below minimum at low battery PWR	• Charging system fault (low B+ when O_2 heater was commanded ON)	Pin-Point Diagnostics (page 825)

O2S Circuit

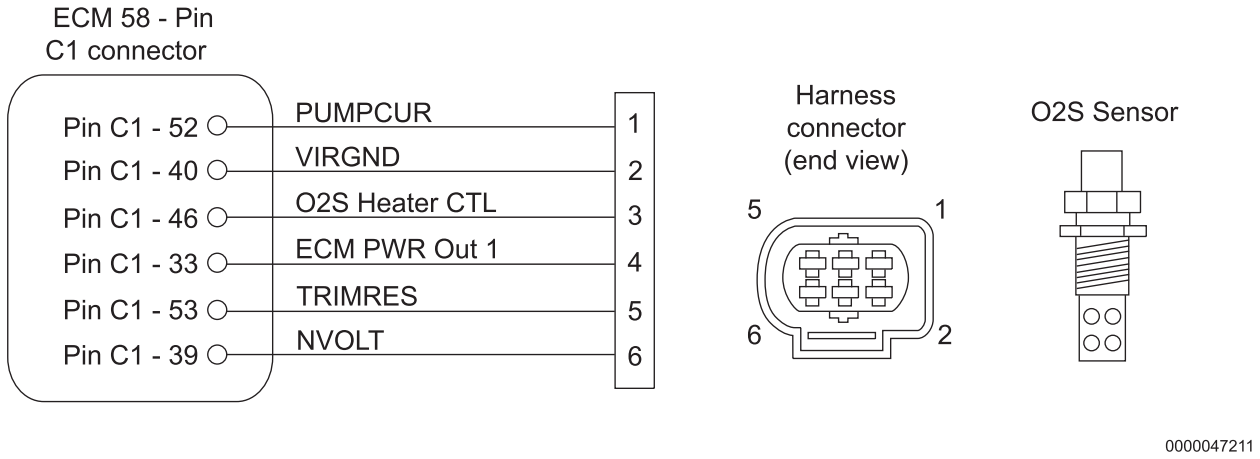


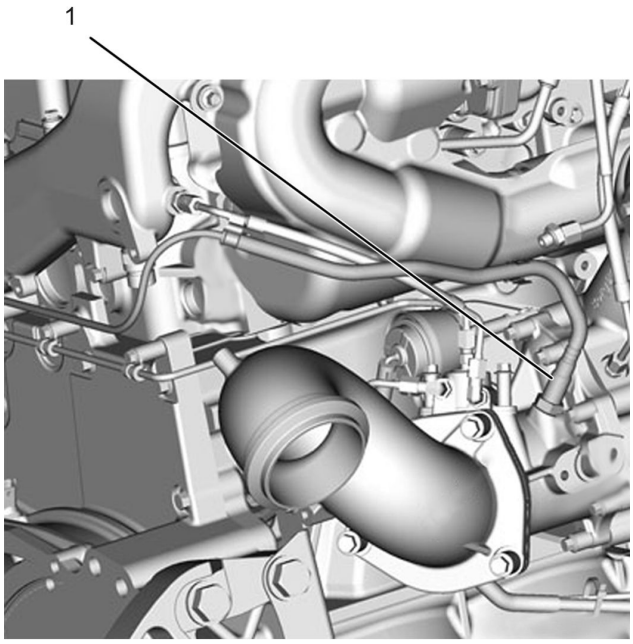
Figure 323 O_2S circuit diagram

Overview

The Oxygen Sensor (O_2S) is a wide band oxygen sensor used to control engine fueling and provide input for Exhaust Gas Recirculation (EGR) valve position. The O_2S is a six wire sensor that provides a variable voltage signal to the Engine Control Module (ECM) to determine the amount of oxygen entering the exhaust system. A heating element is used during initial engine warm-up to bring the sensor up to a normal operating temperature of 1,436°F (780°C). The O_2S heater element is only activated when engine coolant temperature reaches 104°F (40°C), and exhaust gas temperature exceeds 212°F (100°C) for more than 30 seconds.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- 3-Banana Plug Harness ZTSE4498
- 500 Ohm Resistor Harness ZTSE4497
- Big Bore Terminal Test Probe Kit ZTSE4899
- Breakout Harness ZTSE4735A (O_2S)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)



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Figure 324 Oxygen Sensor Location

1. Oxygen Sensor (O_2S)

O2S Circuit

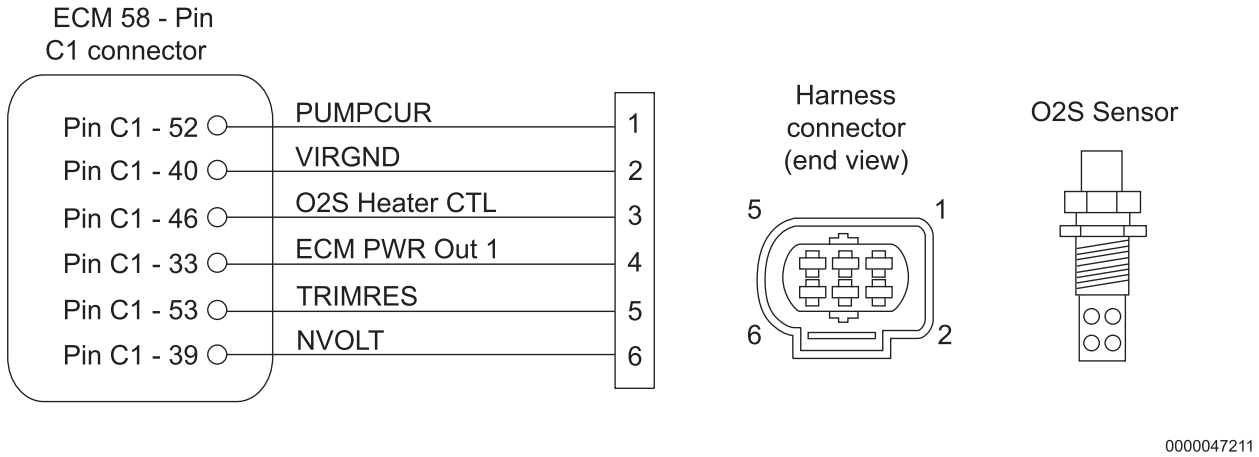


Figure 325 O_2S circuit diagram

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

Pinpoint Diagnostics With ServiceMaxx™ Software

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, verify DTC is active for this sensor.
   - If code is previously active, wiggle the harness of the suspect sensor. If the circuit is interrupted, the DTC will go active.
   - If code is active, proceed to Connector Voltage Check.

NOTE: Inspect connectors for damaged, corrosion, or loose pins. Repair if necessary.

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4735A to O_2S vehicle harness, and leave O_2S sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	2.9 V ± 1 V	If < 1.9 V, check for OPEN or short to GND.
2 to GND	2.6 V ± 1 V	If < 1.6 V, check for OPEN or short to GND.
3 to GND	4.8 V ± 1 V	If < 3.8 V, check for OPEN or short to GND.
4 to GND	12V ± 2 V	If < 10 V, check for OPEN circuit or short to GND.
5 to GND	2.9 V ± 1 V	If < 1.9 V, check for OPEN or short to GND.
6 to GND	3 V ± 1 V	If < 2 V , check for OPEN or short to GND.
If measurements are within specification, do Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4735A to O_2S vehicle harness, and leave O_2S sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to C1-52	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
1 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
2 to C1-40	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
2 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
3 to C1-46	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
3 to GND	>1k Ω	If < 1k Ω, check for short to GND.
4 to C1-33	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
4 to GND	>1k Ω	If < 1k Ω, check for short to GND.
5 to C1-53	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
5 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
6 to C1-39	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
6 to GND	> 1k Ω	If < 1k Ω, check for short to GND.
If measurements are in specification, calibrate and install new O_2S.		

SPN 724 FMI 20 – O_2S adaptation above maximum limit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
The stored adaptation value for the oxygen sensor (O_2S) is above the maximum threshold	Adaptation value > 0.03	Time in overrun (motoring) >0 seconds Exhaust Backpressure Valve (EBPV) not closed Ambient Air Temperature (AAT) < 212°F (100°C) Oxygen sensor temperature >1400°F (760°C) and < 1472°F (800°C) Fresh air flow during overrun > 420 g Not in regeneration mode [Release from dewpoint detection: dew point: ECT1, >10.06 C dew point: DOCIT >100.1 C DOCIT exceeded for >30 seconds] Difference between filtered and unfiltered O2 concentration <0.0018	3 seconds

Fault Overview

Fault code sets when the learned O_2S adaptation value exceeds 0.03.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 3 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Oxygen sensor contamination
- Failed oxygen sensor

Step	Action	Decision
1	Verify ECM has the latest calibration. Check calibration scorecard on Service Portal. Is calibration current?	Yes: Go to step 2. No: Update calibration. After update is complete, go to step 2.

Step	Action	Decision
2	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 724 FMI 3, 4, 5 (O_2S) Is EST DTC list free of SPN 724 FMI 3, 4, 5?	Yes: Go to step 3. No: Repair SPN 724 FMI 3, 4,5. After repairs are complete, retest for SPN 724 FMI 20.

Step	Action	Decision
3	Check O2 sensor adaptation value. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the parameter session. Find parameter ID 99162 : Lambda sensor adaptation value, and document the value. Is the adaptation value > 0.03?	Yes: Go to step 4. No: Clear fault. After repairs are complete, retest for SPN 724 FMI 20.

Step	Action	Decision
4	Run the Relative Compression Test to add oxygen to the exhaust and then run O2 Sensor Calibration. • Connect a battery charger. • Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests> Relative Compression Test. Run the Relative Compression Test (disables the injectors) and crank the engine for 15 seconds. Disregard the results of the Relative Compression Test. • Exit Relative Compression test. Go to Procedures > KOEO Procedures > O2 Sensor Calibration, and run O2 sensor calibration without removing the O2 sensor. Check the value of parameter 99162 : Lambda sensor adaptation value Is the adaptation value > 0.03?	Yes: Replace O2 Sensor. After repairs are complete, go to step 5. No: Clear fault. After repairs are complete, retest for SPN 724 FMI 20.

Step	Action	Decision
5	Run the Relative Compression Test to add oxygen to the exhaust and then run O2 Sensor Calibration. • Connect a battery charger. • Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests> Relative Compression Test. Run the Relative Compression Test (disables the injectors) and crank the engine for 15 seconds. Disregard the results of the Relative Compression Test. • Exit Relative Compression test. Go to Procedures > KOEO Procedures > O2 Sensor Calibration, and run O2 sensor calibration without removing the O2 sensor. Check the value of parameter 99162 : Lambda sensor adaptation value Is the adaptation value > 0.03?	Yes: Verify steps were performed in proper sequence and completed correctly. Notify supervisor if fault remains. No: Go to step 6.

Step	Action	Decision
6	Reset relevant ECM parameters in ServiceMaxx. **NOTE: Not all calibrations have all parameters available.** Using EST, load the parameter session. • Set parameters 99520, 99530, and 99540 to 0. • Set parameter 99550 to 780°C. Were parameters programmed successfully?	Yes: Clear fault. After repairs are complete, retest for SPN 724 FMI 20. No: Verify steps were performed in proper sequence and completed correctly. Notify supervisor if fault remains.

NOTE: After performing all diagnostic steps, if SPN 724 FMI 20 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 724 FMI 21 – O_2S adaptation below minimum limit

Biased Sensor or Circuit Check

Perform TC1TOP Sensor Circuit Check (page 833). Check for restricted exhaust.

1. Check exhaust back pressure valve tube assembly between the Exhaust Back Pressure Valve (EBPV) and Air Control Valve (ACV) for leaks.
   - If leaks are found, repair or replace as necessary. Clear DTC's. If active DTC remains, continue to next step.
   - If no leaks are found, go to next step.
2. Turn ignition switch to ON, engine OFF.
3. Using ServiceMaxx™ software, run the Continuous Monitor Test.
4. Verify S_TC1TOP volts are within specification (lightly wiggle circuits while monitoring TC1TOP signal for spikes). See “APPENDIX A: PERFORMANCE SPECIFICATIONS."
   - If TC1TOP voltage is not within specification, check circuitry for poor continuity. If circuits are acceptable, replace TC1TOP sensor.
   - If TC1TOP voltage is within specification, check for a restricted exhaust system.
   - If TC1TOP voltage is within specification and exhaust is not restricted, verify O_2S circuits are not open or shorted. Calibrate and install new O_2S.

SPN 3223 FMI 0 - O_2S Heater Temperature Above Maximum

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
O_2S temperature too high.	O_2S Temperature ≥ 1472°F (800°C)	Exhaust back pressure valve open < 80% Engine speed > 300 rpm Heater duty cycle > 98% for 6,500 seconds (1.8 hours) Regeneration mode inactive or Oxygen sensor temp > 1202°F (650°C)	30 seconds

Fault Overview

The Oxygen sensor (O_2S) heater element is designed to increase sensor temperature. The O_2S heater is supplied with battery voltage from ECM PWR Out 1 through pin 4 of the O_2S connector. The O_2S heater is active when the Engine Control Module (ECM) supplies ground to the O_2S Heater CTL circuit through ECM connector 1 pin 46. If O_2S temperature is above 1472°F (800°C) this fault will set.

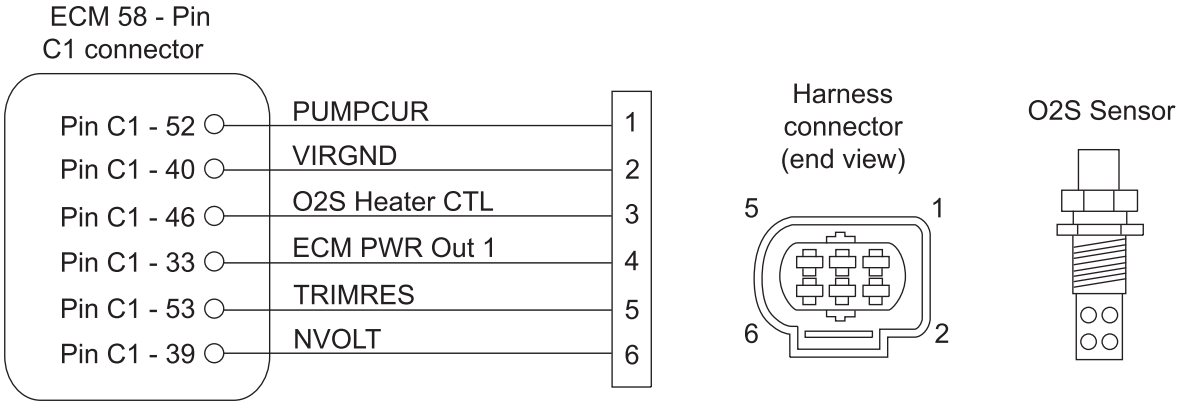
Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

O2S Circuit



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Figure 326 O_2S circuit diagram

Step	Action	Decision
1	Inspect connections at Oxygen Sensor (O_2S). Key OFF, disconnect O_2S connector. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the O_2S connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal. After repairs are complete, retest for SPN 3223 FMI 0.

Step	Action	Decision
2	Check Heater control circuit for short to ground. Connect Breakout Harness ZTSE4735A and leave sensor disconnected. Run engine, using Electronic Service Tool (EST) with ServiceMaxx™ software, monitor O_2S Temp. When O_2S Temp reaches 1,382°F (750°C) or higher (O_2S heater inactive), use a DMM to measure resistance between Breakout Harness ZTSE4735A test point 3, and a known good ground. Is resistance greater than 1,000 ohms?	Yes: Replace Oxygen Sensor. After repairs are complete retest for SPN 3223 FMI 0. No: Repair short to ground between O_2S harness pin 3 and ECM connector 1 pin 46. After repairs are complete, retest for SPN 3223 FMI 0.

NOTE: After doing all diagnostic steps, if SPN 3223 FMI 0 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 3223 FMI 5 – O_2S heater open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Open circuit detected in Oxygen Sensor (O_2S) heater.	O_2S heater current >-100 µA and < 100 µA	Key ON	5 seconds

Fault Overview

Fault code sets when Engine Control Module (ECM) detects an Open circuit in the Oxygen Sensor (O_2S) heater.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 724 FMI 3, 4 (O_2S); SPN 3223 FMI 3, 4 (O_2S); SPN 3597 FMI 4 (ECM PWR).

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

O2S Circuit

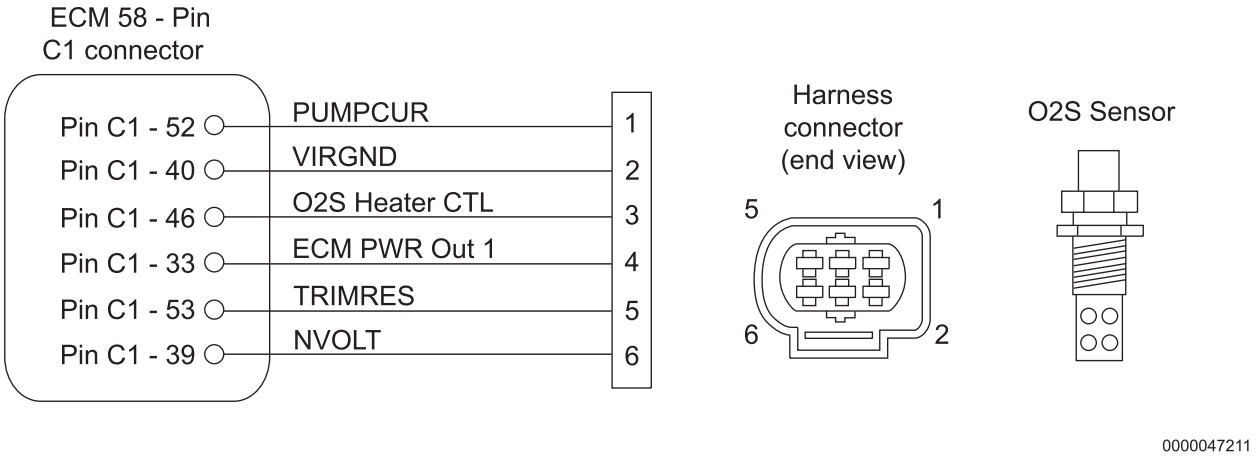


Figure 327 O_2S circuit diagram

Possible Causes

- HTR CTL circuit short to GND
- ECM PWR OUT 1 circuit Open or high resistance
- HTR CTL circuit Open or high resistance
- Failed O_2S

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 724 FMI 3, 4 (O_2S); SPN 3223 FMI 3, 4 (O_2S); SPN 3597 FMI 4 (ECM PWR). Is EST DTC list free of SPN 724 FMI 3, 4; SPN 3223 FMI 3, 4; SPN 3597 FMI 4?	Yes: Go to step 2. No: Repair SPN 724 FMI 3, 4; SPN 3223 FMI 3, 4; SPN 3597 FMI 4. After repairs are complete, retest for SPN 3223 FMI 5.

Step	Action	Decision
2	Inspect connections at Oxygen Sensor (O_2S). Key OFF, disconnect O_2S. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the O_2S connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3223 FMI 5.

Step	Action	Decision
4	Inspect connections at ECM C1 connector. Key OFF, disconnect ECM C1 connector. Check connector and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM C1 connector, harness, and terminals clean and undamaged?	Yes: Go to step 5. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 3223 FMI 5.

Step	Action	Decision
5	Check for short to GND in the HTR CTL circuit. Connect Breakout Harness ZTSE4735A to O_2S harness, and leave sensor disconnected. Key-On, using a DMM, measure voltage between ZTSE4735A pin-3 and pin-4. Is voltage less than 5 volts?	Yes: Go to step 6 No: Repair short to GND in HTR CTL circuit between O_2S connector pin-3 and ECM pin C1-46. After repairs are complete, retest for SPN 3223 FMI 5.

Step	Action	Decision
6	Check for Open or high resistance in the HTR CTL circuit. Connect 180-pin Breakout Box and ECM C1 & C2 Breakout Harness to vehicle harness, and leave ECM disconnected. Connect Breakout Harness ZTSE4735A to O_2S harness, and leave sensor disconnected. Key-Off, using a DMM, measure resistance between ZTSE4735A pin-3 and ECM pin C1-46. Is resistance less than 5 ohms?	Yes: Go to step 7 No: Repair Open in HTR CTL circuit between O_2S connector pin-3 and ECM pin C1-46. After repairs are complete, retest for SPN 3223 FMI 5.

Step	Action	Decision
7	Check for Open or high resistance in the ECM PWR OUT 1 circuit. Connect 180-pin Breakout Box and ECM C1 & C2 Breakout Harness to vehicle harness, and leave ECM disconnected. Connect Breakout Harness ZTSE4735A to O_2S harness, and leave sensor disconnected. Key-Off, using a DMM, measure resistance between ZTSE4735A pin-4 and ECM pin C1-33. Is resistance less than 5 ohms?	Yes: Replace O_2S. After repairs are complete, retest for SPN 3223 FMI 5. No: Repair Open in ECM PWR OUT 1 circuit between O_2S connector pin-4 And ECM pin C1-33. After repairs are complete, retest for SPN 3223 FMI 5.

NOTE: After performing all diagnostic steps, if SPN 3223 FMI 5 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Pinpoint O_2S System Fault

SPN 3223 FMI 1– O_2S heater temperature below minimum

SPN 3223 FMI 17 – O_2S heater temperature below minimum at low battery PWR

NOTE: SPN 3223 FMI 17 will set if battery voltage is below 10 V when the O_2S heater is commanded ON.

1. Check for other active or previously active DTCs. Repair any electrical fault before continuing with this procedure.
2. Verify batteries and changing system are working within specifications. See "PERFORMANCE DIAGNOSTICS."
   - If charging system and battery voltage are working within specification, check for circuit faults to the O_2S. If circuits are within specification, calibrate and install new O_2S.

RAPP (Remote Accelerator Pedal Position)

SPN	FMI	Condition	Possible Causes	Actions
974	3	Remote APP signal Out of Range HIGH	• RPS signal circuit short to PWR • SIG GND circuit OPEN • Failed RAPP system component	Circuit Checks (page 827)
974	4	Remote APP signal Out of Range LOW	• RPS signal circuit OPEN or short to GND • VREF4 circuit OPEN • Failed RAPP system component	Circuit Checks (page 827)

Overview

The Remote Accelerator Pedal Position (RAPP) feature allows the operator to set and maintain a constant engine speed from outside the vehicle cab. This feature may also be know as Remote Engine Speed Control (RESC). Control over engine speed is accomplished by using remote mounted switches to turn on the RESC and select the desired engine speed.

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

Sensor Circuit Check With ServiceMaxx™ Software

Disconnect Body Builder Connector 2. Turn ignition switch to ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Run Continuous Monitor Test and monitor APP1v Short pins 2–A and 2–B	4.5 V to 5 V	If < 4.5 V, check APP1 signal circuit for OPEN. Do Harness Resistance Check (page 827).
DMM — Measure voltage 2–B to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF4 for short to PWR. If < 4.5 V, check VREF4 for OPEN or short to GND. Do Harness Resistance Check (page 827).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Disconnect Body Builder Connector 2. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
2–A to C1–13	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
2–A to GND	> 1k Ω	If < 1k Ω, check for short to GND.
2–B to C1–37	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
2–B to GND	> 1k Ω	If < 1k Ω, check for short to GND.
2–C to C1–24	< 5 Ω	If > 5 Ω, check for OPEN in circuit.
2–C to GND	>1k Ω	If < 1k Ω, check for short to GND.

Service Interval Messages

SPN	FMI	Condition	Possible Causes
1378	31	Change Engine Oil Service Interval	• Change oil and re-set interval counter

Service Interval Messages Operation

The service interval messages are displayed on the instrument cluster message center and include engine oil and fuel filter change reminders.

The change oil reminder can be programmed for kilometers, miles, hours or calculated fuel consumption. These service interval limits may be adjusted at the owner's discretion. The change engine oil message below the odometer illuminates after a preselected parameter is reached.

The fuel filter change message displays when the fuel filter needs replacement due to high filter restriction.

SART (Stand Alone Real Time) Clock

SPN	FMI	Condition	Possible Causes
251	19	ECM not detecting SART module J1939	• SART module powering circuit fault • J1939 to SART module fault • Failed SART module

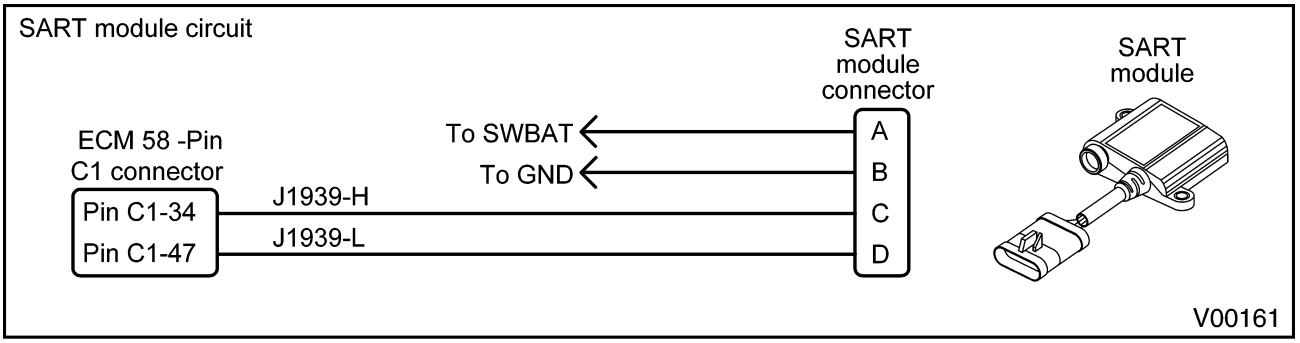


Figure 328 SART circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

NOTE: Reference the truck *Chassis Electrical Circuit Diagram Manual* and *Electrical System Troubleshooting Guide* for vehicle side electrical system.

Connector Voltage Check

Test Point	Specification	Comment – < Less than, > Greater than
A to GND	B+	If < B+, check B+ circuit to SART module for OPEN or short to GND, or blown fuse.
B to B+	B+	If < B+, check GND circuit to SART module for OPEN.
C to GND	1 V to 4 V	The sum of D to GND and C to GND should = 1 V to 4 V
D to GND	1 V to 4 V	The sum of D to GND and C to GND should = 1 V to 4 V

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box. Leave ECM disconnected.

Test Point	Specification	Comment – < Less than, > Greater than
C to C1-34	< 5 Ω	If > 5 Ω, check J1939-H for OPEN in circuit.
C to GND	> 1k Ω	If < 1k Ω, check J1939-H for short to GND.
D to C1-47	< 5 Ω	If > 5 Ω, check J1939-L for OPEN in circuit.
D to GND	> 1k Ω	If < 1k Ω, check J1939-L for short to GND.

TC1TOP Sensor (Turbocharger 1 Turbine Outlet Pressure)

SPN	FMI	Condition	Possible Causes	Actions
5541	2	TC1TOP signal does not agree with BARO	• Biased TC1TOP sensor or circuit • Intermittent TC1TOP circuit fault • Restricted EBPV tube	Pin-Point Diagnostics (page 832)
5541	3	TC1TOP signal Out of Range HIGH	• TC1TOP signal circuit OPEN or short to PWR • SIG GND circuit OPEN • Failed TC1TOP sensor	Pin-Point Diagnostics (page 832)
5541	4	TC1TOP signal Out of Range LOW	• TC1TOP signal circuit short to GND • Failed TC1TOP sensor	Pin-Point Diagnostics (page 832)

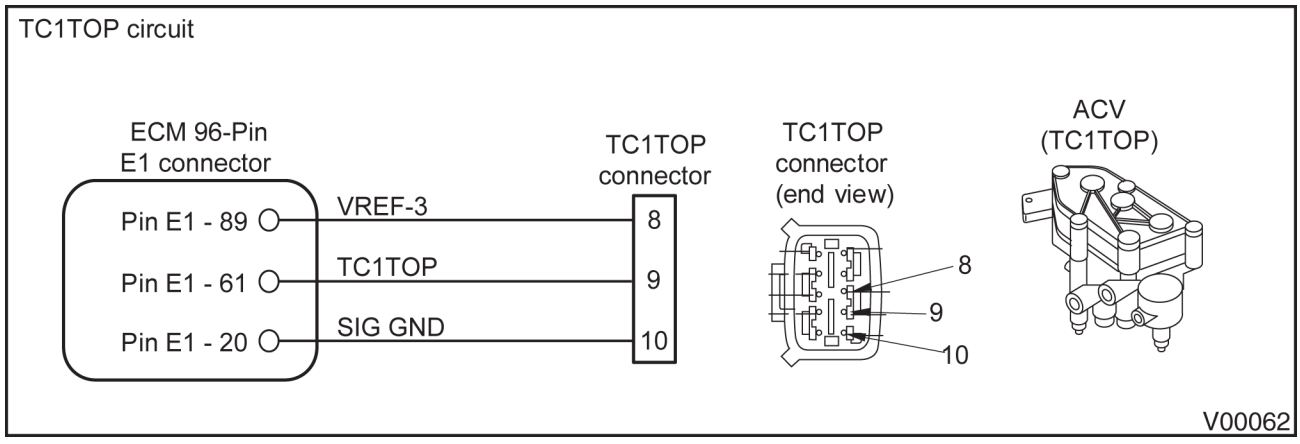


Figure 329 TC1TOP circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6003 (TC1TOP)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Note: The TC1TOP, TC1WC, TC2WC, and EBPV circuits share the same connector to the ACV assembly.

Pinpoint Diagnostics With ServiceMaxx™ Software

⚠ WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, run the Continuous Monitor test.
2. Monitor sensor voltage and verify an active DTC for this sensor.
   - If DTC is previously active, monitor signal while wiggling harness of suspect sensor. If circuit is interrupted, signal will spike and DTC will go active or pending.
   - If DTC is active, continue to Biased Sensor or Circuit Check.

NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.

SPN 5541 FMI 2 – TC1TOP signal does not agree with BARO

Biased Sensor or Circuit Check

1. Turn ignition switch ON, engine OFF
2. Using ServiceMaxx™ software, run the Continuous Monitor test.
3. Verify S_TC1TOP volts are within specification (lightly wiggle circuits while monitoring TC1TOP signal for spikes). See “APPENDIX A: PERFORMANCE SPECIFICATIONS."
   - If TC1TOP voltage is not within specification, check circuitry for poor continuity. If circuits are acceptable, replace TC1TOP sensor.
4. Check Exhaust Back Pressure Valve (EBPV) tube between Air Control Valve (ACV) and EBPV for restriction.

Sensor Circuit Check With ServiceMaxx™ Software

Connect Breakout Harness ZTSE6003 to ACV engine harness, and leave ACV sensor disconnected. Turn ignition ON.

Test Point	Specification	Comment – < Less than, > Greater than
EST – Monitor TC1TOPv	4.5 V to 5 V	If < 4.5 V, check TC1TOP signal circuit for short to GND. Do Harness Resistance Check (page 834).
DMM — Measure voltage 8 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF3 for short to PWR. If < 4.5 V, check VREF3 for OPEN or short to GND. Do Harness Resistance Check (page 834).
DMM — Measure voltage 8 to 10	5 V ± 0.5 V	If < 4.5 V, check SIG GND for OPEN. Do Harness Resistance Check (page 834).
EST – Monitor TC1TOPv Short across Breakout Harness pins 9 and 10	0 V	If > 0.25 V, check TC1TOP signal for OPEN. Do Harness Resistance Check (page 834).
If checks are within specification, connect sensor and clear DTCs. Verify sensor voltage is within KOEO specification. See “APPENDIX A: PERFORMANCE SPECIFICATIONS." If sensor voltage is not within specification, replace the sensor.		

Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE6003 to ACV engine harness, and leave ACV sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
8 to GND	5.0 V ± 0.5 V	If > 5.5 V, check VREF3 for short to PWR. If < 4.5 V, check VREF3 for OPEN or short to GND. Do Harness Resistance Check (page 834).
10 to GND	0 V	If > 0.25 V, check SIG GND circuit for short to PWR.
9 to GND	4.5 V to 5 V	If < 4.5 V, check TC1TOP signal circuit for short to GND. Do Harness Resistance Check (page 834).

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 engine harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE6003 to ACV engine harness, and leave ACV disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
8 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
8 to E1-89	< 5 Ω	If > 5 Ω, check for OPEN circuit.
9 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
9 to E1-61	< 5 Ω	If > 5 Ω, check for OPEN circuit.
10 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
10 to E1–20	< 5 Ω	If > 5 Ω, check for OPEN circuit.

TC1WC (Turbocharger 1 Wastegate Control)

SPN	FMI	Condition	Possible Causes	Actions
1189	3	TC1WC short to PWR	• TC1WC control circuit short to PWR • Failed TC1WC solenoid	Circuit Checks
1189	4	TC1WC short to GND	• TC1WC control circuit short to GND • Failed TC1WC solenoid	Circuit Checks

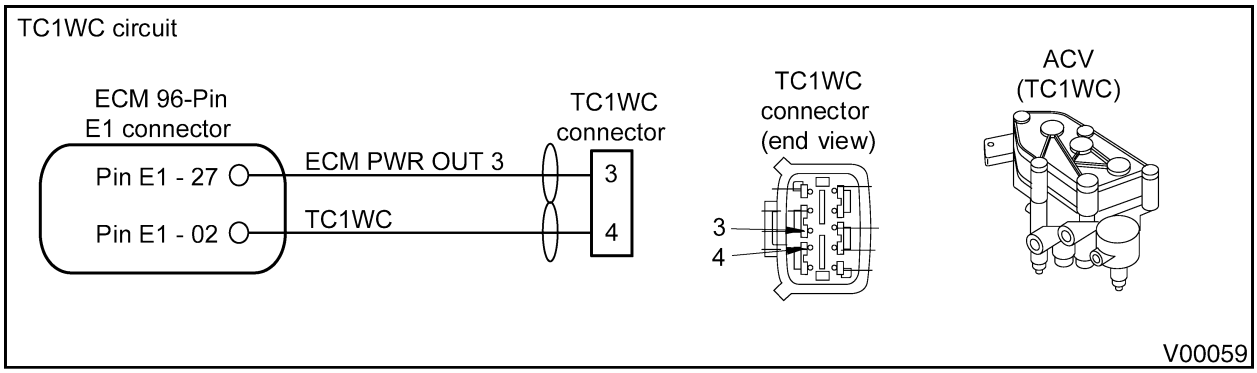


Figure 330 TC1WC circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6003 (TC1WC)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Note: The TC2WC, TC1TOP, and EBPV circuits share the same connector to the Air Control Valve (ACV) assembly.

Connector Voltage Check – TC2WC Disconnected

Connect Breakout Harness ZTSE6003 to ACV engine harness, and leave ACV disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
3 to GND	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check.
4 to GND	3.5 V ± 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check.
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure air tanks have at least 90 psi (621 kPa) of pressure.

1. Connect Breakout Harness ZTSE6003 between TC2WC and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select TC1 Wastegate Control from the drop-down menu.
3. Command TC1 Wastegate Control to 5%.
4. Use DMM to measure voltage.
5. Command TC1 Wastegate Control to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
4 to GND	5% = 12 V ± 2.0 V	If < 10 V, check for OPEN circuit.
4 to GND	95% = 0.5 V ± 0.5 V	If > 1 V, check for OPEN circuit or failed ACV.

Actuator Resistance Check

Turn ignition switch OFF. Connect Breakout Harness ZTSE6003 to ACV and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
3 to 4	4 Ω to 11 Ω	If not within specification, replace the ACV.
If measurements are within specifications, go to Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE6003. Leave ECM and TC2WC disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
3 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
3 to E1-27	< 5 Ω	If > 5 Ω, check for OPEN circuit.
4 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
4 to E1-02	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, check for DTCs. If DTC returns, replace ACV.		

TC2WC (Turbocharger 2 Wastegate Control)

SPN	FMI	Condition	Possible Causes	Actions
1189	3	TC2WC short to PWR	• TC2WC control circuit short to PWR • Failed TC2WC solenoid	Circuit Checks (page 839)
1189	4	TC2WC short to GND	• TC2WC control circuit short to GND • Failed TC2WC solenoid	Circuit Checks (page 839)
1189	5	TC2WC open load/circuit	• TC2WC control OPEN circuit • Failed TC2WC solenoid	Circuit Checks (page 839)

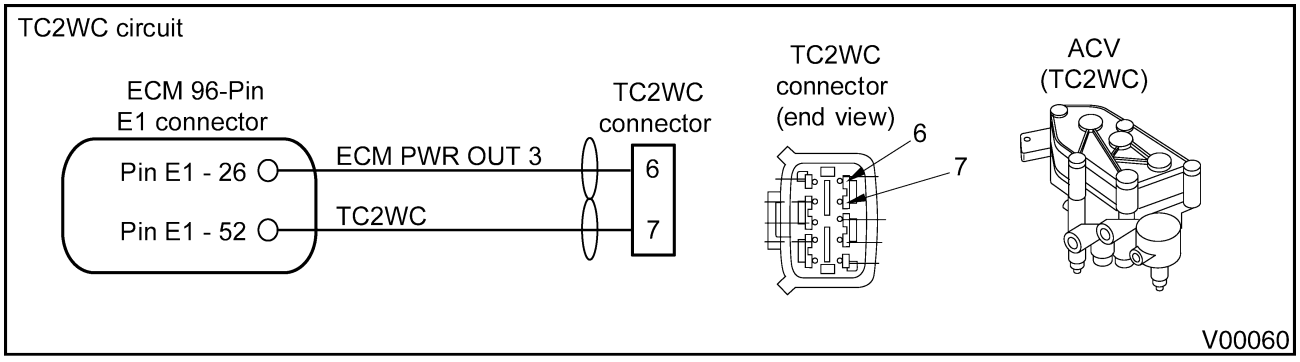


Figure 331 TC2WC circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6003 (TC2WC)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Note: The TC2WC, TC1TOP, and EBPV circuits share the same connector to the Air Control Valve (ACV) assembly.

Connector Voltage Check – TC2WC Disconnected

Connect Breakout Harness ZTSE6003 to ACV engine harness, and leave ACV disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
6 to GND	B+	If < B+, check for OPEN circuit. Do Harness Resistance Check.
7 to GND	3.5 V ± 1.0 V	If < 2.5 V, check for OPEN circuit. Do Harness Resistance Check.
If measurements are within specifications, do Operational Voltage Check.		

Operational Voltage Check

NOTE: Ensure air tanks have at least 90 psi (621 kPa) of pressure.

1. Connect Breakout Harness ZTSE6003 between TC2WC and engine harness.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, go to Tests > KOEO Tests > Actuator Test. Select TC2 Wastegate Control from the drop-down menu.
3. Command TC2 Wastegate Control to 5%.
4. Use DMM to measure voltage.
5. Command TC2 Wastegate Control to 95%.
6. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
7 to GND	5% = 12 V ± 2.0 V	If < 10 V, check for OPEN circuit.
7 to GND	95% = 0.5 V ± 0.5 V	If > 1 V, check for OPEN circuit or failed ACV.

Actuator Resistance Check

Turn ignition switch OFF. Connect Breakout Harness ZTSE6003 to ACV and leave engine harness disconnected. Use DMM to measure resistance.

Test Point	Spec	Comment
6 to 7	4 Ω to 11 Ω	If not within specification, replace the ACV.
If measurements are within specifications, go to Harness Resistance Check.		

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box and Breakout Harness ZTSE6003. Leave ECM and TC2WC disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
6 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
6 to E1-26	< 5 Ω	If > 5 Ω, check for OPEN circuit.
7 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
7 to E1-52	< 5 Ω	If > 5 Ω, check for OPEN circuit.
If voltage and resistance checks are within specifications, check for DTCs. If DTC returns, replace ACV.		

TC2CIS (Turbocharger 2 Compressor Inlet Sensor)

SPN	FMI	Condition	Possible Causes	Actions
1173	2	TC2CIT signal does not agree with other sensors	• TC2CIT high resistance • SIG GND high resistance • Failed TC2CIS sensor	Step-Based Diagnostics (page 843)
1173	3	TC2CIT Out of Range HIGH	• TC2CIT shorted to PWR • TC2CIT Open or high resistance • SIG GND Open or high resistance • Failed TC2CIS sensor	Step-Based Diagnostics (page 846)
1173	4	TC2CIT Out of Range LOW	• TC2CIT shorted to GND • TC2CIT shorted to SIG GND • Failed TC2CIS sensor	Step-Based Diagnostics (page 849)
1173	16	TC2CIT signal above desired (Interstage CAC under cooling)	• Failed TC2CIS • Failed Coolant Control Valve (CCV) • Restricted or leaking LPCAC • Inoperative engine cooling fan • Restricted low-temperature radiator • Engine fan or shroud problem	Step-Based Diagnostics (page 851)
1177	2	TC2CIP signal erratic, intermittent, or incorrect	• TC2CIP high resistance • SIG GND high resistance • Failed TC2CIS sensor	Step-Based Diagnostics (page 854)

1177	3	TC2CIP signal Out of Range HIGH	• TC2CIP shorted to PWR • TC2CIP Open or high resistance • SIG GND Open or high resistance • Failed TC2CIS sensor	Step-Based Diagnostics (page 856)
1177	4	TC2CIP signal Out of Range LOW	• TC2CIP shorted to GND • TC2CIP shorted to SIG GND • Failed TC2CIS sensor	Step-Based Diagnostics (page 859)

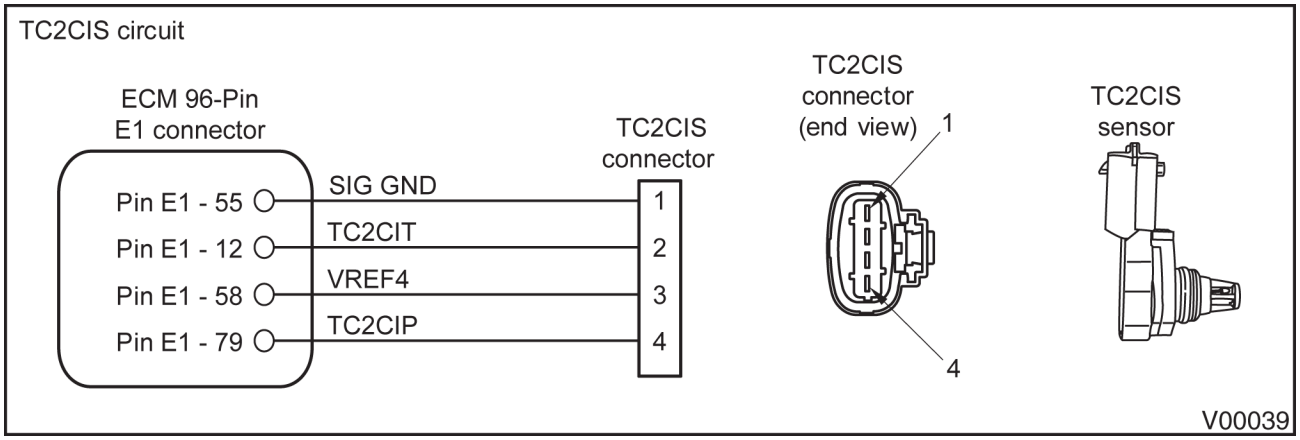


Figure 332 TC2CIS sensor circuit diagram

NOTE: See latest version of Maxxforce 11 and 13 Engine Wiring Schematic Form 0000002941 for additional circuit information.

Overview

The Turbocharger 2 Compressor Inlet Sensor (TC2CIS) is a combined temperature and pressure sensor located in the piping between the low-pressure compressor outlet and the high-pressure compressor inlet. This sensor monitors boost pressure for the low-pressure turbo and the temperature of the charge-air entering the high-pressure turbo. The ECM uses these measurements for calculating fuel delivery and controlling the wastegate.

Tools Required

- 180-Pin Breakout Box 00-00956-08
- ECM Breakout Harness 00-01468-00
- Breakout Harness ZTSE4830 (TC2CIS)
- Digital Multimeter (DMM)
- Charge Air Cooler (CAC) Tester ZTSE4341
- Electronic Service Tool (EST) with ServiceMaxx™ software
- Interface cable (RP1210B compliant supporting J1939 and J1708)

SPN 1173 FMI 2 - TC2CIT signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Difference between Turbocharger 2 Compressor Inlet temperature (TC2CIT) sensor reading and Intake Manifold Temperature (IMT) and Inlet Air Temperature (IAT) sensor readings greater than expected.	TC2CIT deviation from IMT and IAT greater than expected	Key ON Engine is cold soaked (8 hours)	Immediate

Fault Overview

Fault code sets when Turbocharger 2 Compressor Inlet temperature (TC2CIT) signal difference compared to Inlet Air Temperature (IAT) and Intake Manifold Temperature (IMT) is greater than expected.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 1173 FMI 3 and 4 (TC2CIT), SPN 105 (IMT), SPN 172 (IAT)

Drive Cycle to Determine Fault Status

Drive Cycle 10 then 2 in 2013 HD-OBD Diagnostic Reference Manual.

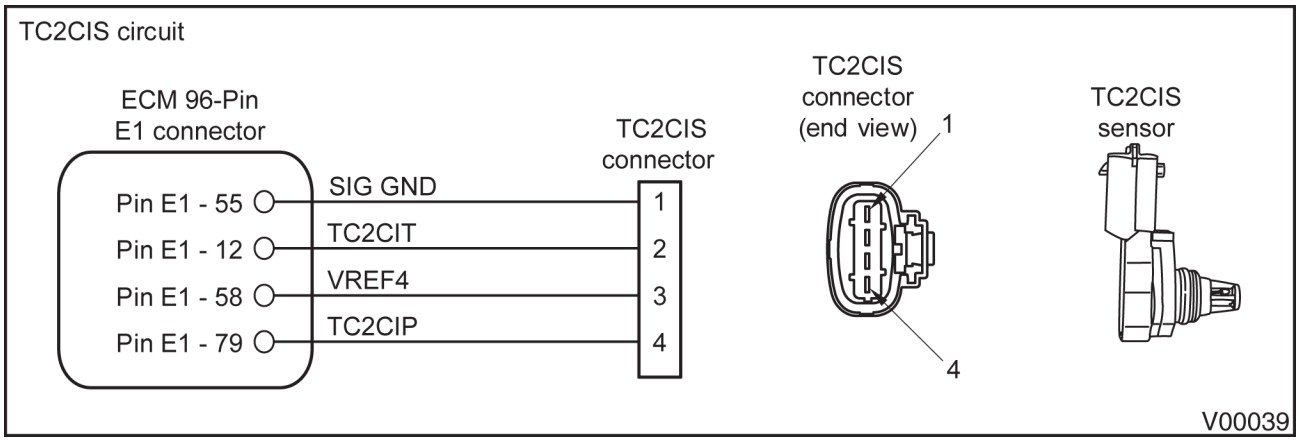


Figure 333 TC2CIS sensor circuit diagram

Possible Causes

- TC2CIT high resistance
- SIG GND high resistance
- Failed TC2CIS sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1173 FMI 3 and 4 (TC2CIT). Is EST DTC list free of SPN 1173 FMI 3 and 4?	Yes: Go to step 2. No: Repair SPN 1173 FMI 3 and 4. After repairs are complete, retest for SPN 1173 FMI 2.

Step	Action	Decision
2	Inspect connections at Turbocharger 2 Compressor Inlet Sensor (TC2CIS). Key OFF, disconnect TC2CIS sensor. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the TC2CIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 2.

Step	Action	Decision
3	Inspect connections at ECM E1 connector. Key OFF, disconnect ECM E1 connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E1 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 2.

Step	Action	Decision
4	Check SIG GND for high resistance. Connect 180-pin Breakout Box and ECM Breakout Harness 00-01468-00 to ECM E1 harness, and leave ECM disconnected. Key-Off, using a DMM, measure resistance between breakout harness pin-1 and breakout box E1 pin-55. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair high resistance between TC2CIS pin-1 and ECM connector E1 pin-55. After repairs are complete, retest for SPN 1173 FMI 2.

Step	Action	Decision
5	Check TC2CIT for high resistance. Using a DMM, measure resistance between breakout harness pin-2 and Breakout Box E1 pin-12. Is resistance less than 5 ohms?	Yes: Replace TC2CIS sensor. After repairs are complete, retest for SPN 1173 FMI 2. No: Repair high resistance between TC2CIS pin-2 and ECM connector E1 pin-12. After repairs are complete, retest for SPN 1173 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 1173 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1173 FMI 3 - TC2CIT signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Turbocharger 2 Compressor Inlet Temperature (TC2CIT) signal is above the maximum valid value.	TC2CIT > 4.78 volts	Key ON	2 seconds

Fault Overview

Fault code sets when signal from the Turbocharger 2 Compressor Inlet Sensor (TC2CIS), Turbocharger 2 Compressor Inlet Temperature (TC2CIT) circuit is greater then 4.78 volts.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

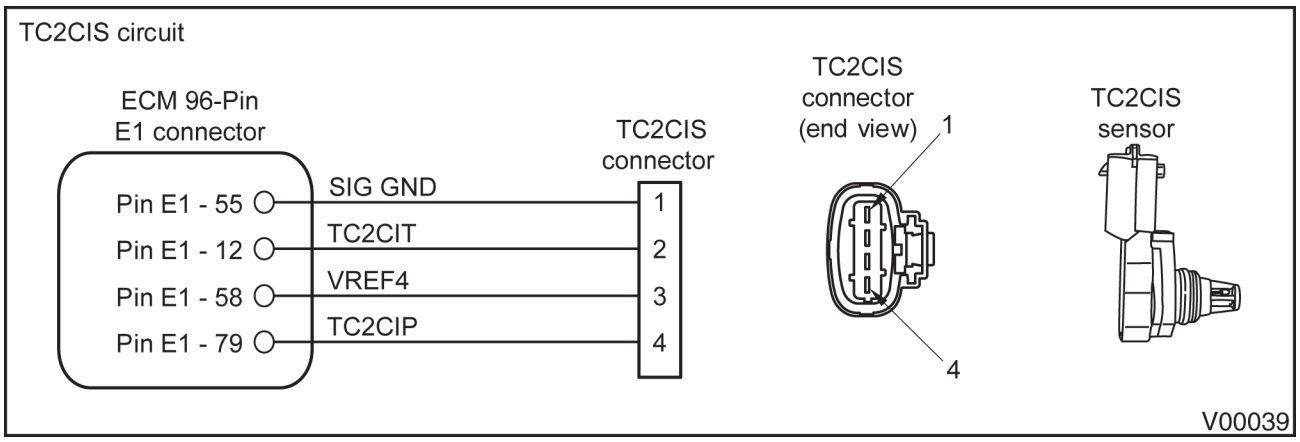


Figure 334 TC2CIS sensor circuit diagram

Possible Causes

- TC2CIT shorted to PWR
- TC2CIT Open or high resistance
- SIG GND Open or high resistance
- Failed TC2CIS sensor

Step	Action	Decision
1	Inspect connections at Turbocharger 2 Compressor Inlet Sensor (TC2CIS) sensor. Key OFF, disconnect TC2CIS sensor. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the TC2CIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 3.

Step	Action	Decision
2	Check TC2CIT for a short to PWR. Connect Breakout Harness ZTSE4830 to engine harness, and leave TC2CIS disconnected. Using a DMM, Key-On Engine-Off (KOEO) measure voltage between breakout harness pin-2 and a known good ground. Is voltage less than 5.5 volts?	Yes: Go to step 3. No: Repair short to PWR between TC2CIS pin-2 and ECM pin E1-12. After repairs are complete, retest for SPN 1173 FMI 3.

Step	Action	Decision
3	Inspect connections at ECM E1 connector. Key OFF, disconnect ECM E1 connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E1 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 3.

Step	Action	Decision
4	Check SIG GND for Open or high resistance. Connect 180-pin Breakout Box and ECM Breakout Harness 00-01468-00 to ECM E1 engine harness, and leave ECM disconnected. Key-Off, using a DMM, measure resistance between breakout harness pin-1 and breakout box E1 pin-55. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance between TC2CIS pin-1 and ECM connector E1 pin-55. After repairs are complete, retest for SPN 1173 FMI 3.

Step	Action	Decision
5	Check TC2CIT for Open or high resistance. Key-Off, using a DMM, measure resistance between ECM E1 pin-12 and breakout harness pin-2. Is resistance less than 5 ohms?	Yes: Replace TC2CIS sensor. After repairs are complete, retest for SPN 1173 FMI 3. No: Repair Open or high resistance between TC2CIS pin-2 and ECM connector E1 pin-12. After repairs are complete, retest for SPN 1173 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 1173 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1173 FMI 4 - TC2CIT signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Turbocharger 2 Compressor Inlet Temperature (TC2CIT) signal is below minimum.	TC2CIT less than 0.1 volt	Key ON	0.5 seconds

Fault Overview

Fault code sets when signal from the Turbocharger 2 Compressor Inlet Sensor (TC2CIS), Turbocharger 2 Compressor Inlet Temperature (TC2CIT) circuit is less then 0.1 volts.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

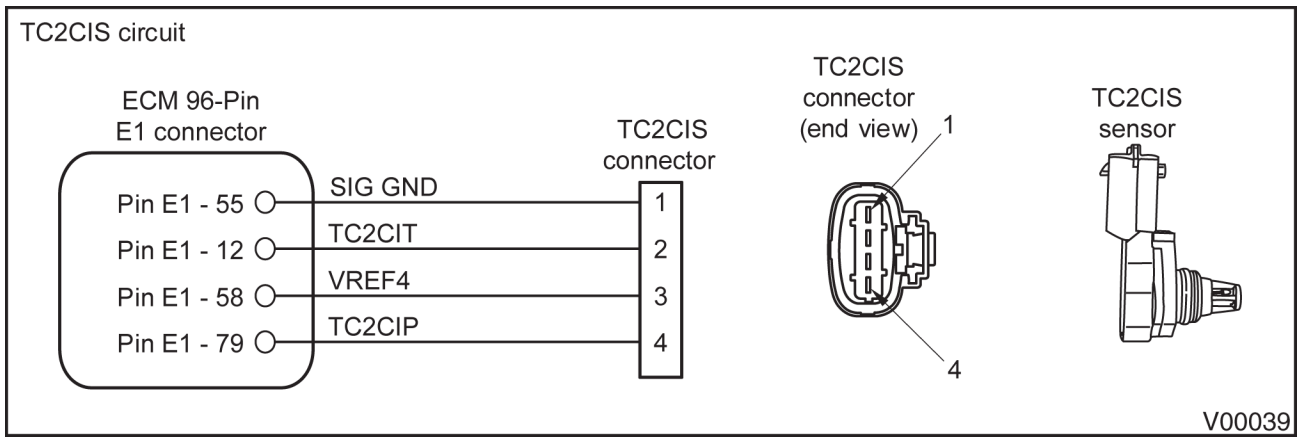


Figure 335 TC2CIS sensor circuit diagram

Possible Causes

- TC2CIT shorted to GND
- TC2CIT shorted to SIG GND
- Failed TC2CIS sensor

Step	Action	Decision
1	Inspect connections at Turbocharger 2 Compressor Inlet Sensor (TC2CIS) sensor. Key OFF, disconnect TC2CIS sensor. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the TC2CIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1173 FMI 3.

Step	Action	Decision
2	Check TC2CIT for a short to GND. Connect Breakout Harness ZTSE4830 to engine harness, and leave TC2CIS disconnected. Using a DMM, Key OFF measure resistance between breakout harness pin-2 and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 3. No: Repair short to GND between TC2CIS pin-2 and ECM pin E1-12. After repairs are complete, retest for SPN 1173 FMI 4.

Step	Action	Decision
3	Check TC2CIT for a short to SIG GND. Using a DMM, measure resistance between breakout harness pin-1 and pin-2. Is resistance greater than 1000 ohms?	Yes: Replace TC2CIS sensor. After repairs are complete, retest for SPN 1173 FMI 4. No: Repair short between TC2CIT and SIG GND circuits. After repairs are complete, retest for SPN 1173 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 1173 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1173 FMI 16 - TC2CIT signal above desired (Interstage CAC under cooling)

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Turbocharger 2 Compressor Inlet Temperature (TC2CIT) signal is greater than expected.	Difference between TC2CIT and engine coolant temperature > a predetermined value, based on engine speed and load.	Engine running Ambient Air Temperature (AAT) between 19°F (-7°C) and 131°F (55°C) Barometric Pressure (BARO) > 10.9 psi (75 kPa) Difference between coolant temperature and expected temperature of the Low Pressure Change Air Cooler (LPCAC) > 68°F (20°C) for 3 seconds or more	3 events

Fault Overview

Fault code sets when Turbocharger 2 Compressor Inlet Temperature (TC2CIT) is above a calculated range, based on operating conditions.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 1173 FMI 3 and 4 (TC2CIT); SPN 5546 (CMV); and SPN 5547 (CFV)

Drive Cycle to Determine Fault Status

Drive Cycle 1 then 2 in 2013 HD-OBD Diagnostic Reference Manual.

Possible Causes

- Failed TC2CIS
- Failed Coolant Control Valve (CCV)
- Restricted or leaking LPCAC
- Inoperative engine cooling fan
- Restricted low-temperature radiator
- Engine fan or shroud problem

NOTE: Repair engine cooling system problems and engine overheating before doing this procedure (see "Engine Symptoms Diagnostics").

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1173 FMI 3 and 4 (TC2CIT); SPN 5546 (CMV); and SPN 5547 (CFV). Is EST DTC list free of SPN 1173 FMI 3, 4; SPN 5546; and SPN 5547?	Yes: Go to step 2. No: Repair SPN 1173 FMI 3, 4; SPN 5546; and SPN 5547. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
2	Inspect for damaged or missing engine cooling fan, fan shroud, and fan hub assembly. Check for air flow restrictions around low temperature radiator. Is engine cooling fan, hub, and shroud, and low temperature radiator free of air restrictions and is not missing or damaged?	Yes: Go to step 3. No: Repair air restriction, or replace engine cooling fan or fan hub assembly. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
3	Check for an inoperative engine cooling fan. Using EST with ServiceMaxx™ software, run Tests > Key-On Engine-Running (KOER) Tests > Engine Fan Tests. Determine the engine cooling fan's capability to maintain desired speeds. Is the engine cooling fan operating properly?	Yes: Go to step 4. No: Replace fan hub assembly. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
4	Check for a failed TC2CIS sensor. Run engine at high idle for 20 seconds. Using EST with ServiceMaxx™ software, compare TC2CIT temperature values with ECT1 and ECT2. Is TC2CIT within 10°F (6°C) of ECT1 and ECT2?	Yes: Go to step 5. No: Replace TC2CIS sensor. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
5	Check for a failed Coolant Control Valve (CCV). Using EST with ServiceMaxx™ software, run the Tests > Key-On Engine-Running (KOER) Tests > Coolant Control Valve Test (page 93). Follow on screen instructions. Are both Coolant Flow Valve (CFV) and Coolant Mixer Valve (CMV) operating properly?	Yes: Go to step 6. No: Replace CCV. After repairs are complete, retest for SPN 1173 FMI 16.

Step	Action	Decision
6	Check for a restricted or leaking interstage CAC. Install Charge Air Cooler (CAC) Tester ZTSE4341 and test for leakages (see Engine Service Manual). Is the LPCAC free of excessive leaks or other defects?	Yes: Retest for SPN 1173 FMI 16. No: Replace the LPCAC. After repairs are complete, retest for SPN 1173 FMI 16.

NOTE: After performing all diagnostic steps, if SPN 1173 FMI 16 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1177 FMI 2 - TC2CIP signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Turbocharger 2 Compressor Inlet Pressure (TC2CIP) signal does not agree with Barometric Pressure (BARO) sensor.	Difference between TC2CIP and BARO > 1.45 psi (12 kpa)	Key-On Engine-Running (KOER)	2 seconds

Fault Overview

Fault code sets when Turbocharger 2 Compressor Inlet Pressure (TC2CIP) signal is not within 12 kpa of the Barometric Pressure (BARO) sensor.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Associated Faults

SPN 1177 FMI 3 and 4 (TC2CIT)

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

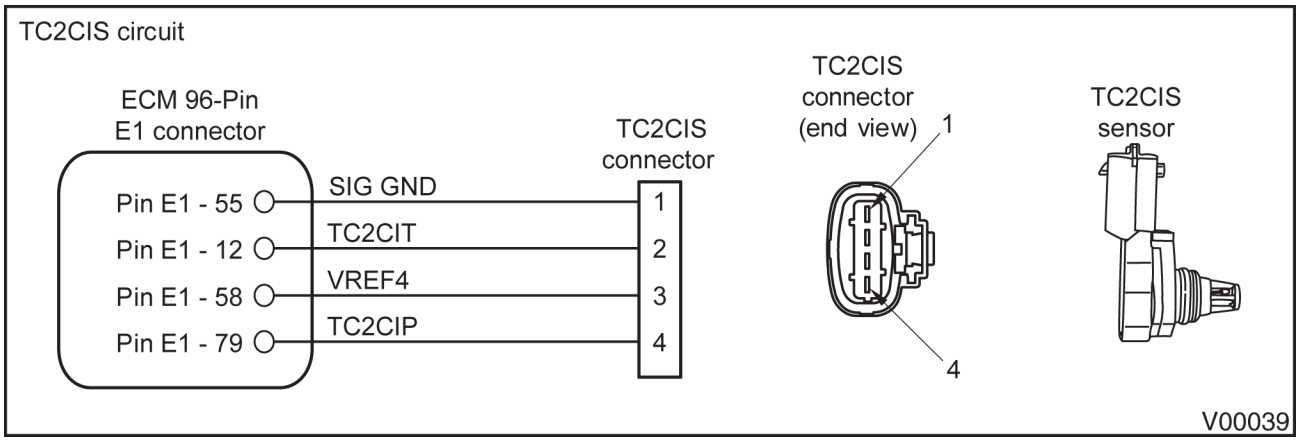


Figure 336 TC2CIS sensor circuit diagram

Possible Causes

- TC2CIP high resistance
- SIG GND high resistance
- Failed TC2CIS sensor

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check Diagnostic Trouble Code (DTC) list for SPN 1177 FMI 3 and 4 (TC2CIP). Is EST DTC list free of SPN 1177 FMI 3 and 4?	Yes: Go to step 2. No: Repair SPN 1177 FMI 3 and 4. After repairs are complete, retest for SPN 1177 FMI 2.

Step	Action	Decision
2	Inspect connections at Turbocharger 2 Compressor Inlet Sensor (TC2CIS). Key OFF, disconnect TC2CIS sensor. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the TC2CIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 3. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1177 FMI 2.

Step	Action	Decision
3	Inspect connections at ECM E1 connector. Key OFF, disconnect ECM E1 connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E1 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1177 FMI 2.

Step	Action	Decision
4	Check SIG GND for high resistance. Connect 180-pin Breakout Box and ECM Breakout Harness 00-01468-00 to ECM E1 engine harness, and leave ECM disconnected. Key-Off, using a DMM, measure resistance between breakout harness pin-1 and breakout box E1 pin-55. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair high resistance between TC2CIS pin-1 and ECM connector pin E1-55. After repairs are complete, retest for SPN 1177 FMI 2.

Step	Action	Decision
5	Check TC2CIP for high resistance. using a DMM, measure resistance between breakout harness pin-4 and Breakout Box E1 pin-79. Is resistance less than 5 ohms?	Yes: Replace TC2CIS sensor. After repairs are complete, retest for SPN 1177 FMI 2. No: Repair high resistance between TC2CIS pin-4 and ECM connector pin E1-79. After repairs are complete, retest for SPN 1177 FMI 2.

NOTE: After performing all diagnostic steps, if SPN 1177 FMI 2 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1177 FMI 3 - TC2CIP signal Out of Range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Turbocharger 2 Compressor Inlet Pressure (TC2CIP) signal is greater than expected.	TC2CIP > 4.9 volts	Key ON	0.5 seconds

Fault Overview

Fault code sets when signal from the Turbocharger 2 Compressor Inlet Sensor (TC2CIS), Turbocharger 2 Compressor Inlet Pressure (TC2CIP) circuit is greater then 4.9 volts.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

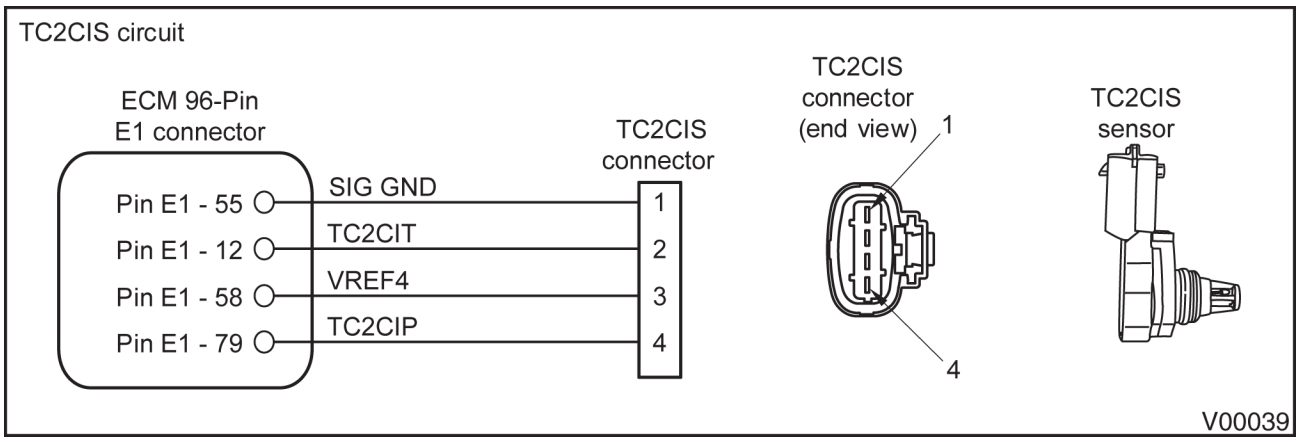


Figure 337 TC2CIS sensor circuit diagram

Possible Causes

- TC2CIP shorted to PWR
- TC2CIP Open or high resistance
- SIG GND Open or high resistance
- Failed TC2CIS sensor

Step	Action	Decision
1	Inspect connections at Turbocharger 2 Compressor Inlet Sensor (TC2CIS) sensor. Key OFF, disconnect TC2CIS sensor. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the TC2CIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1177 FMI 3.

Step	Action	Decision
2	Check TC2CIP for a short to PWR. Connect Breakout Harness ZTSE4830 to engine harness, and leave TC2CIS disconnected. Using a DMM, Key-On Engine-Off (KOEO) measure voltage between breakout harness pin-4 and a known good ground. Is voltage less than 5.5 volts?	Yes: Go to step 3. No: Repair short to PWR between TC2CIS pin-4 and ECM pin E1-79. After repairs are complete, retest for SPN 1177 FMI 3.

Step	Action	Decision
3	Inspect connections at ECM E1 connector. Key OFF, disconnect ECM E1 connector. Check ECM and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the ECM E1 connector, harness, and terminals clean and undamaged?	Yes: Go to step 4. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1177 FMI 3.

Step	Action	Decision
4	Check SIG GND for Open or high resistance. Connect 180-pin Breakout Box and ECM Breakout Harness 00-01468-00 to ECM E1 engine harness, and leave ECM disconnected. Key-Off, using a DMM, measure resistance between breakout harness pin-1 and breakout box E1 pin-55. Is resistance less than 5 ohms?	Yes: Go to step 5. No: Repair Open or high resistance between TC2CIS pin-1 and ECM connector E1 pin-55. After repairs are complete, retest for SPN 1177 FMI 3.

Step	Action	Decision
5	Check TC2CIP for Open or high resistance. Key-Off, using a DMM, measure resistance between ECM E1 pin-79 and breakout harness pin-4. Is resistance less than 5 ohms?	Yes: Replace TC2CIS sensor. After repairs are complete, retest for SPN 1173 FMI 3. No: Repair Open or high resistance between TC2CIS pin-4 and ECM connector E1 pin-79. After repairs are complete, retest for SPN 1177 FMI 3.

NOTE: After performing all diagnostic steps, if SPN 1177 FMI 3 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1177 FMI 4 - TC2CIP signal Out of Range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Turbocharger 2 Compressor Inlet Pressure (TC2CIP) signal is less than expected.	TC2CIP < 0.1 volt	Key ON	0.5 seconds

Fault Overview

Fault code sets when signal from the Turbocharger 2 Compressor Inlet Sensor (TC2CIS), Turbocharger 2 Compressor Inlet Pressure (TC2CIP) circuit is less then 0.1 volts.

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

Drive Cycle to Determine Fault Status

Drive Cycle 2 in 2013 HD-OBD Diagnostic Reference Manual.

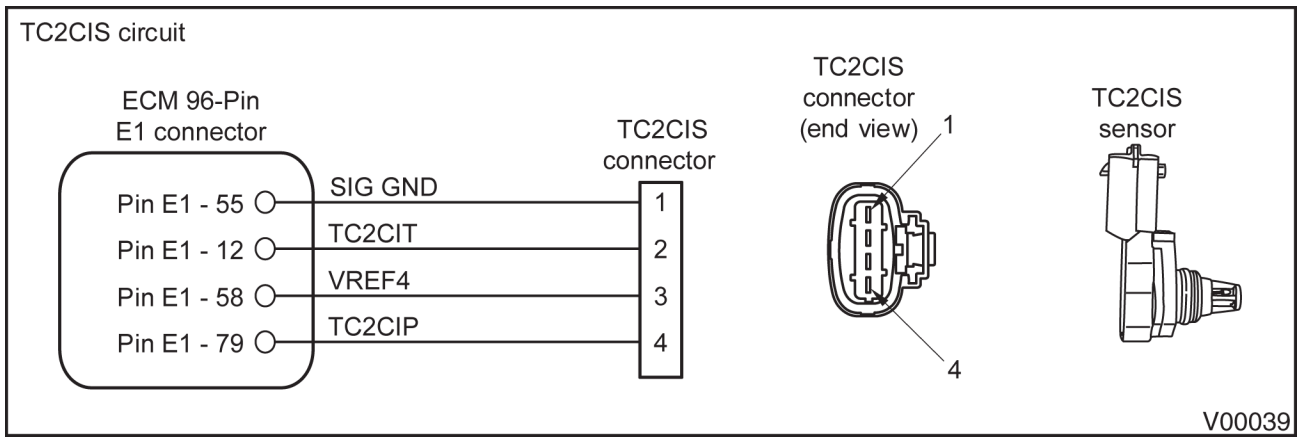


Figure 338 TC2CIS sensor circuit diagram

Possible Causes

- TC2CIP shorted to GND
- TC2CIP shorted to SIG GND
- Failed TC2CIS sensor

Step	Action	Decision
1	Inspect connections at Turbocharger 2 Compressor Inlet Sensor (TC2CIS) sensor. Key OFF, disconnect TC2CIS sensor. Check sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose, bent, or broken pins; or broken connector housing. Are the TC2CIS sensor connector, harness, and terminals clean and undamaged?	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 1177 FMI 4.

Step	Action	Decision
2	Check TC2CIP for a short to GND. Connect Breakout Harness ZTSE4830 to engine harness, and leave TC2CIS disconnected. Using a DMM, Key OFF measure voltage between breakout harness pin-4 and a known good ground. Is resistance less than 1000 ohms?	Yes: Go to step 3. No: Repair short to GND between TC2CIS pin-4 and ECM pin E1-79. After repairs are complete, retest for SPN 1177 FMI 4.

Step	Action	Decision
3	Check TC2CIT for a short to SIG GND. Using a DMM, measure resistance between breakout harness pin-1 and pin-4. Is resistance greater than 1000 ohms?	Yes: Replace TC2CIS sensor. After repairs are complete, retest for SPN 1177 FMI 4. No: Repair short between TC2CIP and SIG GND circuits. After repairs are complete, retest for SPN 1177 FMI 4.

NOTE: After performing all diagnostic steps, if SPN 1177 FMI 4 remains, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

TOSS / VSS (Transmission Output Shaft Speed / Vehicle Speed Sensor) Sensor

SPN	FMI	Condition	Possible Causes	Actions
84	2	Vehicle speed anti-tampering fault	• Incorrect programmable parameter	Pinpoint Diagnostics (page 864)
191	1	TOSS / VSS not detected while vehicle moving	• VSS sensor circuit OPEN • VSS sensor circuit short PWR • VSS sensor circuit short to GND • VSS sensor failure • Air gap too large between VSS sensor and 16 toothed gear • Damaged 16 toothed gear	Step-based Diagnostics (page 866)
191	2	TOSS / VSS signal erratic, intermittent, or incorrect	• VSS sensor circuit short PWR • VSS sensor circuit short to GND • VSS sensor failure • Air gap too large between VSS sensor and 16 toothed gear • Damaged 16 toothed gear	Step-based Diagnostics (page 869)
191	3	TOSS / VSS signal out of range HIGH	• VSS sensor circuit short PWR • VSS sensor failure	Step-based Diagnostics (page 872)

191	4	TOSS / VSS signal out of range LOW	• VSS sensor circuit OPEN • VSS sensor circuit short to GND • VSS sensor failure	Step-based Diagnostics (page 875)
191	16	TOSS / VSS reading higher then limit (Hard-wired)	• VSS sensor circuit OPEN • VSS sensor circuit short PWR • VSS sensor circuit short to GND • VSS sensor failure • Air gap too large between VSS sensor and 16 toothed gear • Damaged 16 toothed gear	Step-based Diagnostics (page 878)

VSS circuit

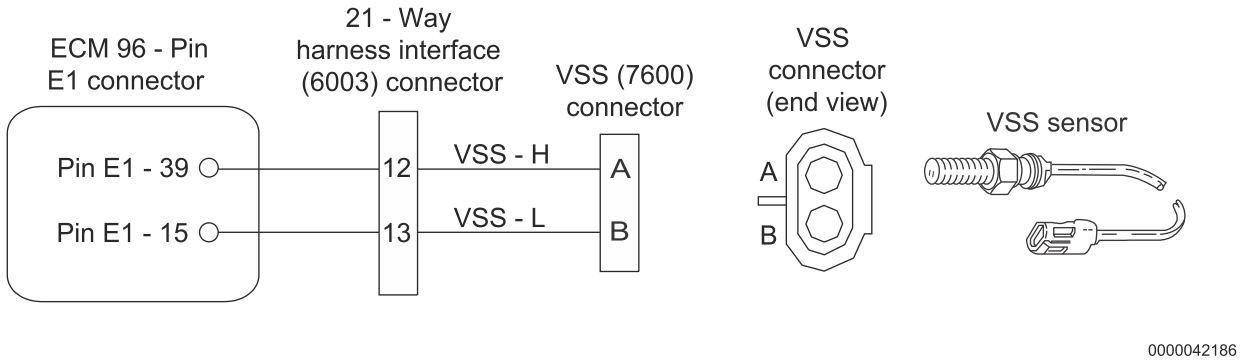


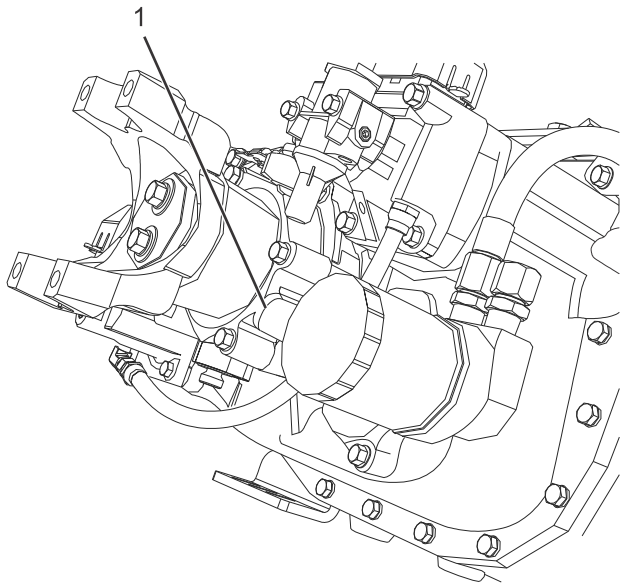
Figure 339 TOSS / VSS Circuit Diagram

Overview

Transmission tailshaft speed is detected by a magnetic pickup mounted on the transmission that senses the rotation of a 16 toothed gear installed on the rear of the transmission. The AC (alternating current) sine wave signal is received by the Engine Control Module (ECM) and is utilized along with tire size and axle ratio, to calculate vehicle speed. Calculated vehicle speed is transmitted to the instrument cluster through the Drive Train Data Link to operate the speedometer within the instrument cluster. Calculated vehicle speed is also utilized in the control strategies that control features such as Cruise Control, PTO operation and Road Speed Limiting.

Tools Required

- 00-00956-08 – 180-pin Breakout Box
- 2010 MaxxForce ® 11 & 13 Harness Kit 00-01462-00
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device



0000042183

Figure 340 TOSS / VSS Location (Typical)

1. Transmission Output Shaft Speed / Vehicle Speed Sensor (TOSS / VSS)

VSS circuit

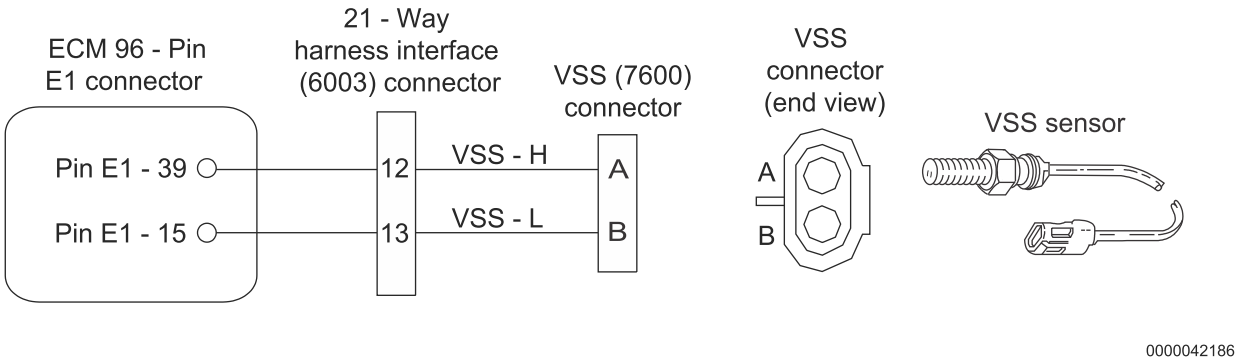


Figure 341 TOSS / VSS Circuit Diagram

Pinpoint Diagnostics With ServiceMaxx™ Software

SPN 84 FMI 2 - Vehicle speed anti-tampering fault

1. Using Electronic Service Tool (EST) with ServiceMaxx™ software, load the Parameters session. Verify the correct value is selected under parameter ID 89003 Vehicle Speed Signal Mode (Hardwired sensor, Public J1939 / CAN OSS, or Public J1939 / Vehicle Speed Sensor).

   Is the correct value selected under parameter ID 89003 Vehicle Speed Signal Mode?

   - Yes: Retest for SPN 84 FMI 2.
   - No: Correct parameter ID 89003 and program engine. Retest for SPN 84 FMI 2.

TOSS / VSS Connector Voltage Check Without ServiceMaxx™ Software

Connect Breakout Harness ZTSE4850 to TOSS/VSS vehicle harness, and leave TOSS/VSS sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
B to GND	2 V to 3 V	If no voltage is present, check for OPEN or short to GND.
A to GND	2 V to 3 V	If no voltage is present, check for OPEN or short to GND.

TOSS / VSS Sensor Continuity Check Without ServiceMaxx™ Software

Turn ignition switch to OFF. Connect Breakout Harness ZTSE4850 to TOSS/VSS sensor harness, and leave vehicle harness disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
B to GND	> 100 Ω	If < 100 Ω, check for short to GND.
A to GND	> 100 Ω	If > 100 Ω check for short to GND.
B to A	600 Ω to 800 Ω	If not within specification, replace VSS sensor.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness to ECM E1 and E2 vehicle harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE4850 to TOSS/VSS vehicle harness, and leave TOSS/VSS sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E1–15 to B	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E1–39 to A	< 5 Ω	If > 5 Ω, check for OPEN circuit.
E1–15 to GND	> 100 Ω	If < 100 Ω, check for short to GND.
E1–39 to GND	> 100 Ω	If < 100 Ω, check for short to GND.

TOSS / VSS Operational Check Without ServiceMaxx™ Software

Turn ignition switch OFF. Connect 180-Pin Breakout Box with ECM E1 and E2 harness between ECM E1 and E2 connectors and ECM. Turn ignition switch to ON. Use DMM to measure voltage or EST to read signal. Place rear axles on jack stands and block front wheels. Have an assistant rotate drive wheels while performing test.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.

Test Point	Specification	Comment – < Less than, > Greater than
E1–15 to E1–39	> 2 V AC	If < 2 V AC, check sensor adjustment or replace defective sensor.

SPN 191 FMI 1 TOSS / VSS not detected while vehicle moving

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
No vehicle speed reading when engine load is high	Vehicle speed	Engine speed > 1500 rpm Time after key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts Engine torque > 74 lb ft (100 Nm) Speed and torque levels met time > 60 seconds Engine not in PTO mode	1 second

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

VSS circuit

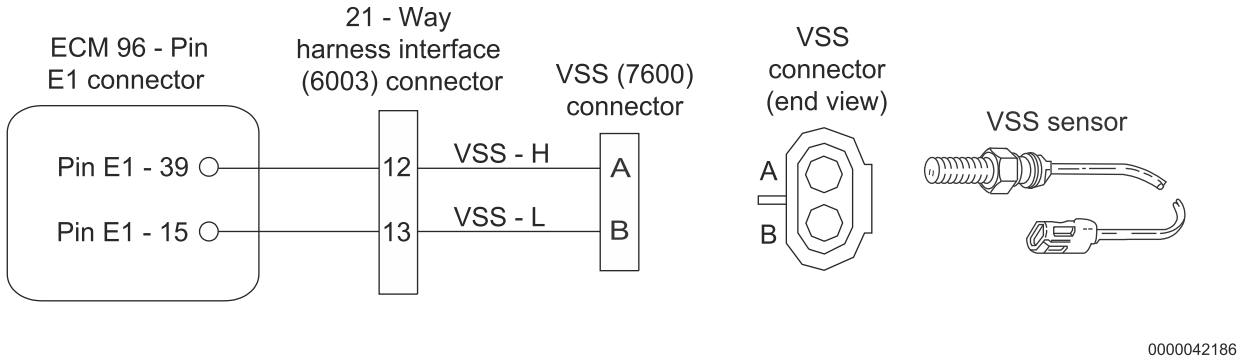


Figure 342 TOSS / VSS Circuit Diagram

Step	Action	Decision
1	Inspect connections at VSS sensor. Key OFF, disconnect VSS sensor connector. Check VSS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Is the VSS sensor connector, harness, and terminal clean and undamaged.	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 191 FMI 1.

Step	Action	Decision
2	Disconnect VSS connector (7600). Key-On Engine-Off (KOEO), measure voltage at VSS connector (7600) pins A & B. Do both pins measure 2 to 3 volts?	Yes: Go to step 3.
		No: Go to step 4.

Step	Action	Decision
3	Do TOSS / VSS Sensor Continuity Check without ServiceMaxx™ Software (page 864). Is VSS sensor within specification?	Yes: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 1.
		No: Replace VSS sensor. After repairs are complete, retest for SPN 191 FMI 1.

Step	Action	Decision
4	Disconnect 21–Way Engine Sensor Interface connector (6033). KOEO, measure voltage at engine side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 2 to 3 volts?	Below 2 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to ground or open circuit. After repairs are complete, retest for SPN 191 FMI 1.
		Yes: Go to step 5.
		Above 3 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 1.

Step	Action	Decision
5	KOEO, measure voltage at chassis side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 0 volts?	Yes: Go to step 6.
		No: Repair harness between VSS (7600) connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 1.

Step	Action	Decision
6	Do TOSS / VSS Operational Check Without ServiceMaxx™ Software (page 865). Was voltage above 2 volts AC?	Yes: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 1.

NOTE: After doing all diagnostic steps, if SPN 191 FMI 1 remain verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 191 FMI 2 TOSS / VSS signal erratic, intermittent, or incorrect

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
VSS signal not detected	Vehicle speed sensor voltage	Time after key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	5 second

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

VSS circuit

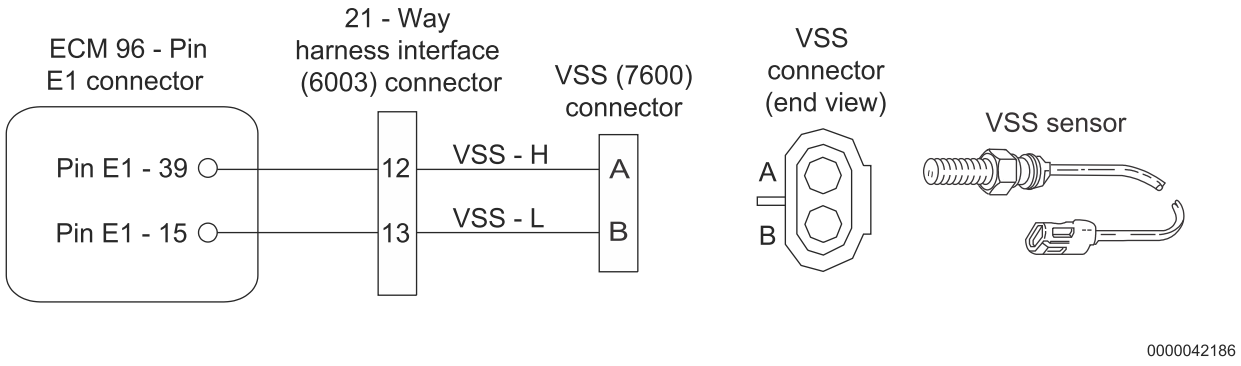


Figure 343 TOSS / VSS Circuit Diagram

Step	Action	Decision
1	Inspect connections at VSS sensor. Key OFF, disconnect VSS sensor connector. Check VSS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Is the VSS sensor connector, harness, and terminal clean and undamaged.	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 191 FMI 2.

Step	Action	Decision
2	Disconnect VSS connector (7600). Key-On Engine-Off (KOEO), measure voltage at VSS connector (7600) pins A & B. Do both pins measure 2 to 3 volts?	Yes: Go to step 3. No: Go to step 4.

Step	Action	Decision
3	Do TOSS / VSS Sensor Continuity Check without ServiceMaxx™ Software (page 864). Is VSS sensor within specification?	Yes: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 2.
		No: Replace VSS sensor. After repairs are complete, retest for SPN 191 FMI 2.

Step	Action	Decision
4	Disconnect 21–Way Engine Sensor Interface connector (6033). KOEO, measure voltage at engine side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 2 to 3 volts?	Below 2 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to ground or open circuit. After repairs are complete, retest for SPN 191 FMI 2.
		Yes: Go to step 5.
		Above 3 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 2.

Step	Action	Decision
5	KOEO, measure voltage at chassis side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 0 volts?	Yes: Go to step 6.
		No: Repair harness between VSS (7600) connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 2.

Step	Action	Decision
6	Do TOSS / VSS Operational Check Without ServiceMaxx™ Software (page 865). Was voltage above 2 volts AC?	Yes: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 2.

NOTE: After doing all diagnostic steps, if SPN 191 FMI 2 remain verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 191 FMI 3 TOSS / VSS signal out of range HIGH

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
VSS signal out of range HIGH	Vehicle speed sensor voltage	Time after key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	0.5 seconds

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

VSS circuit

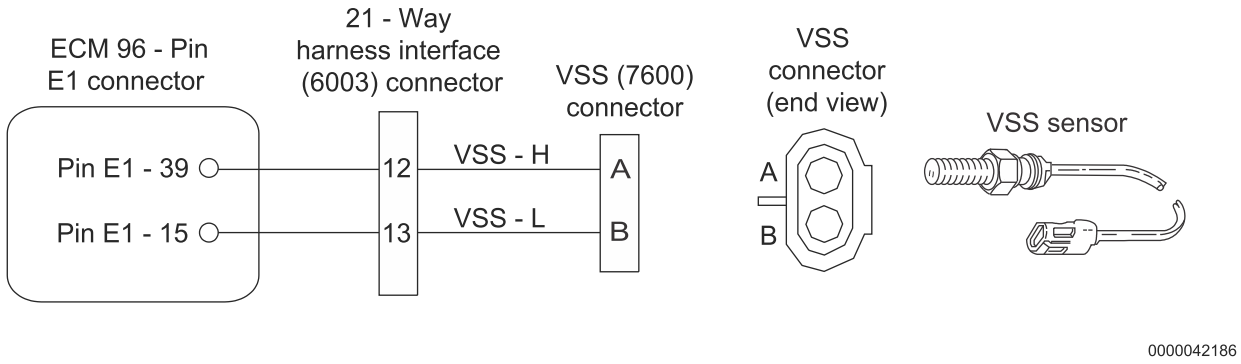


Figure 344 TOSS / VSS Circuit Diagram

Step	Action	Decision
1	Inspect connections at VSS sensor. Key OFF, disconnect VSS sensor connector. Check VSS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Is the VSS sensor connector, harness, and terminal clean and undamaged.	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 191 FMI 3.

Step	Action	Decision
2	Disconnect VSS connector (7600). Key-On Engine-Off (KOEO), measure voltage at VSS connector (7600) pins A & B. Do both pins measure 2 to 3 volts?	Yes: Go to step 3. No: Go to step 4.

Step	Action	Decision
3	Do TOSS / VSS Sensor Continuity Check without ServiceMaxx™ Software (page 864). Is VSS sensor within specification?	Yes: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 3.
		No: Replace VSS sensor. After repairs are complete, retest for SPN 191 FMI 3.

Step	Action	Decision
4	Disconnect 21–Way Engine Sensor Interface connector (6033). KOEO, measure voltage at engine side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 2 to 3 volts?	Below 2 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to ground or open circuit. After repairs are complete, retest for SPN 191 FMI 3.
		Yes: Go to step 5.
		Above 3 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 3.

Step	Action	Decision
5	KOEO, measure voltage at chassis side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 0 volts?	Yes: Go to step 6.
		No: Repair harness between VSS (7600) connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 3.

Step	Action	Decision
6	Do TOSS / VSS Operational Check Without ServiceMaxx™ Software (page 865). Was voltage above 2 volts AC?	Yes: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 191 FMI 3 remain verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 191 FMI 4 TOSS / VSS signal out of range LOW

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
VSS signal out of range LOW	Vehicle speed sensor voltage	Time after key On > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	0.5 seconds

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

VSS circuit

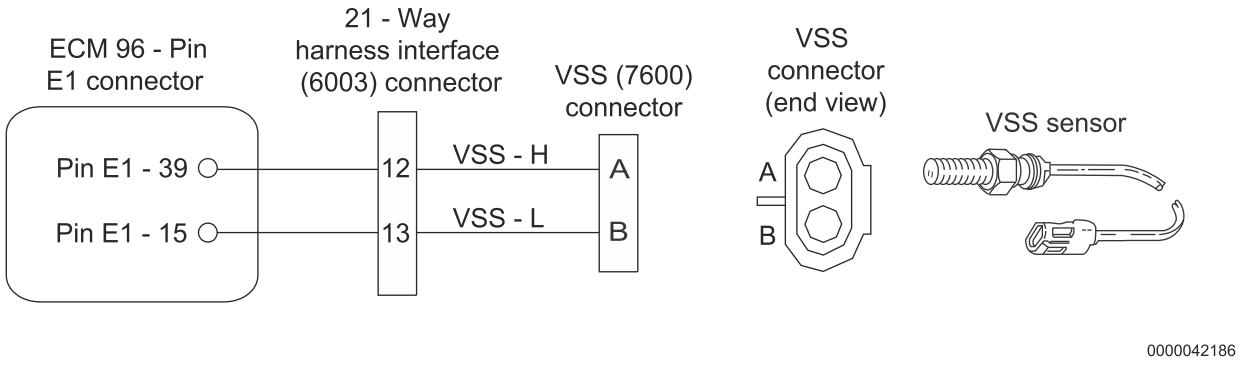


Figure 345 TOSS / VSS Circuit Diagram

Step	Action	Decision
1	Inspect connections at VSS sensor. Key OFF, disconnect VSS sensor connector. Check VSS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Is the VSS sensor connector, harness, and terminal clean and undamaged.	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 191 FMI 4.

Step	Action	Decision
2	Disconnect VSS connector (7600). Key-On Engine-Off (KOEO), measure voltage at VSS connector (7600) pins A & B. Do both pins measure 2 to 3 volts?	Yes: Go to step 3. No: Go to step 4.

Step	Action	Decision
3	Do TOSS / VSS Sensor Continuity Check without ServiceMaxx™ Software (page 864). Is VSS sensor within specification?	Yes: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 4.
		No: Replace VSS sensor. After repairs are complete, retest for SPN 191 FMI 4.

Step	Action	Decision
4	Disconnect 21–Way Engine Sensor Interface connector (6033). KOEO, measure voltage at engine side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 2 to 3 volts?	Below 2 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to ground or open circuit. After repairs are complete, retest for SPN 191 FMI 4.
		Yes: Go to step 5.
		Above 3 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 4.

Step	Action	Decision
5	KOEO, measure voltage at chassis side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 0 volts?	Yes: Go to step 6.
		No: Repair harness between VSS (7600) connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 4.

Step	Action	Decision
6	Do TOSS / VSS Operational Check Without ServiceMaxx™ Software (page 865). Was voltage above 2 volts AC?	Yes: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 191 FMI 4 remain verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 191 FMI 16 TOSS / VSS reading higher then limit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
TOSS / VSS reading higher then limit (Hard-wired)	Vehicle speed sensor voltage	Time after key on > 0 seconds Battery voltage > 10.7 volts Battery voltage < 15 volts	0.5 seconds

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two drive cycles.

Drive Cycle to Determine Fault Status

See 2013 HD-OBD Diagnostic Reference Manual.

VSS circuit

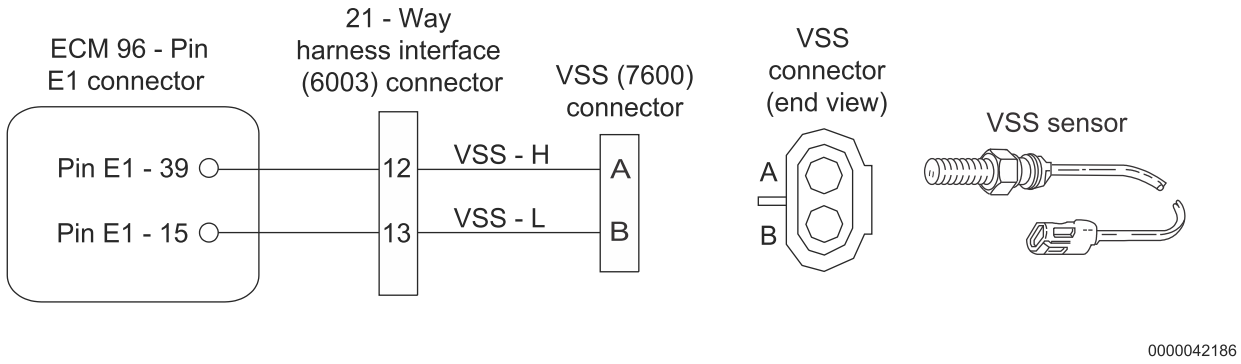


Figure 346 TOSS / VSS Circuit Diagram

Step	Action	Decision
1	Inspect connections at VSS sensor. Key OFF, disconnect VSS sensor connector. Check VSS sensor and connector terminals for: damaged or pinched wires; corroded terminals; loose bent, or broken pins; or broken connector housing. Is the VSS sensor connector, harness, and terminal clean and undamaged.	Yes: Go to step 2. No: Repair connector, harness, or terminal damage. After repairs are complete, retest for SPN 191 FMI 16.

Step	Action	Decision
2	Disconnect VSS connector (7600). Key-On Engine-Off (KOEO), measure voltage at VSS connector (7600) pins A & B. Do both pins measure 2 to 3 volts?	Yes: Go to step 3. No: Go to step 4.

Step	Action	Decision
3	Do TOSS / VSS Sensor Continuity Check without ServiceMaxx™ Software (page 864). Is VSS sensor within specification?	Yes: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 16.
		No: Replace VSS sensor. After repairs are complete, retest for SPN 191 FMI 16.

Step	Action	Decision
4	Disconnect 21–Way Engine Sensor Interface connector (6033). KOEO, measure voltage at engine side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 2 to 3 volts?	Below 2 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to ground or open circuit. After repairs are complete, retest for SPN 191 FMI 16.
		Yes: Go to step 5.
		Above 3 volts: Repair harness between ECM 96–pin E1 connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 16.

Step	Action	Decision
5	KOEO, measure voltage at chassis side 21 Way Engine Sensor Interface connector (6033) pins 12 and 13. Do both pins measure 0 volts?	Yes: Go to step 6.
		No: Repair harness between VSS (7600) connector and 21 Way Engine Sensor Interface (6033) connector for short to power. After repairs are complete, retest for SPN 191 FMI 16.

Step	Action	Decision
6	Do TOSS / VSS Operational Check Without ServiceMaxx™ Software (page 865). Was voltage above 2 volts AC?	Yes: After doing all diagnostic steps, verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.
		No: Check VSS sensor air gap or 16 toothed gear and repair as necessary. After repairs are complete, retest for SPN 191 FMI 16.

NOTE: After doing all diagnostic steps, if SPN 191 FMI 16 remain verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

VREF (Voltage Reference)

SPN	FMI	Condition	Possible Causes	Action
3509	14	VREF1 voltage deviation ECM pins: C1-36	• VREF1 circuit short to GND • VREF1 circuit short to PWR • Failed sensor causing short to GND on VREF1 circuit	Pin-Point Tests (page 883)
3510	14	VREF2 voltage deviation ECM pins: E1-85 and E1-86	• VREF2 circuit short to GND • VREF2 circuit short to PWR • Failed sensor causing short to GND on VREF2 circuit	Pin-Point Tests (page 884)
3511	14	VREF3 voltage deviation ECM pins: E1-89	• VREF3 circuit short to GND • VREF3 circuit short to PWR • Failed sensor causing short to GND on VREF3 circuit	Pin-Point Tests (page 884)
3512	14	VREF4 voltage deviation ECM pins: C1-37, C1-49, and C2-08, E1-58	• VREF4 circuit short to GND • VREF4 circuit short to PWR • Failed sensor causing short to GND on VREF4 circuit • Failed fan clutch	Pin-Point Tests (page 885)

3513	14	VREF5 voltage deviation ECM pins: C1-50, E1-81, and E1-82	• VREF5 circuit short to GND • VREF5 circuit short to PWR • Failed sensor causing short to GND on VREF5 circuit	Pin-Point Tests (page 886)
3514	14	VREF6 voltage deviation ECM pin: E1-88	• VREF6 circuit short to GND • VREF6 circuit short to PWR • Failed sensor causing short to GND on VREF6 circuit	Pin-Point Tests (page 887)

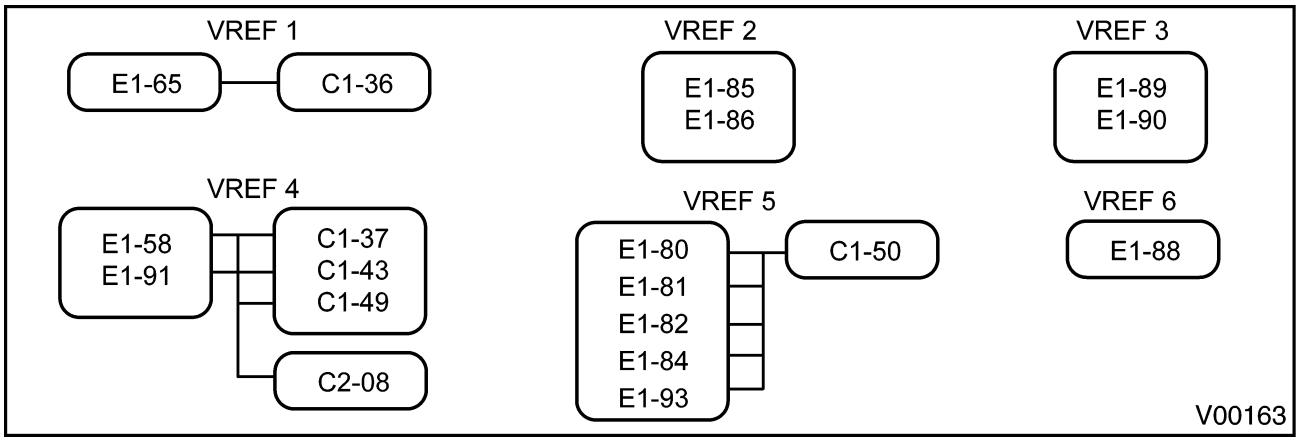


Figure 347 VREF circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Voltage Checks for SPN 3509 FMI 14 – VREF1

NOTE: If circuit fault is intermittent, wiggle harness while measuring voltage.

1. Connect 180-Pin Breakout Box between ECM and engine harness. Use DMM to measure voltage.

   Result Comments

   - If voltage is above 5.7 V, check VREF1 for short to PWR.
   - If voltage is below 4.3 V, check VREF1 for short to GND. Go to next step.

2. Disconnect one component at a time on VREF1 circuit.
   - If voltage returns within specification, replace the internally shorted sensor that pulled voltage down.
   - If voltage remains below specification after disconnecting all sensors on VREF1 circuit. Go to Harness Resistance Check (page 883) and look for VREF1 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
C1-36 to GND	5 V ± 0.7 V	See Result Comments.

Harness Resistance Check for SPN 3509 FMI 14 – VREF1

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Leave VREF1 sensors disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C1-36 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

Voltage Checks for SPN 3510 FMI 14 – VREF2

NOTE: If circuit fault is intermittent, wiggle harness while measuring voltage.

1. Connect 180-Pin Breakout Box between ECM and engine harness. Use DMM to measure voltage.

   Result Comments

   - If voltage is above 5.7 V, check VREF2 for short to PWR
   - If voltage is below 4.3 V, check VREF2 for short to GND. Go to next step.

2. Disconnect one component at a time on VREF2 circuit.
   - If voltage returns within specification, replace the internally shorted sensor that pulled voltage down.
   - If voltage remains below specification after disconnecting all sensors on VREF2 circuit. Go to Harness Resistance Check (page 884) and look for VREF2 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
E1-85 to GND	5 V ± 0.7 V	See Result Comments.
E1-86 to GND	5 V ± 0.7 V	See Result Comments.

Harness Resistance Check for SPN 3510 FMI 14 – VREF2

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Leave VREF2 sensors disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E1-85 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-86 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

Voltage Checks for SPN 3511 FMI 14 – VREF3

NOTE: If circuit fault is intermittent, wiggle harness while measuring voltage.

1. Connect 180-Pin Breakout Box between ECM and engine harness. Use DMM to measure voltage.

   Result Comments

   - If voltage is above 5.7 V, check VREF3 for short to PWR
   - If voltage is below 4.3 V, check VREF3 for short to GND. Go to next step.

2. Disconnect one component at a time on VREF3 circuit.
   - If voltage returns within specification, replace the internally shorted sensor that pulled voltage down.
   - If voltage remains below specification after disconnecting all sensors on VREF3 circuit. Go to Harness Resistance Check (page 885) and look for VREF3 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
E1-89 to GND	5 V ± 0.7 V	See Result Comments.

Harness Resistance Check for SPN 3511 FMI 14 – VREF3

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Leave VREF3 sensors disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E1-89 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

Voltage Checks for SPN 3512 FMI 14 – VREF4

NOTE: If circuit fault is intermittent, wiggle harness while measuring voltage.

1. Connect 180-Pin Breakout Box between ECM and engine harness. Use DMM to measure voltage.

   Result Comments

   - If voltage is above 5.7 V, check VREF4 for short to PWR.
   - If voltage is below 4.3 V, check VREF4 for short to GND. Go to next step.

2. Disconnect one component at a time on VREF4 circuit.
   - If voltage returns within specification, replace the internally shorted sensor that pulled voltage down.
   - If voltage remains below specification after disconnecting all sensors on VREF4 circuit. Go to Harness Resistance Check (page 885) and look for VREF4 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
C1-37 to GND	5 V ± 0.7 V	See Result Comments.
C1-49 to GND	5 V ± 0.7 V	See Result Comments.
C2-08 to GND	5 V ± 0.7 V	See Result Comments.
E1-58 to GND	5 V ± 0.7 V	See Result Comments.

Harness Resistance Check for SPN 3512 FMI 14 – VREF4

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Leave VREF4 sensors disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C1-37 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
C1-49 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
C2-08 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-58 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

Voltage Checks for SPN 3513 FMI 14 – VREF5

NOTE: If circuit fault is intermittent, wiggle harness while measuring voltage.

1. Connect 180-Pin Breakout Box between ECM and engine harness. Use DMM to measure voltage.

   Result Comments

   - If voltage is above 5.7 V, check VREF5 for short to PWR
   - If voltage is below 4.3 V, check VREF5 for short to GND. Go to next step.

2. Disconnect one component at a time on VREF5 circuit.
   - If voltage returns within specification, replace the internally shorted sensor that pulled voltage down.
   - If voltage remains below specification after disconnecting all sensors on VREF5 circuit. Go to Harness Resistance Check (page 886) and look for VREF5 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
C1-50 to GND	5 V ± 0.7 V	See Result Comments.
E1-81 to GND	5 V ± 0.7 V	See Result Comments.
E1-82 to GND	5 V ± 0.7 V	See Result Comments.

Harness Resistance Check for SPN 3513 FMI 14 – VREF5

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Leave VREF5 sensors disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
C1-50 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-81 to GND	> 1k Ω	If < 1k Ω, check for short circuit.
E1-82 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

Voltage Checks for SPN 3514 FMI 14 – VREF6

NOTE: If circuit fault is intermittent, wiggle harness while measuring voltage.

1. Connect 180-Pin Breakout Box between ECM and engine harness. Use DMM to measure voltage.

   Result Comments

   - If voltage is above 5.7 V, check VREF6 for short to PWR
   - If voltage is below 4.3 V, check VREF6 for short to GND. Go to next step.

2. Disconnect one component at a time on VREF6 circuit.
   - If voltage returns within specification, replace the internally shorted sensor that pulled voltage down.
   - If voltage remains below specification after disconnecting all sensors on VREF6 circuit. Go to Harness Resistance Check (page 887) and look for VREF6 circuit short to GND.

Test Point	Specification	Comment – < Less than, > Greater than
E1-88 to GND	5 V ± 0.7 V	See Result Comments.

Harness Resistance Check for SPN 3514 FMI 14 – VREF6

NOTE: If circuit fault is intermittent, wiggle harness while measuring resistance.

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Leave VREF6 sensors disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
E1-88 to GND	> 1k Ω	If < 1k Ω, check for short circuit.

WIF Sensor (Water In Fuel)

SPN	FMI	Condition	Possible Causes	Action
4192	3	WIF signal Out of Range HIGH	• WIF circuit short to PWR	Pin-Point Diagnostics (page 889)
4192	4	WIF signal Out of Range LOW	• WIF circuit short to GND	Pin-Point Diagnostics (page 889)

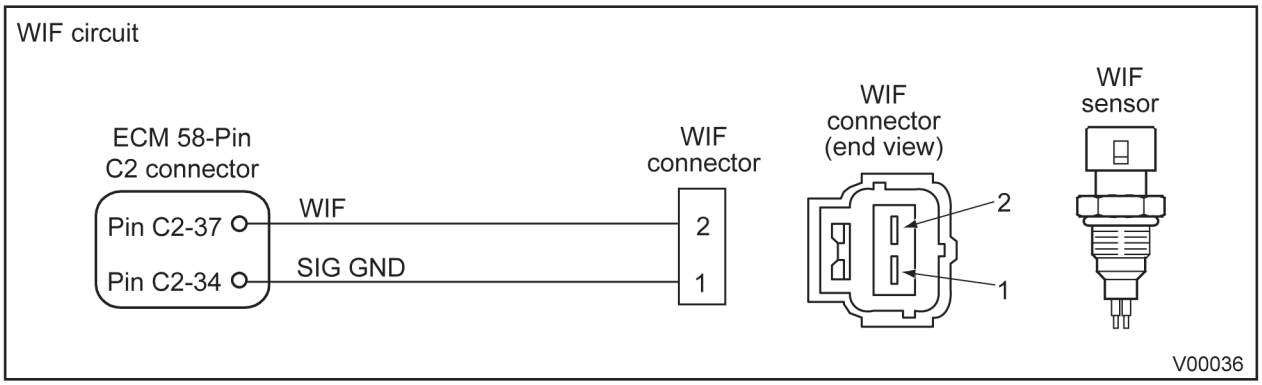


Figure 348 WIF circuit diagram

Tools Required

- 00-00956-08 – 180-Pin Breakout Box
- 2010 MaxxForce 11 & 13 Harness Kit 00-01462-00
- ZTSE4498 – 3-Banana Plug Harness
- ZTSE4497 – 500 Ohm Resistor Harness
- ZTSE4899 – Big Bore Terminal Test Probe Kit
- Breakout Harness ZTSE6002 (WIF)
- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

Pinpoint Diagnostics With ServiceMaxx™ Software

WARNING: To prevent personal injury or death, stay clear of rotating parts (belts and fan) and hot engine surfaces.

1. Drain a fuel sample from the water drain valve on the primary fuel filter housing. See Drain Water from Primary Fuel Filter in the “ENGINE SYMPTOMS DIAGNOSTICS."
   - If water is present, drain all the water out of the system.
   - If no water is present in the fuel sample, continue to next step.
2. Using Electronic Service Tool (EST) with ServiceMaxx™ software, open the Continuous Monitor session.

   NOTE: The WIF signal will read YES if there is water in the fuel filter housing, or if the WIF signal circuit is shorted high.
   - If DTC is inactive, monitor the signal while wiggling the connector and all wires at suspected location. If the circuit is interrupted, the signal will change from No to Yes and the DTC will go active.
   - If DTC is active, go to the next step.
3. Disconnect engine harness from sensor.

   NOTE: Inspect connectors for damaged pins, corrosion, or loose pins. Repair if necessary.
4. Connect Breakout Harness ZTSE6002 to engine harness. Leave sensor disconnected.

Voltage Check

Connect Breakout Harness ZTSE6002 to WIF vehicle harness, and leave WIF sensor disconnected. Turn ignition ON. Use DMM to measure voltage.

Test Point	Specification	Comment – < Less than, > Greater than
1 to B+	B+	If < B+, check SIG GND circuit for OPEN.
2 to GND	4.6 V	If > 5.5 V, check WIF circuit for short to PWR.
		If < 4.0 V, check WIF circuit for short to GND.

Connector Resistance Check to GND

Turn ignition switch OFF. Connect Breakout Harness ZTSE6002 to WIF vehicle harness, and leave WIF sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to GND	< 5 Ω	If > 5 Ω, check SIG GND for OPEN circuit.
2 to GND	> 1k Ω	If < 1k Ω, check WIF circuit for short to GND.

Harness Resistance Check

Turn ignition switch to OFF. Connect 180-Pin Breakout Box with ECM C1 and C2 harness to ECM C1 and C2 vehicle harness connectors, and leave ECM disconnected. Connect Breakout Harness ZTSE6002 to WIF vehicle harness, and leave WIF sensor disconnected. Use DMM to measure resistance.

Test Point	Specification	Comment – < Less than, > Greater than
1 to C2-34	< 5 Ω	If > 5 Ω, check for OPEN circuit.
2 to C2-37	< 5 Ω	If > 5 Ω, check for OPEN circuit.

WIFL (Water In Fuel Lamp)

SPN	FMI	Condition	Possible Causes	Actions
97	3	WIFL short to PWR	• WIFL circuit short to PWR • Failed WIFL	Step-Based Diagnostics (page 892)
97	4	WIFL short to GND	• WIFL circuit short to GND • Failed WIFL	Step-Based Diagnostics (page 893)
97	5	WIFL Open load / circuit	• WIFL circuit open • Failed WIFL	Step-Based Diagnostics (page 895)

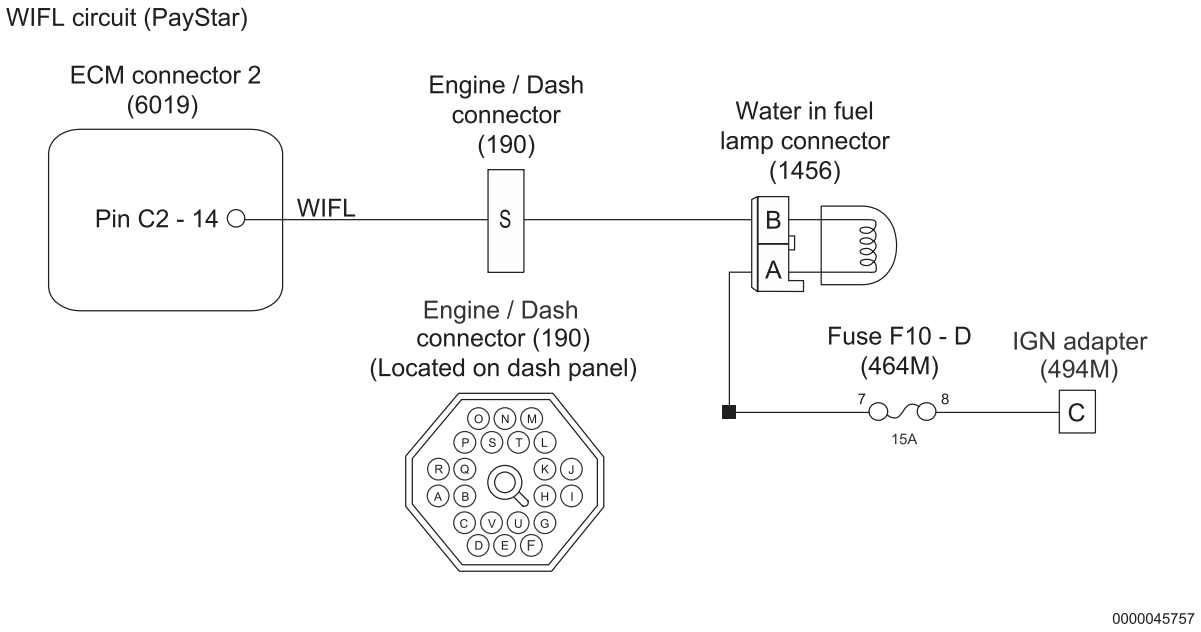


Figure 349 WIFL Circuit Diagram (PayStar)

Overview

The Water-in-Fuel Lamp (WIFL) informs the operator when the fuel / water separator is getting full of water. Water must be drained from the separator to protect the fuel system from contamination.

Tools Required

- Digital Multimeter (DMM)
- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device

SPN 97 - FMI 3 - WIFL short to PWR

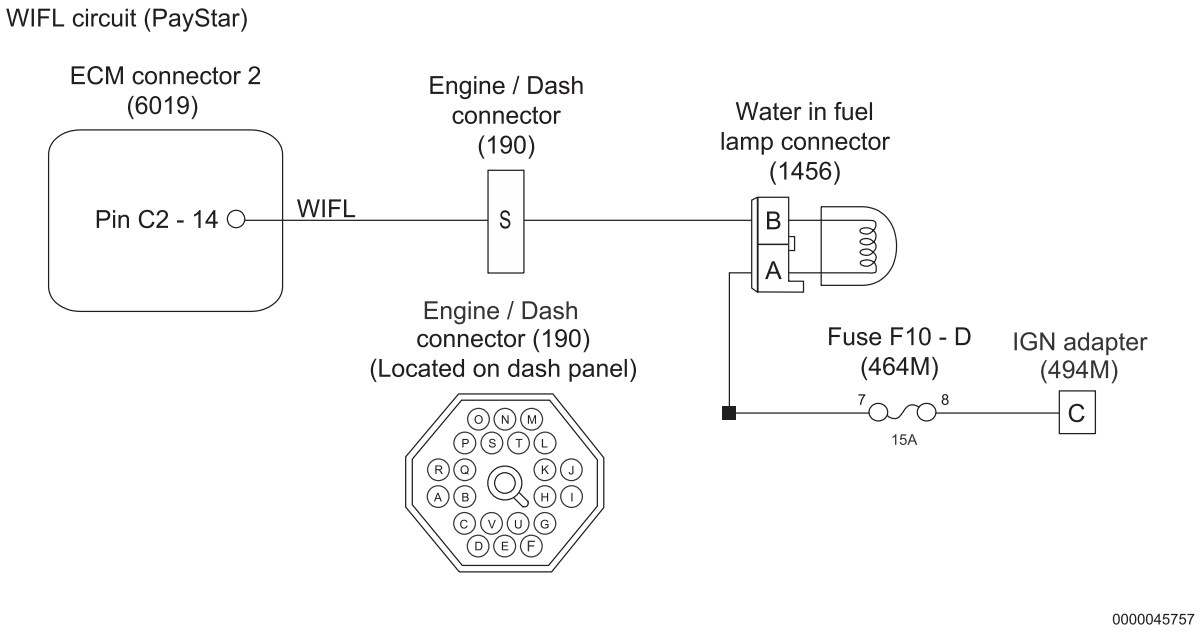


Figure 350 WIFL Circuit Diagram (PayStar)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 97 FMI 3 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 97 FMI 3.

Step	Action	Decision
2	Measure for short to power on engine side of WIFL circuit. Disconnect WIFL connector (1456) located in the vehicle instrument panel (see WIFL Circuit Diagram and vehicle Electrical Circuit Diagrams manual for additional details). Key ON, measure voltage at pin B of connector (1456). Is voltage less than 4.2 volts?	Yes: Replace Water in Fuel Lamp. After repairs are complete, retest for SPN 97 FMI 3. No: Repair short to power between WIFL connector (1456) pin B and ECM 58-pin connect C2 pin 14. After repairs are complete, retest for SPN 97 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 97 FMI 3 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 97 - FMI 4 - WIFL short to GND

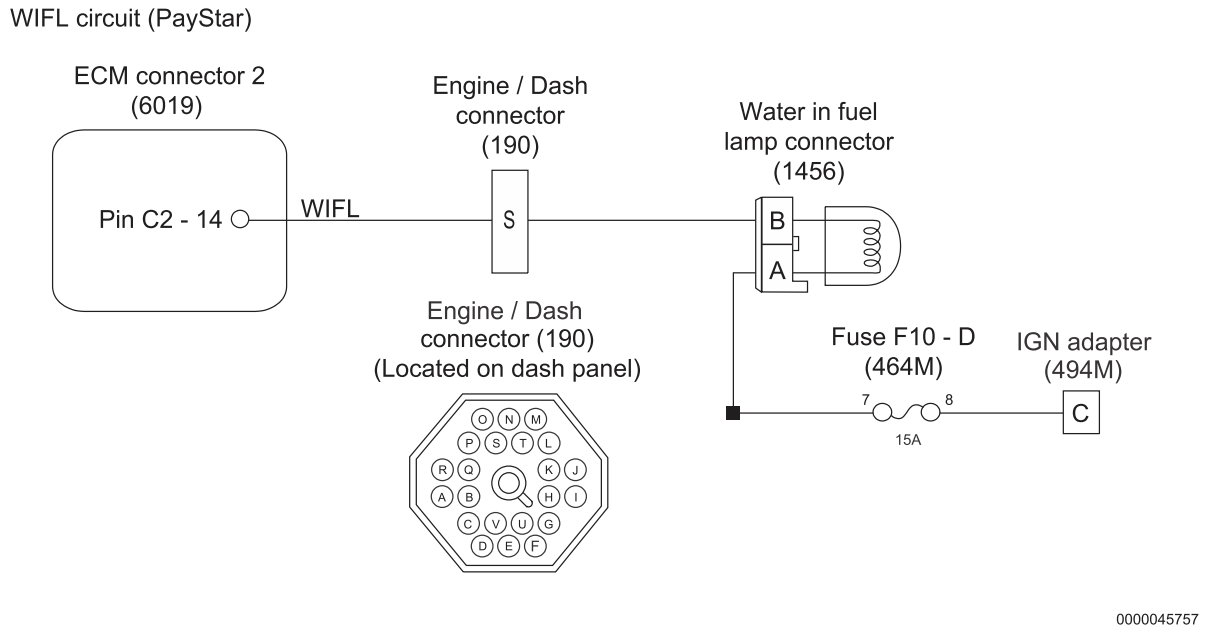


Figure 351 WIFL Circuit Diagram (PayStar)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 97 FMI 4 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 97 FMI 4.

Step	Action	Decision
2	Measure engine side of WIFL circuit for short to ground. Disconnect WIFL connector (1456) located in the vehicle instrument panel (see WIFL Circuit Diagram and vehicle Electrical Circuit Diagrams for additional details). Key OFF, measure resistance between pin B of connector (1456) and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 3. No: Repair short to ground between WIFL connector (1456) pin B and ECM 58-pin connector C2 pin 14. After repairs are complete, retest for SPN 97 FMI 4.

Step	Action	Decision
3	Measure vehicle side of WIFL circuit for short to ground. Key OFF, measure resistance between pin A of connector (1456) and a known good ground. Is resistance greater than 1000 ohms?	Yes: Replace Water in Fuel Lamp.
		No: Repair short to ground between WIFL connector (1456) pin A and vehicle wiring (see WIFL Circuit Diagram and vehicle Electrical Circuit Diagrams for additional details) . After repairs are complete, retest for SPN 97 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 97 FMI 4 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 97 - FMI 5 - WIFL open / load circuit

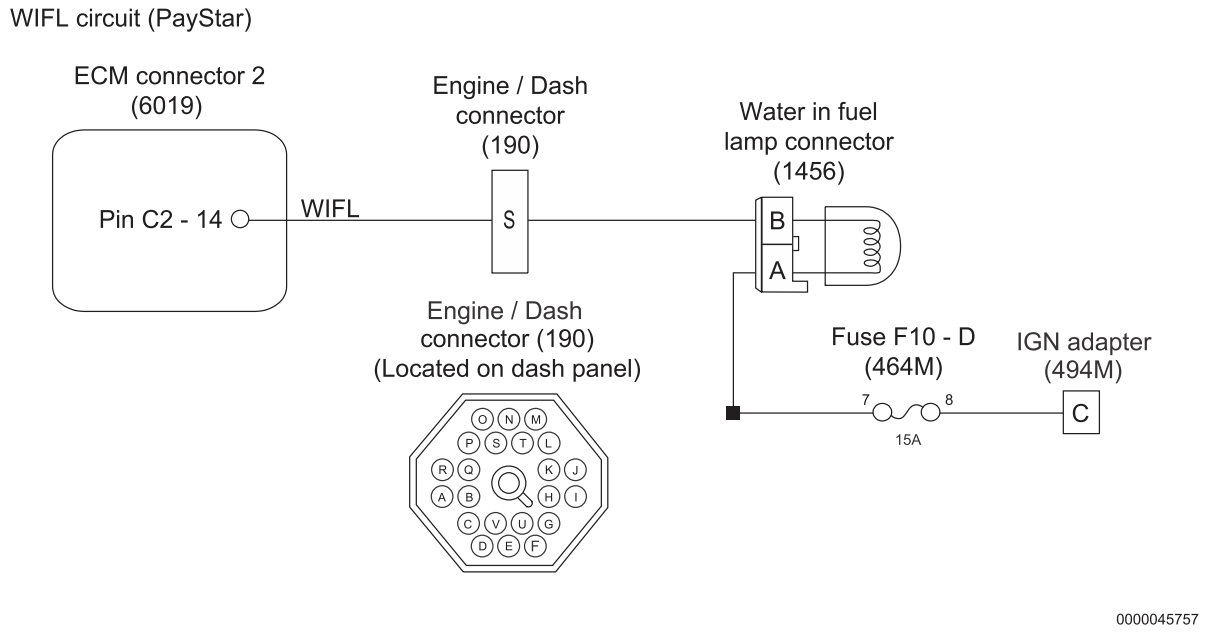


Figure 352 WIFL Circuit Diagram (PayStar)

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 97 FMI 5 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 97 FMI 5.

Step	Action	Decision
2	Check 15 amp fuse F10-D (464M) (see vehicle Electrical Circuit Diagrams for additional details). Is fuse in good condition and not blown (Open)?	Yes: Go to step 3. No: Replace 15 amp fuse F10–D (464M). After repairs are complete, retest for SPN 97 FMI 5.

Step	Action	Decision
3	Test vehicle side of circuit for Open. Key OFF, disconnect WIFL connector (1456) located in the vehicle instrument panel (see vehicle Electrical Circuit diagrams for additional details). Key ON, measure voltage at pin A of connector (1456). Is voltage 12 volts or greater while the WIFL circuit is activated?	Yes Go to step 4. No: Repair Open or high resistance between WIFL connector pin A and vehicle wiring (see WIFL Circuit Diagram and vehicle Electrical Circuit Diagrams for additional details). After repairs are complete, retest for SPN 97 FMI 5.

Step	Action	Decision
4	Measure engine side of WIFL circuit for Open. Key OFF, disconnect Engine Control Module (ECM) C2 connector. Measure resistance between ECM connector C2 pin 14 and WIFL connector pin B. Is resistance more than 5 ohms?	Yes: Repair open or high resistance in circuit between ECM connector C2 pin 14 and WIFL connector pin B. No: Replace Water in Fuel Lamp. After repairs are complete, retest for SPN 97 FMI 5.

NOTE: After doing all diagnostic steps, if SPN 97 FMI 5 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

WTSL (Wait to Start Lamp)

SPN	FMI	Condition	Possible Causes	Actions
1081	3	WTSL circuit short to PWR	• Failed WTSL • WTSL circuit shorted to PWR	Step-Based Diagnostics (page 898)
1081	4	WTSL circuit short to GND	• Failed WTSL • WTSL circuit shorted to GND	Step-Based Diagnostics (page 900)
1081	5	WTSL open load/circuit	• Failed WTSL • Fuse blown / open • WTSL circuit OPEN	Step-Based Diagnostics (page 902)

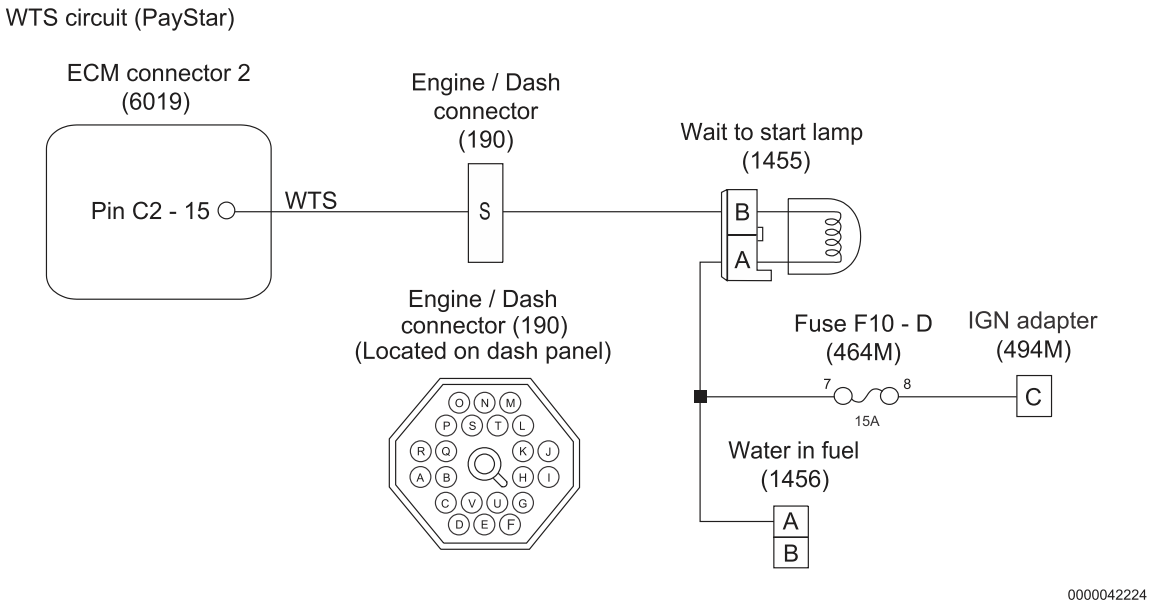


Figure 353 WTSL Circuit Diagram

Overview

The wait-to-start lamp illuminates when the ignition switch is turned ON. For Engine Coolant Temperature (ECT) lower than 50°F (10°C), the Engine Control Module (ECM) activates the Inlet Air Heater Relay (IAHR). The IAHR then energizes the Inlet Air Heater Fuel Igniter (IAHFI) for approximately 35 seconds. Once the IAHFI is heated, the wait-to-start lamp starts to flash and the engine is ready to be started. Once the engine starts, the IAHFI remains energized and the wait-to-start lamp continues to flash for a maximum of four minutes. When the wait-to-start lamp stops flashing, the IAHFI and the IAHS valve are deactivated. If the operator accelerates while the wait-to-start lamp is flashing, the inlet air heater system will shutdown.

Tools Required

- Electronic Service Tool (EST) with ServiceMaxx™ software
- J1939 and J1708 RP1210B Compliant Device
- Digital Multimeter (DMM)

SPN 1081 - FMI 3 - WTSL circuit short to PWR

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Wait to Start Lamp (WTSL) circuit short to power.	ECM indicates short to battery	Battery voltage > 10.7 volts Battery voltage < 15 volts Key On	0.5 seconds

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

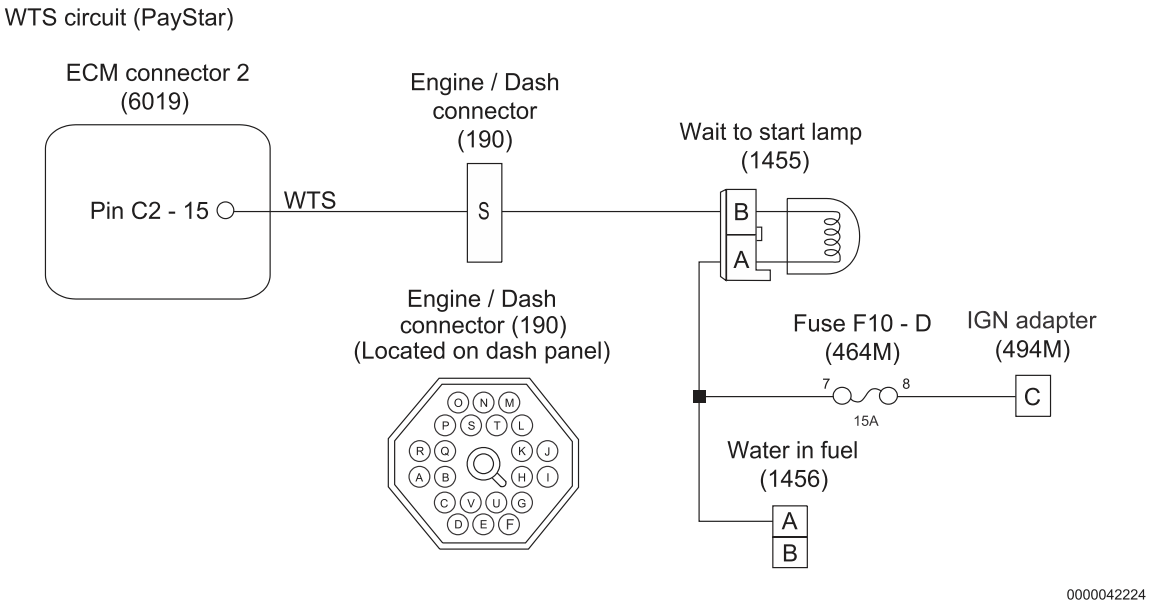


Figure 354 WTSL Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 1081 FMI 3 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 1081 FMI 3.

Step	Action	Decision
2	Measure for short to power on engine side of WTSL circuit. Disconnect WTSL connector (1455) located in the vehicle instrument panel (see WTSL Circuit Diagram and vehicle Electrical Circuit Diagrams manual for additional details). Key ON, measure voltage at pin B of connector (1455). Is voltage less than 4.2 volts?	Yes: Replace Wait to Start Lamp. After repairs are complete, retest for SPN 1081 FMI 3.
		No: Repair short to power between WTSL connector (1455) pin B and ECM 58–pin connector C2 pin 15. After repairs are complete, retest for SPN 1081 FMI 3.

NOTE: After doing all diagnostic steps, if SPN 1081 FMI 3 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1081 - FMI 4 - WTSL circuit short to GND

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Wait to Start Lamp (WTSL) circuit short to ground.	ECM indicates short to ground	Battery voltage > 10.7 volts Battery voltage < 15 volts Key On	0.5 seconds

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

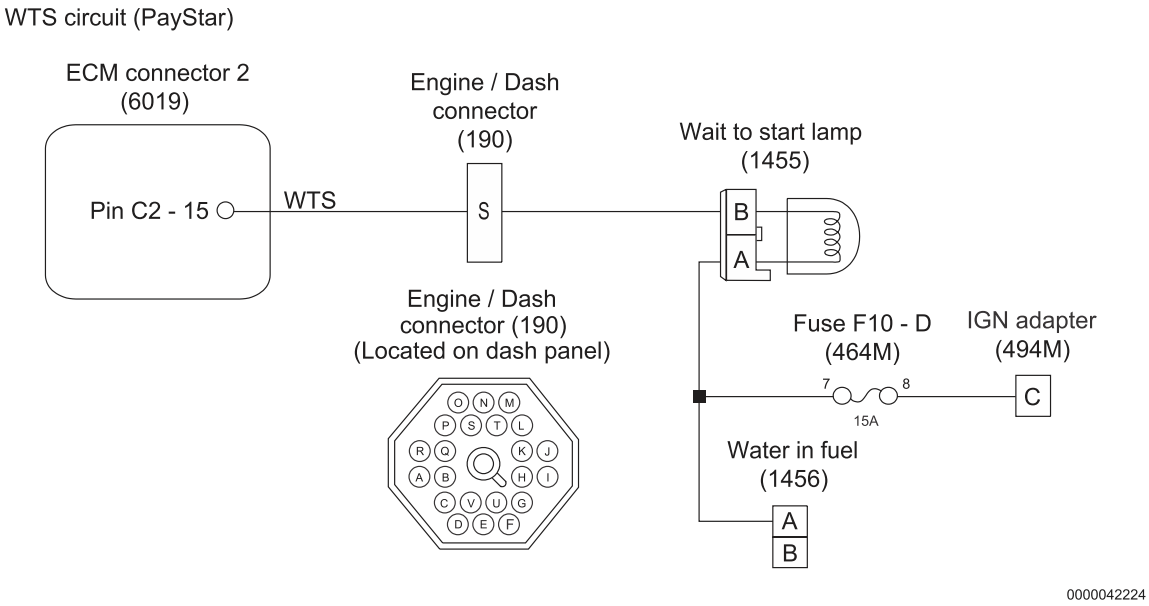


Figure 355 WTSL Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 1081 FMI 4 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 1081 FMI 4.

Step	Action	Decision
2	Measure engine side of WTSL circuit for short to ground. Disconnect WTSL connector (1455) located in the vehicle instrument panel (see vehicle Electrical Circuit Diagrams for additional details). Key OFF, measure resistance between pin B of connector (1455) and a known good ground. Is resistance greater than 1000 ohms?	Yes: Go to step 3. No: Repair short to ground between WTSL connector (1455) pin B and ECM 58–pin connector C2 pin 15. After repairs are complete, retest for SPN 1081 FMI 4.

Step	Action	Decision
3	Measure vehicle side of WTSL circuit for short to ground. Key OFF, measure resistance between pin A of connector (1455) and a known good ground. Is resistance greater than 1000 ohms?	Yes: Replace Wait to Start Lamp. After repairs are complete, retest for SPN 1081 FMI 4. No: Repair short to ground between WTSL connector (1455) pin A and vehicle wiring (see WTSL Circuit Diagram and vehicle Electrical Circuit Diagrams for additional details). After repairs are complete, retest for SPN 1081 FMI 4.

NOTE: After doing all diagnostic steps, if SPN 1081 FMI 4 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

SPN 1081 - FMI 5- WTSL open load / circuit

Condition / Description	Setting Criteria	Enable Conditions / Values	Time Required
Wait to Start Lamp (WTSL) circuit open.	ECM indicates no load	Battery voltage > 10.7 volts Battery voltage < 15 volts Key On	0.5 seconds

Malfunction Indicator Lamp (MIL) Reaction

MIL will illuminate when this fault is detected during two consecutive drive cycles.

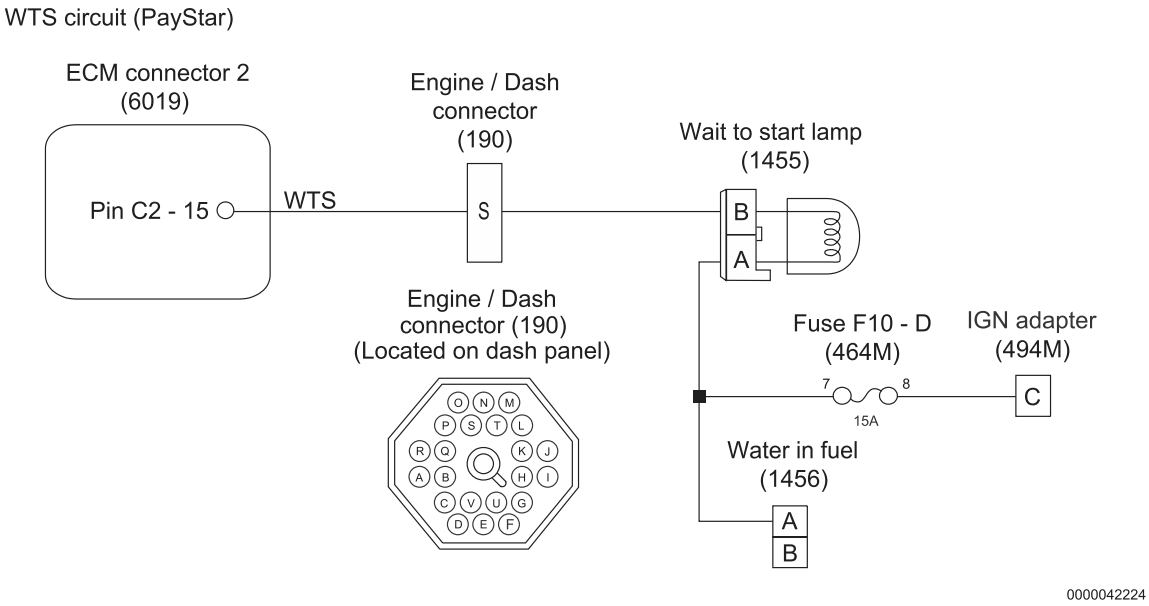


Figure 356 WTSL Circuit Diagram

Step	Action	Decision
1	Using Electronic Service Tool (EST) with ServiceMaxx™ software, check for other fault codes. Is SPN 1081 FMI 5 the only fault code active?	Yes: Go to step 2. No: Repair other fault code(s). After repairs are complete, retest for SPN 1081 FMI 5.

Step	Action	Decision
2	Check 15 amp fuse F10-D (464M) (see vehicle Electrical Circuit Diagrams for additional details). Is fuse in good condition and not blown (Open)?	Yes: Go to step 3. No: Replace 15 amp fuse F10-D (464M). After repairs are complete, retest for SPN 1081 FMI 5.

Step	Action	Decision
3	Test vehicle side of circuit for Open. Key OFF, disconnect WTSL connector (1455) located in the vehicle instrument panel (see vehicle Electrical Circuit Diagrams for additional details). Key ON, measure voltage at pin A of connector (1455). Is voltage 12 volts or greater while the WTSL circuit is activated?	Yes: Go to step 4. No: Repair Open or high resistance between WTSL connector pin A and vehicle wiring (see WTSL Circuit Diagram and vehicle Electrical Circuit Diagrams for additional details). After repairs are complete, retest for SPN 1081 FMI 5.

Step	Action	Decision
4	Measure engine side of WTSL circuit for Open. Key OFF, disconnect Engine Control Module (ECM) C2 connector. Measure resistance between ECM connector C2 pin 15 and WTSL connector pin B. Is resistance more than 5 ohms?	Yes: Repair open or high resistance in circuit between ECM connector C2 pin 15 and WTSL connector pin B. After repairs are complete, retest for SPN 1081 FMI 5. No: Replace Wait to Start Lamp. After repairs are complete, retest for SPN 1081 FMI 5.

NOTE: After doing all diagnostic steps, if SPN 1081 FMI 5 remains verify each step was completed correctly and the proper decision was made. Notify supervisor for further action.

Sensor and Actuator Locations

Engine Mounted Components

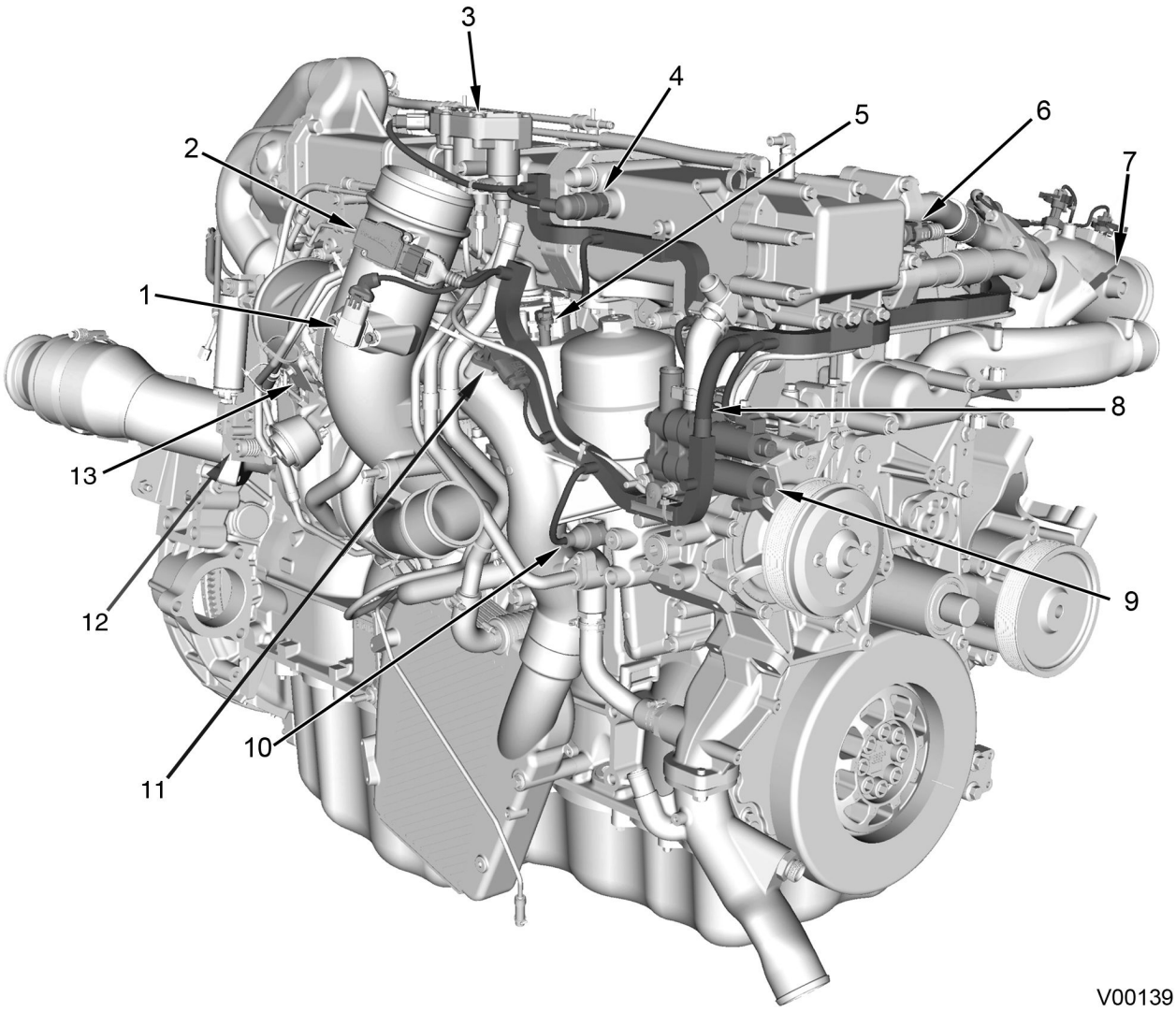


Figure 357 Component location – right side/front

1. Humidity Sensor (HS) / Inlet Air Temperature (IAT)
2. Mass Air Flow (MAF) sensor
3. Air Control Valve (ACV) assembly
4. Engine Coolant Temperature 2 (ECT2) sensor
5. Crankcase Oil Separator Speed (CCOSS) sensor
6. Exhaust Gas Recirculation Temperature (EGRT) sensor
7. Inlet Air Heater Fuel Igniter (IAHFI)
8. Engine Oil Temperature (EOT) sensor (behind the CCV in oil module flange)
9. Coolant Control Valve (CCV) assembly (CCV contains CMV and CFV)
10. Engine Oil Pressure (EOP) sensor
11. Turbocharger 2 Compressor Inlet Sensor (TC2CIS)
12. Exhaust Back Pressure Valve (EBPV)
13. Oxygen Sensor (O_2S)

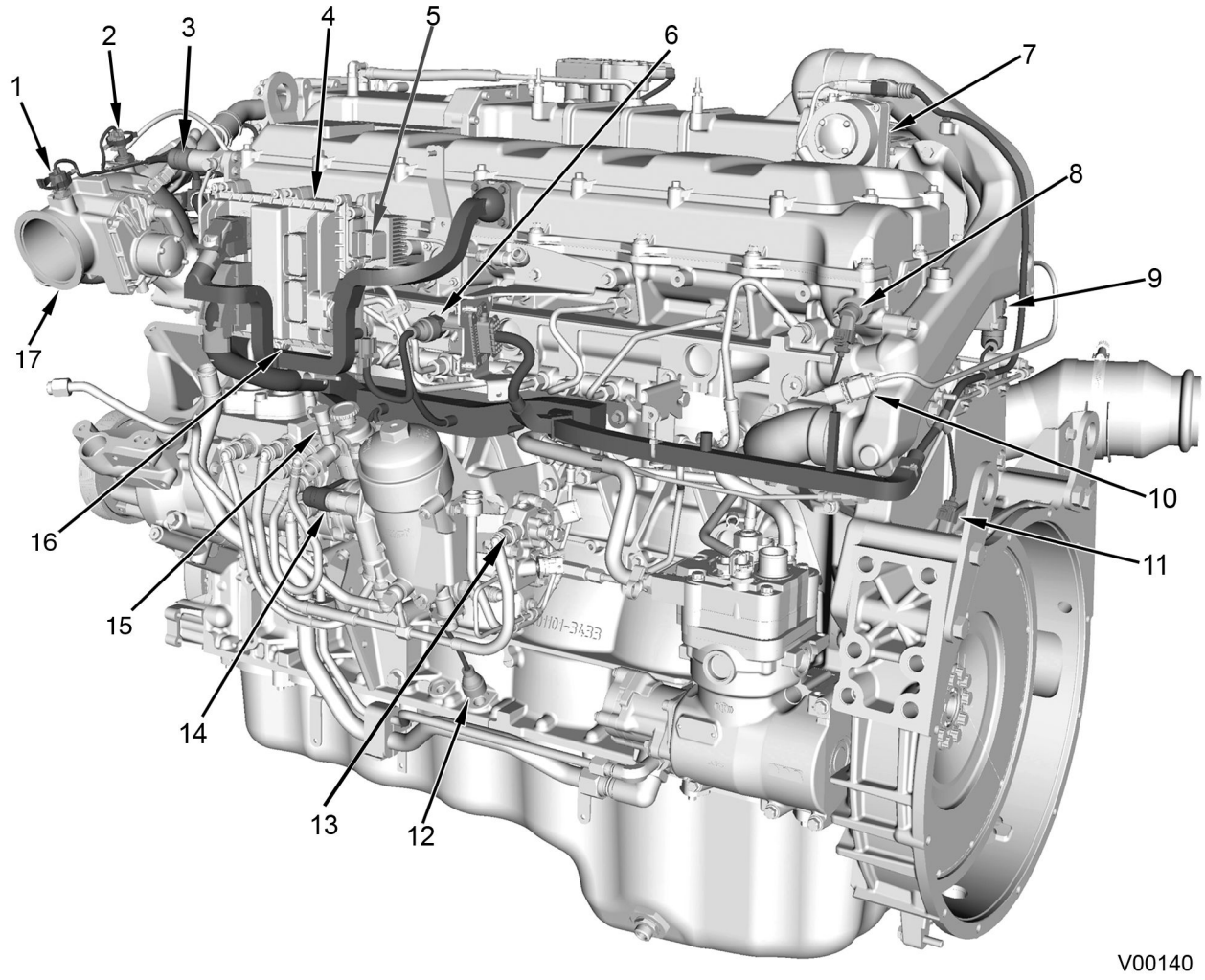


Figure 358 Component location – left side/rear

1. Charger Air Cooler Outlet Temperature (CACOT) sensor
2. Intake Manifold Pressure (IMP) sensor
3. Inlet Air Heater Solenoid (IAHFS)
4. Engine Control Module (ECM) with Barometric Pressure (BARO) internal sensor
5. Inlet Air Heater Relay (IAHR)
6. Intake Manifold Temperature (IMT) sensor
7. Exhaust Gas Recirculation (EGR) valve
8. Camshaft Position (CMP) sensor
9. Engine Coolant Temperature (ECT1) sensor
10. Oxygen Sensor (O_2S) connector
11. Crankshaft Position (CKP) sensor
12. Engine Oil level (EOL) sensor
13. Downstream Injection (DSI) (DSI unit contains AFTFD, AFTFIS, AFTFP2, and AFTFSV sensors)
14. Fuel Delivery Pressure (FDP) sensor
15. Fuel Pressure Control Valve (FPCV) (at back of high-pressure fuel pump)
16. Fuel Rail Pressure (FRP) sensor (behind ECM, at front of fuel rail)
17. Engine Throttle Valve (ETV)

AFT System

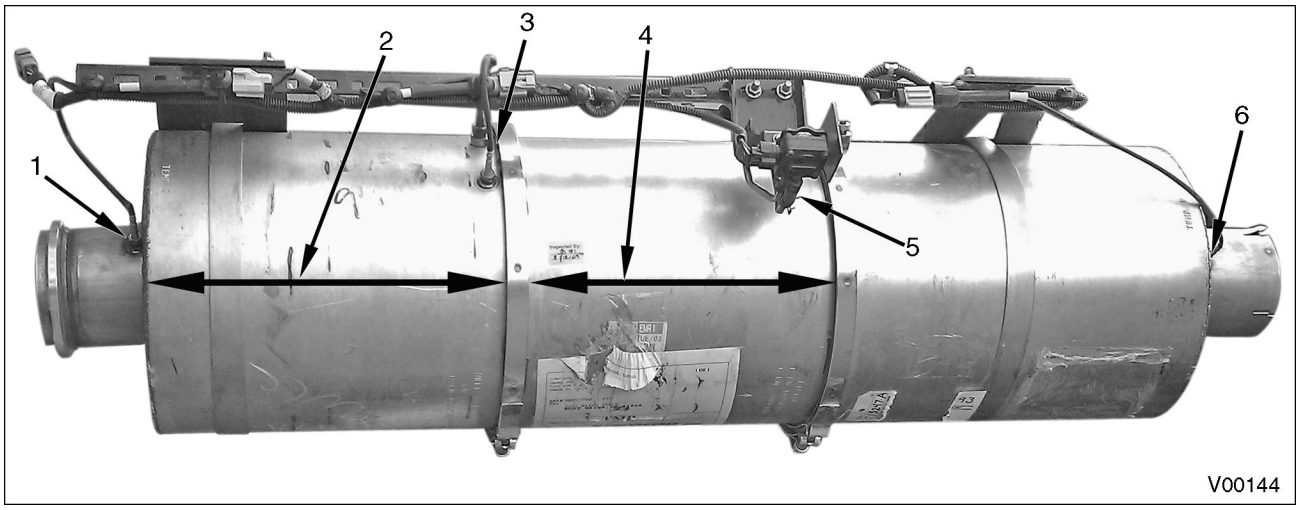


Figure 359 AFT System Operation

1. Diesel Oxidation Catalyst Inlet Temperature (DOCIT)
2. Diesel Oxidation Catalyst (DOC)
3. Diesel Oxidation Catalyst Outlet Temperature (DOCOT)
4. Diesel Particulate Filter (DPF)
5. Diesel Particulate Filter Differential Pressure (DPFDP)
6. Diesel Particulate Filter Outlet Temperature (DPFOT)

Engine Compression Brake Locations

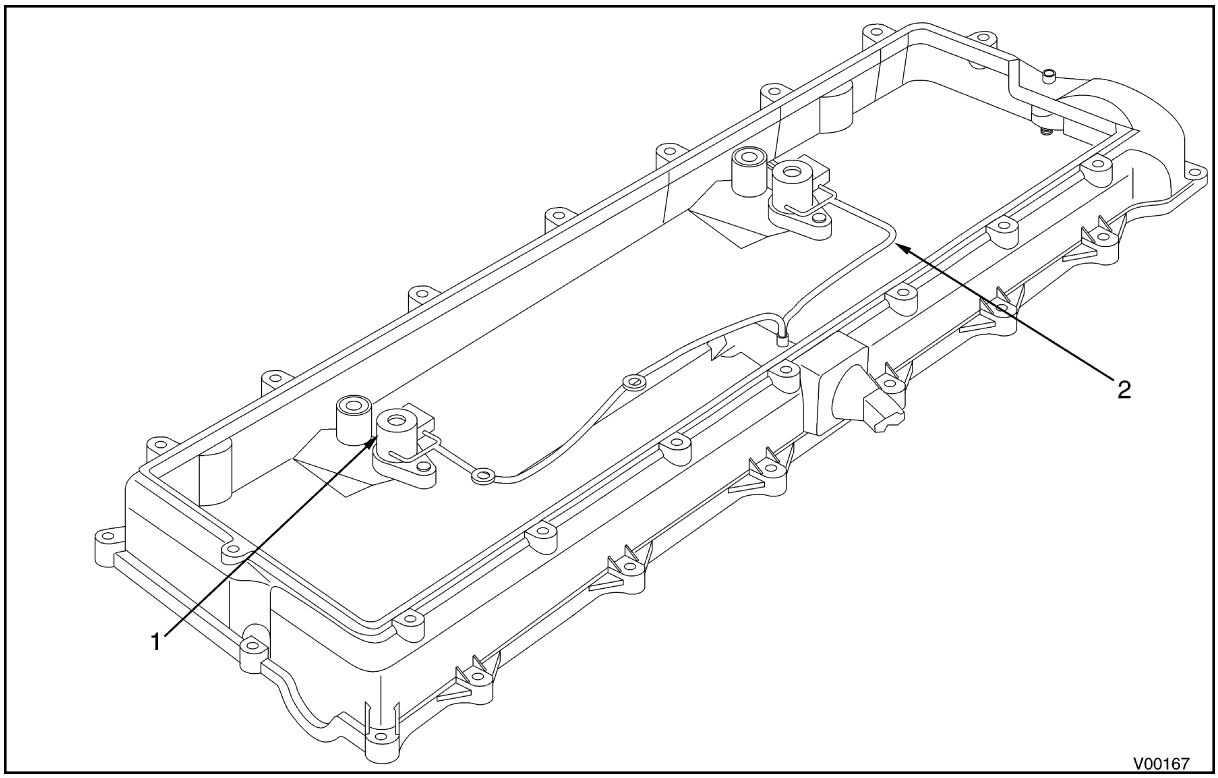


Figure 360 Engine Compression Brake (Solenoid Assembly)

1. Engine Compression Brake 1 (ECB1)
2. Engine Compression Brake 2 (ECB2)

Vehicle Mounted Components

Accelerator Pedal Position Sensor

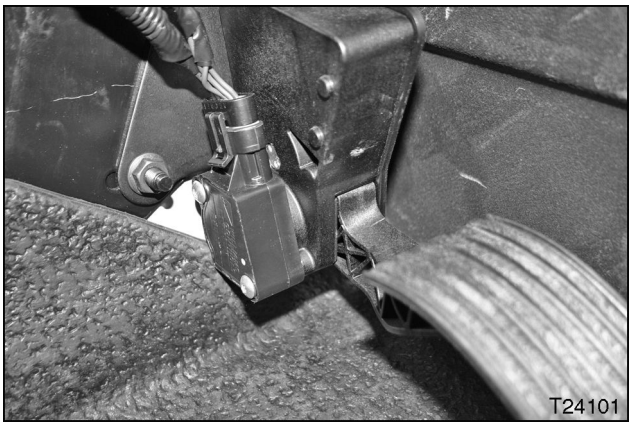


Figure 361 Accelerator Pedal Position (APP) sensor

The APP sensor is mounted on the accelerator pedal.

Ambient Air Temperature Sensor

The AAT is mounted in various cab locations, depending on vehicle configuration.

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Electrical Tools

180-Pin Breakout Box

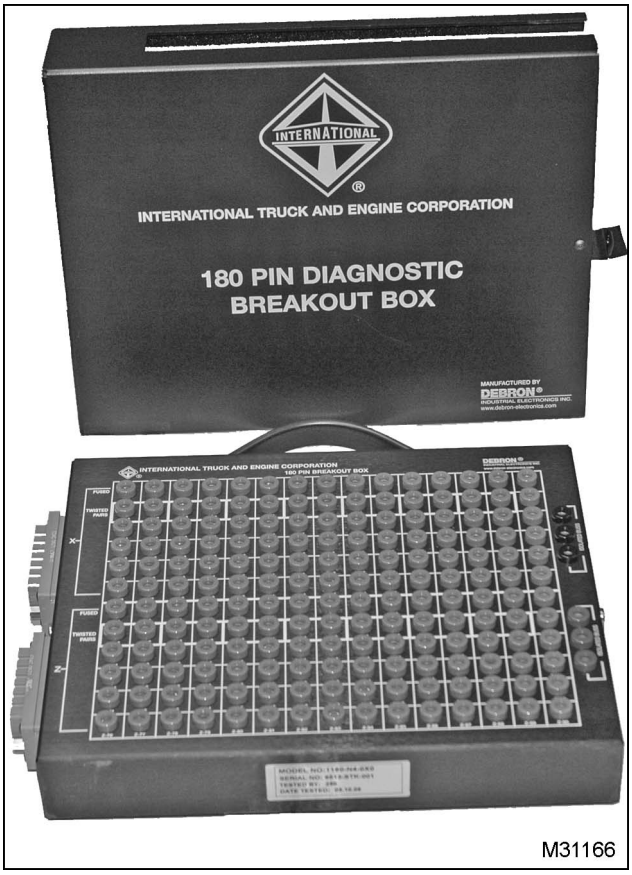


Figure 362 00-00956-08

The 180-Pin Breakout Box allows testing of electronic control system components without disturbing connections or piercing wire insulation to access various signal voltages in the electronic control system.

CAUTION: To prevent damage to the 180-Pin Breakout Box, the 180-Pin Breakout Box is used for measurement only, not to activate or control circuits. High current passing through the 180-Pin Breakout Box will burn out the internal circuitry.

This box is universal and can adapt to any control system by means of a unique jumper harness. Each jumper harness is a separate part, complete with a 180-Pin Breakout Box overlay (pin identifier) sheet.

The standard box layout is as follows:

- Two 90-pin connectors which feed 90 banana plug probing points.
- Each 90-pin section of the box is basically a stand-alone box.
- The top row is all fuse protected circuits, the second row is all twisted pair circuits.

3-Banana Plug Harness

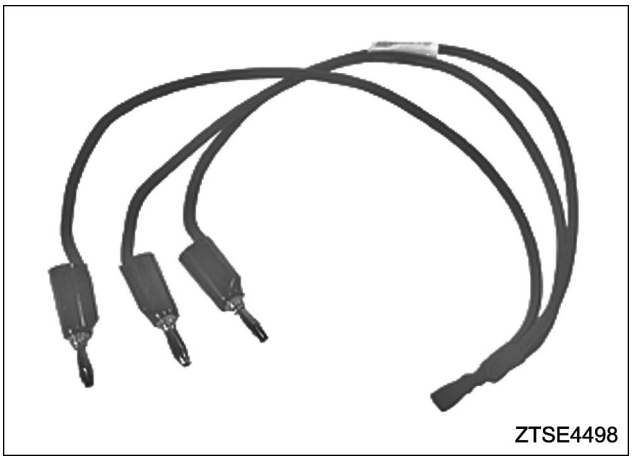


Figure 363 ZTSE4498

The 3-Banana Plug Harness is used for sensor end diagnostics of sensor circuits.

500 Ohm Resistor Harness



Figure 364 ZTSE4497

The 500 Ohm Resistor Harness is used for sensor end diagnostics of sensor circuits, and for performing loaded circuit tests.

Electronic Engine Terminal Test Kit

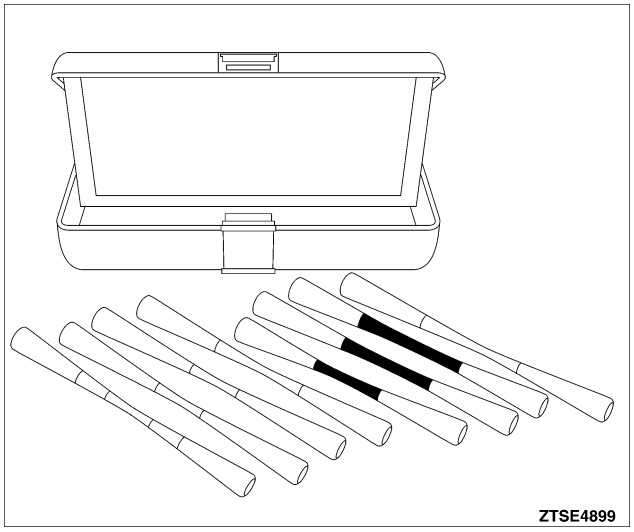


Figure 365 ZTSE4435C

The Electronic Engine Terminal Test Kit is used to access circuits in the connector harness and allows for the use of a DMM without damaging the harness connectors.

Big Bore Terminal Test Probe Kit

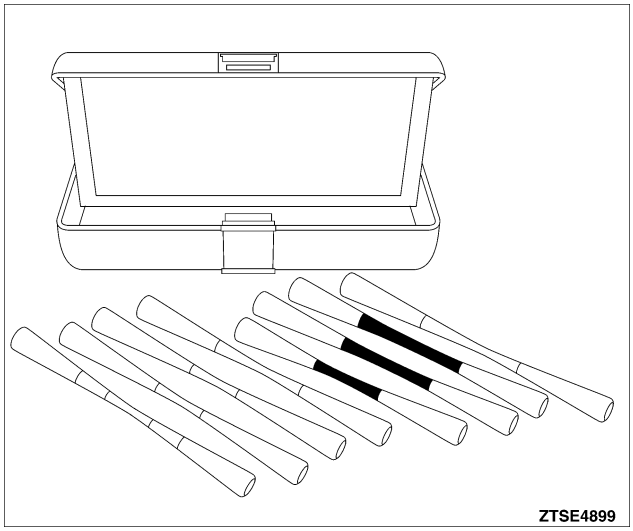


Figure 366 ZTSE4899

The terminal test probe kit is used to access circuit in the connector harness and allows for the use of a DMM without damaging the harness connectors.

Digital Multimeter (DMM)



Figure 367 ZTSE4357

The DMM is used to troubleshoot electrical components, sensors, injector solenoids, relays, and wiring harnesses. The DMM has a high input impedance that allows testing of sensors while the engine is running, without loading the circuit being tested. This ensures the signal voltage measurement will not be affected by the voltmeter.

EXP-1000 HD by Midtronics



Figure 368 EXP-1000 HD INTL

The EXP-1000 HD by Midtronics is used to measure current draw for the inlet air heater system.

EZ-Tech® Electronic Service Tool (EST)

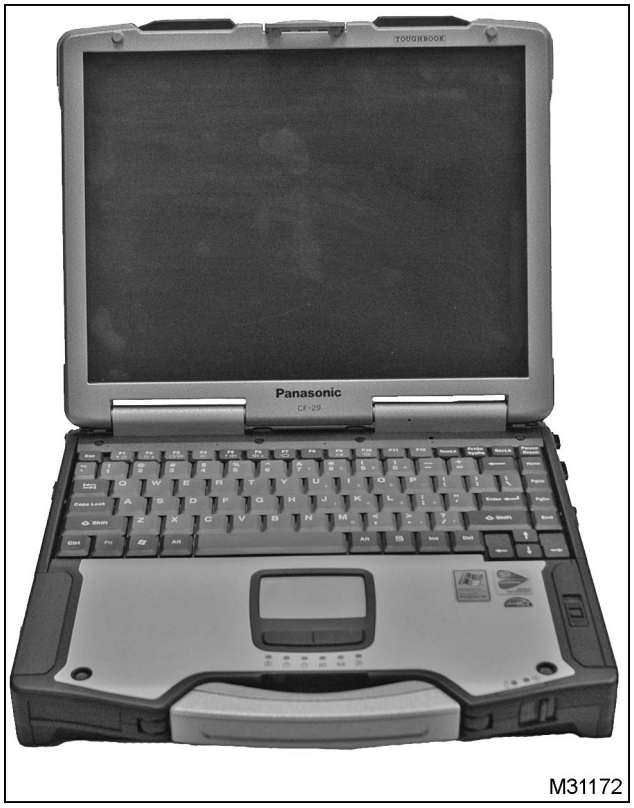


Figure 369 Electronic Service Tool (EST) (typical)

The EST is used to run ServiceMaxx™ software for diagnosing and troubleshooting engine and vehicle problems.

ServiceMaxx™ Software

ServiceMaxx™ software, loaded to an EST or laptop computer, is used to check performance of engine systems, diagnose engine problems, and store troubleshooting history for an engine.

Interface cable (RP1210B compliant supporting J1939 and J1708)

The Interface cable (RP1210B compliant supporting J1939 and J1708) is used to connect the EST to the vehicle. It is available from various suppliers.

MaxxForce® 11 and 13 Engine Tool Kit



Figure 370 ZTSE4904

The Breakout Harness Kit contains the following:

- Breakout Harness 4485A
- Breakout Harness 4735A
- Breakout Harness 4760A
- Breakout Harness 4761A
- Breakout Harness 4827
- Breakout Harness 4828
- Breakout Harness 4830
- Breakout Harness 4833
- Breakout Harness 4834
- Breakout Harness 4844
- Breakout Harness 4850
- Breakout Harness 4870
- Breakout Harness 4871
- Breakout Harness 4881
- Breakout Harness 4882
- Breakout Harness 4883
- Breakout Harness 4885

Breakout Harness 4485A (APP)

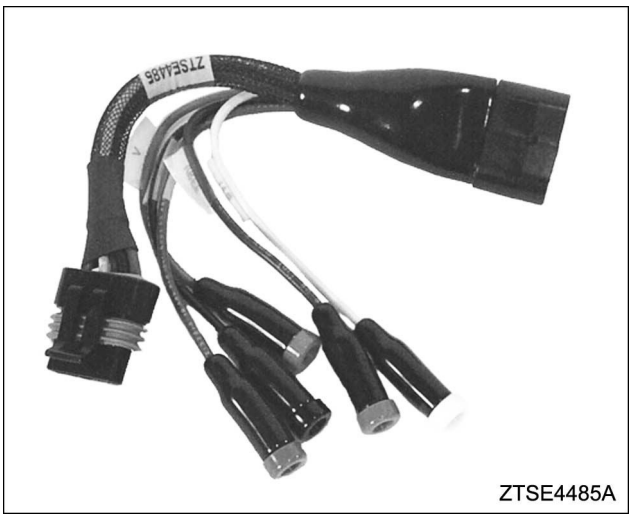


Figure 371 ZTSE4485A

Breakout Harness 4485A is used to measure voltage and resistance on circuits that go to the Accelerator Pedal Position (APP) sensor.

Breakout Harness 4602 (AFTFSV)

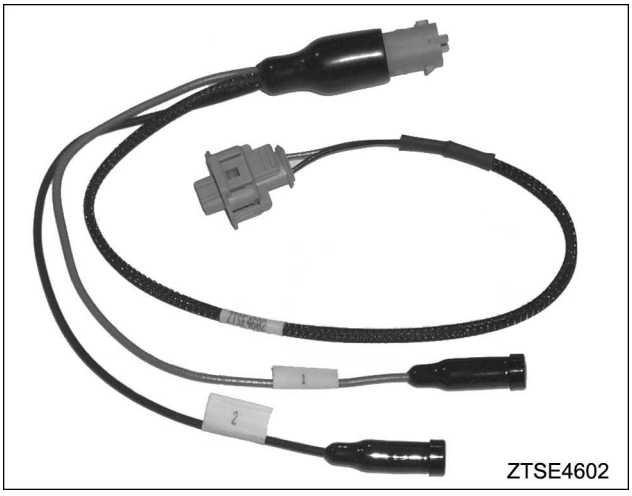


Figure 372 ZTSE4602

Breakout Harness 4602 is used to measure voltage and resistance on circuits that go to the Aftertreatment Fuel Shutoff Valve (AFTFSV).

Breakout Harness 4735A (O_2S)



Figure 373 ZTSE4735A

Breakout Harness 4735A is used to measure voltage and resistance on circuits connected to the Oxygen Sensor (O_2S).

Breakout Harness 4760A (DOCIT, DOCOT, DPFOT, and EGRT)

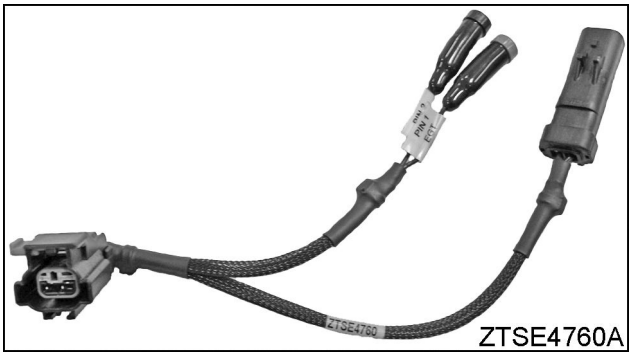


Figure 374 ZTSE4760A

Breakout Harness 4760A is used to measure voltage and resistance on circuits that go to the Diesel Oxidation Catalyst Inlet Temperature (DOCIT), Diesel Oxidation Catalyst Outlet Temperature (DOCOT), Diesel Particulate Filter Outlet Temperature (DPFOT), and Exhaust Gas Recirculation Temperature (EGRT) sensors.

Breakout Harness 4761A (DPFDP)

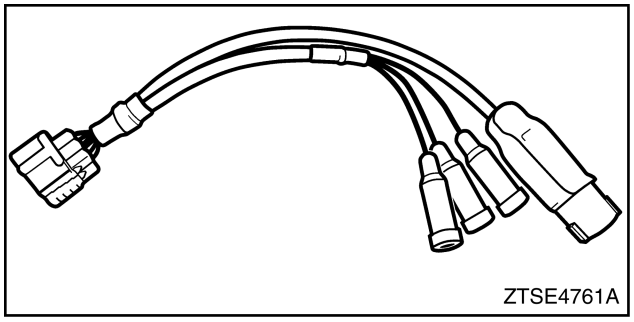


Figure 375 ZTSE4761A

Breakout Harness 4761A is used to measure voltage and resistance on circuits that go to the Diesel Particulate Filter Differential Pressure (DPFDP) sensor.

Breakout Harness 4827 (IAHFS, ECT1, ECT2, EOL, and EOT)

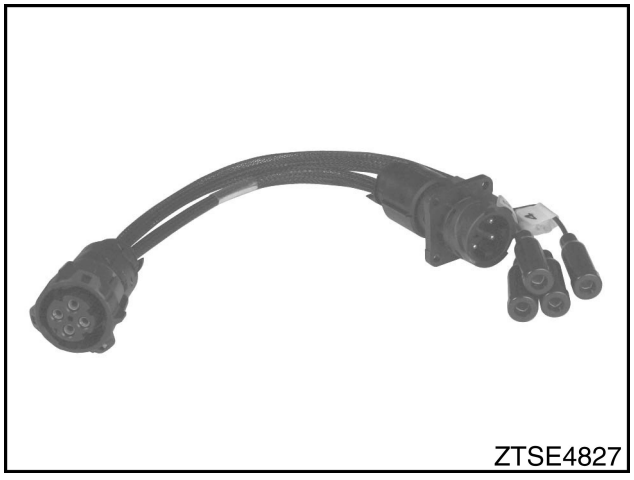


Figure 376 ZTSE4827

Breakout Harness 4827 is used to measure voltage and resistance on circuits connected to the Inlet Air Heater Fuel Solenoid (IAHFS), Engine Coolant Temperature 1 (ECT1), Engine Coolant Temperature 2 (ECT2), Engine Oil Level (EOL), and Engine Oil Temperature (EOT) sensors.

Breakout Harness 4828 (AFTFD and FPCV)

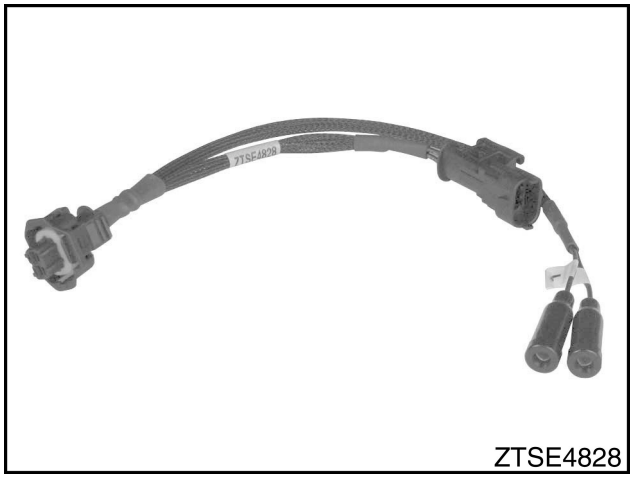


Figure 377 ZTSE4828

Breakout Harness 4828 is used to measure voltage and resistance on circuits connected to the Aftertreatment Fuel Doser (AFTFD) and Fuel Pressure Control Valve (FPCV) .

Breakout Harness 4829 (FRP)

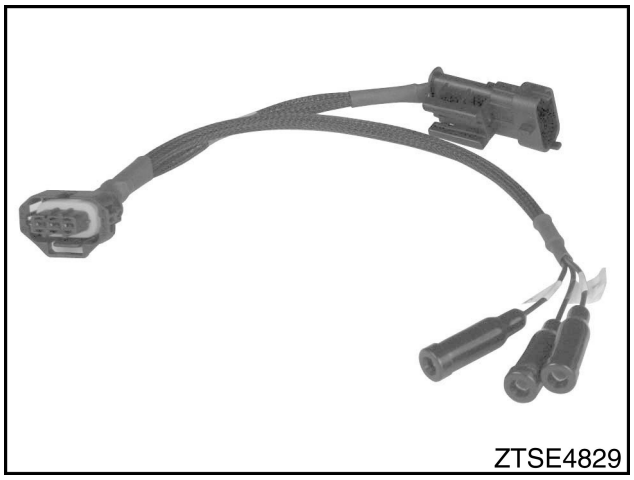


Figure 378 ZTSE4829

Breakout Harness 4829 is used to measure voltage and resistance on circuits connected to the Fuel Rail Pressure (FRP) sensor.

Breakout Harness 4830 (AFTFIS, HS/IAT, and TC2CIS)

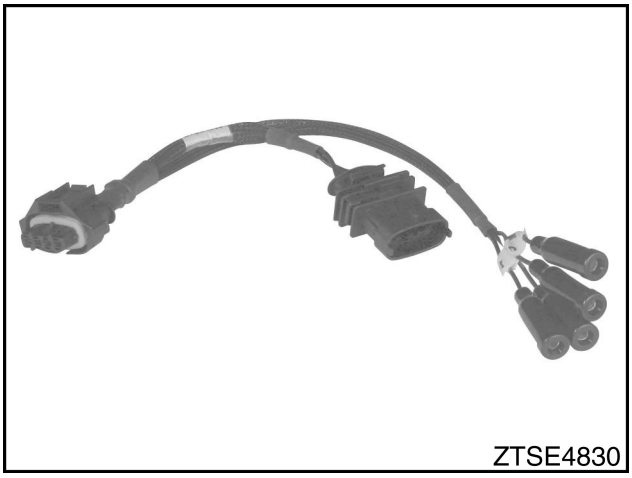


Figure 379 ZTSE4830

Breakout Harness 4830 is used to measure voltage and resistance on circuits connected to the Aftertreatment Fuel Inlet Sensor (AFTFIS), Humidity/Inlet Air Temperature (HS/IAT) sensor, and Turbocharger 2 Compressor Inlet Sensor (TC2CIS).

Breakout Harness 4844 (EFAN)

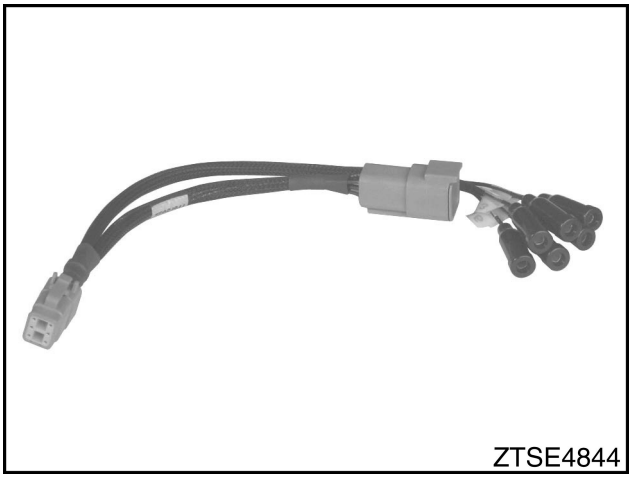


Figure 380 ZTSE4844

Breakout Harness 4844 is used to measure voltage and resistance on circuits connected to the variable Electronic Fan (EFAN) control .

Breakout Harness 4850 (IMP)

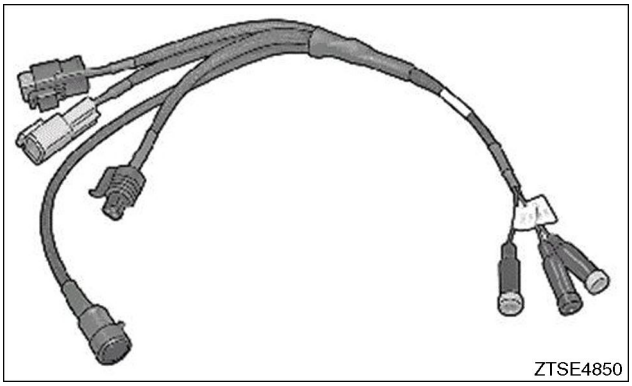


Figure 381 ZTSE4850

Breakout Harness 4850 is used to measure voltage and resistance on circuits connected to the Intake Manifold Pressure (IMP) sensor.

Breakout Harness 4870 (CMV)

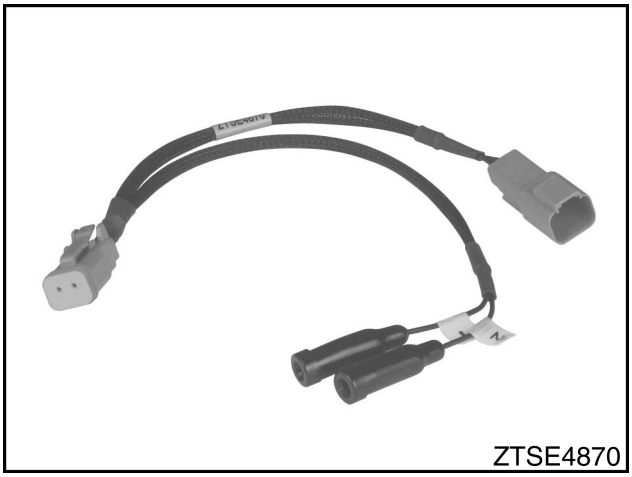


Figure 382 ZTSE4870

Breakout Harness 4870 is used to measure voltage and resistance on circuits connected to the Coolant Mixer Valve (CMV).

Breakout Harness 4871 (AAT and CFV)

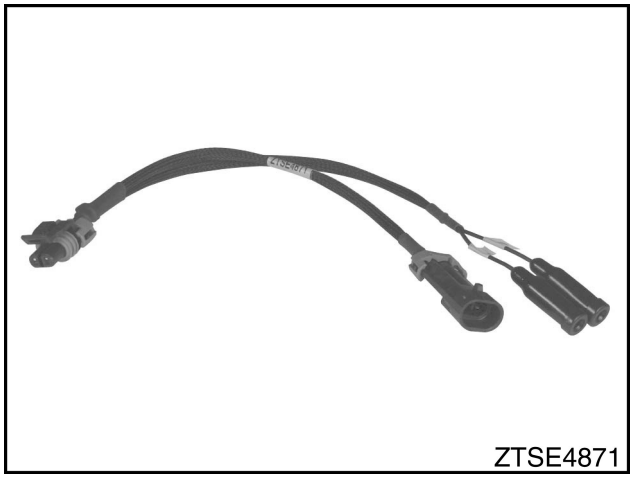


Figure 383 ZTSE4871

Breakout Harness 4871 is used to measure voltage and resistance on circuits connected to the Ambient Air Temperature (AAT) sensor and Coolant Flow Valve (CFV).

Breakout Harness 4881 (FDP)

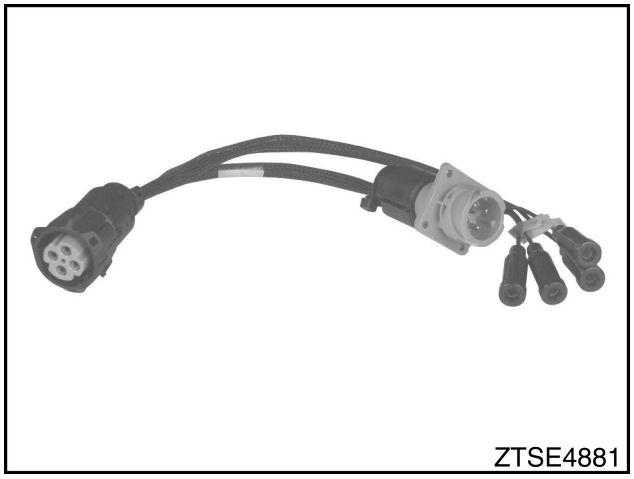


Figure 384 ZTSE4881

Breakout Harness 4881 is used to measure voltage and resistance on circuits connected to the Fuel Delivery Pressure (FDP) sensor.

Breakout Harness 4882 (EOP)

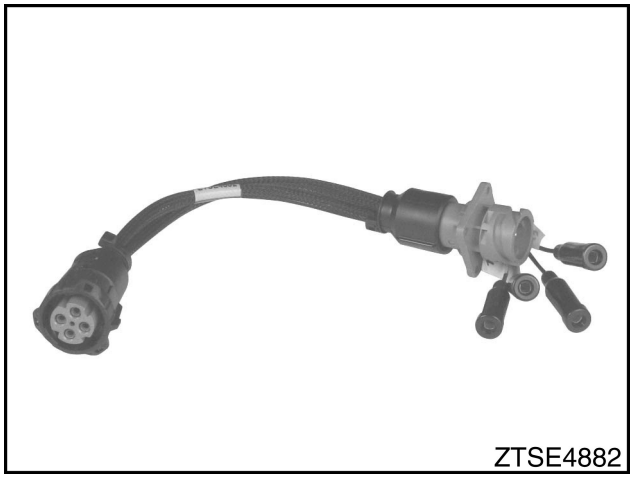


Figure 385 ZTSE4882

Breakout Harness 4882 is used to measure voltage and resistance on circuits connected to the Engine Oil Pressure (EOP) sensor.

Breakout Harness 4883 (IMT)

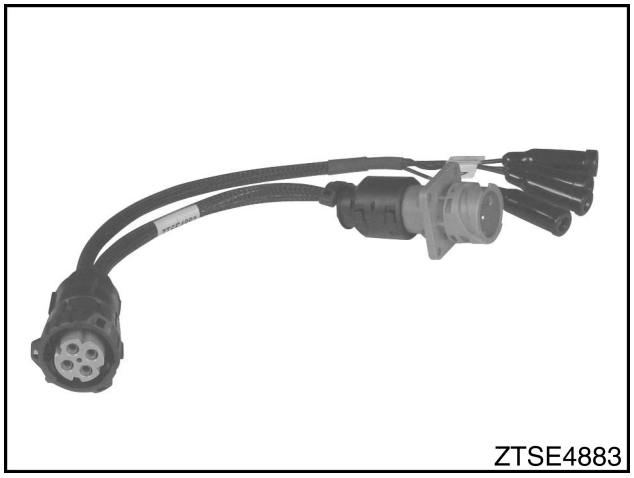


Figure 386 ZTSE4883

Breakout Harness 4883 is used to measure voltage and resistance on circuits connected to the Intake Manifold Temperature (IMT) sensor.

Breakout Harness 4885 (IAHR)

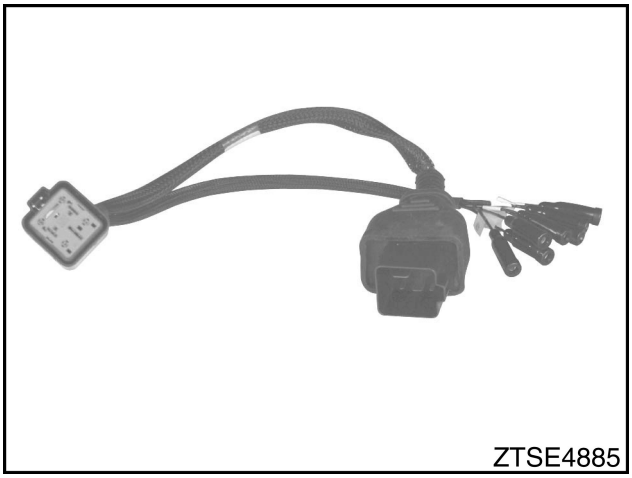


Figure 387 ZTSE4885

Breakout Harness 4885 is used to measure voltage and resistance on circuits connected to the Inlet Air Heater Relay (IAHR).

Breakout Harness 4951 (CCOSS)

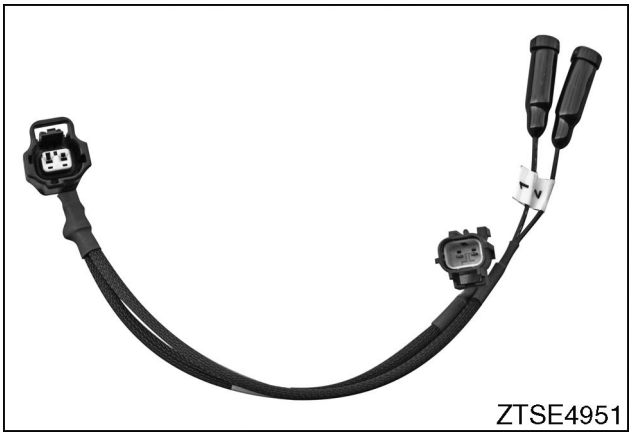


Figure 388 ZTSE4951

Breakout Harness 4951 is used to measure voltage and resistance on circuits connected to the Crankcase Oil Separator Speed (CCOSS) sensor.

Breakout Harness 4993 (CACOT)

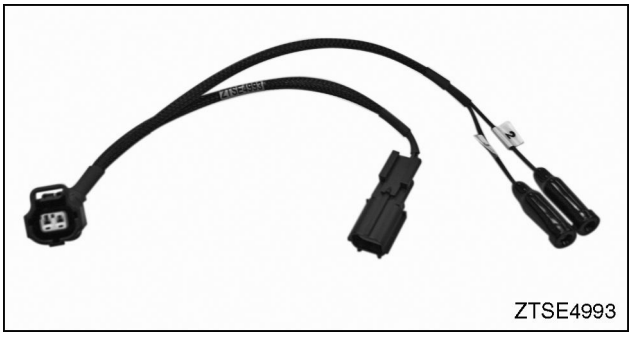


Figure 389 ZTSE4993

Breakout Harness 4993 is used to measure voltage and resistance on circuits that go to the Charge Air Cooler Outlet Temperature (CACOT) sensor.

Breakout Harness 6002 (WIF)

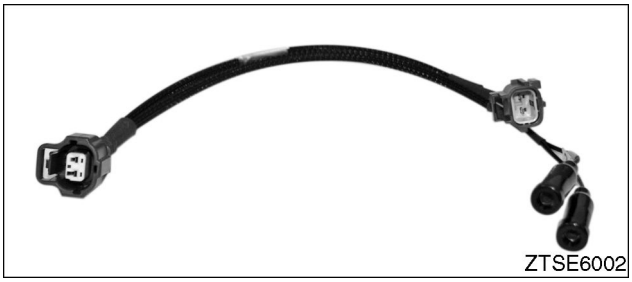


Figure 390 ZTSE6002

Breakout Harness 6002 is used to measure voltage and resistance on circuits that go to the Water In Fuel (WIF) sensor.

Breakout Harness 6003 (EBPV, TC1TOP, TC1WC, and TC2WC)



Figure 391 ZTSE6003

Breakout Harness 6003 is used to measure voltage and resistance on circuits that go to the Exhaust Back Pressure Valve (EBPV), Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor, Turbocharger 1 Wastegate Control (TC1WC), and Turbocharger 2 Wastegate Control (TC2WC).

Breakout Harness 6004 (ECB)

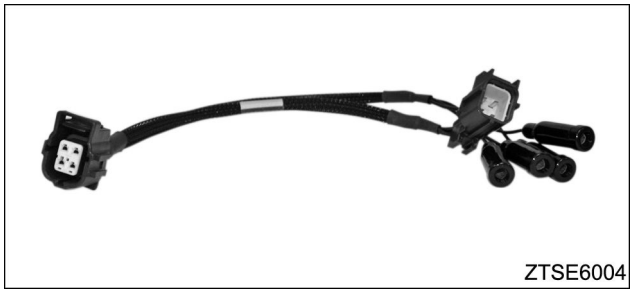


Figure 392 ZTSE6004

Breakout Harness 6004 is used to measure voltage and resistance on circuits that go to the Engine Compression Brake (ECB).

Breakout Harness 6016 (ETV and EGR Valve)



Figure 393 ZTSE6016

Breakout Harness 6016 is used to measure voltage and resistance on circuits that go to the Engine Throttle Valve (ETV) and EGR valve.

Breakout Harness 6021 (CKP and CMP)

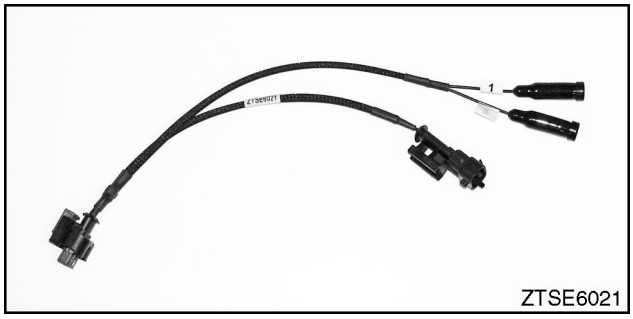


Figure 394 ZTSE6021

Breakout Harness 6021 is used to measure voltage and resistance on circuits that go to the Crankshaft Position (CKP) and Camshaft Position (CMP) sensors.

Breakout Harness 6027 (AFTFP2)

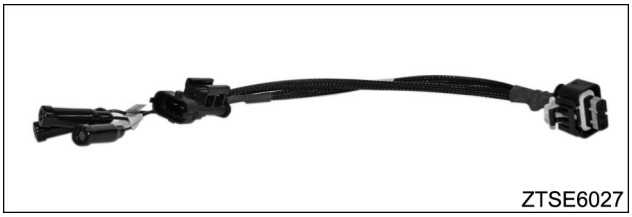


Figure 395 ZTSE6027

Breakout Harness 6027 is used to measure voltage and resistance on circuits that go to the Aftertreatment Fuel Pressure 2 (AFTFP2) sensor.

Mechanical Tools

Air Cap, Fuel Cap and Plug Kit

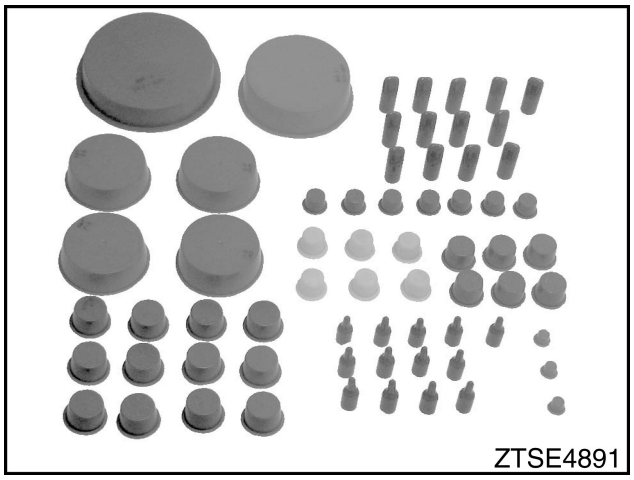


Figure 396 ZTSE4891

The Disposable Air and Fuel Caps are used to cap the fuel system lines and fittings when the fuel system is disconnected for diagnostics. The Disposable Air and Fuel Caps prevent dirt and foreign particles from entering and contaminating the fuel system.

Air Compressor Coolant Line Release Tool

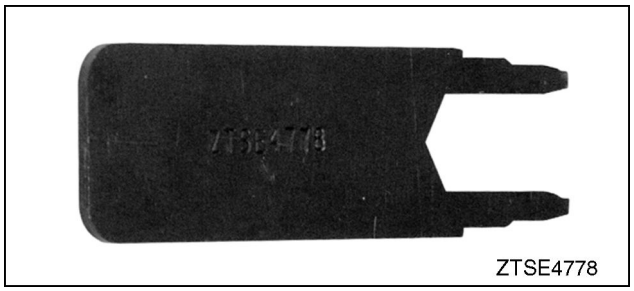


Figure 397 ZTSE4778

Air Compressor Coolant Line Release Tool releases the locking mechanism to allow the removal of the coolant line on the air compressor.

Air Intake Guard

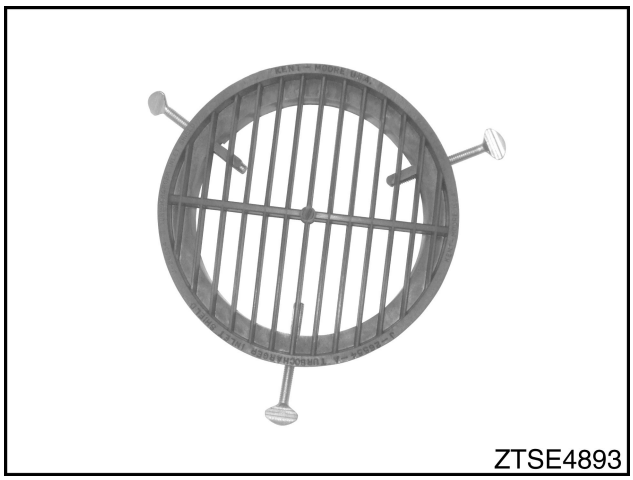


Figure 398 ZTSE4893

The Air Intake Guard is used to protect the turbochargers while performing diagnostics with the air cleaner disconnected.

Blow-by Test Tool

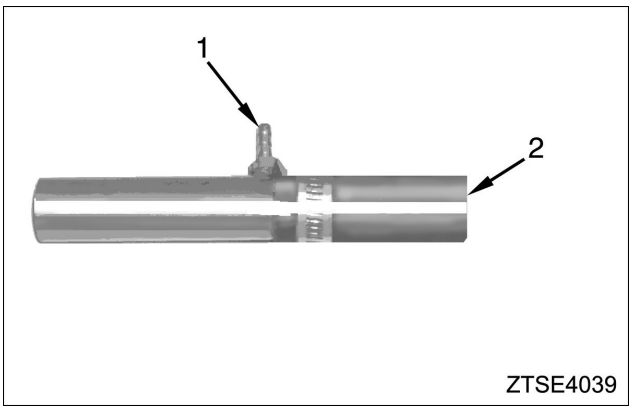


Figure 399 ZTSE4039 (0.406 in. diameter)

1. To magnehelic gauge or manometer
2. To valve cover

The Blow-by Test Tool is used to measure combustion gas flow from the crankcase oil separator and may be used with the digital or Slack Tube® manometer.

Use the pressure readings obtained with this adapter as the main source of engine condition. Use oil consumption trend data if the pressure readings are over the specified limits. Neither changes in oil consumption trends nor crankcase diagnostic pressure trends can establish a specific problem. These changes only indicate that a problem exists.

Clean Fuel Source Tool

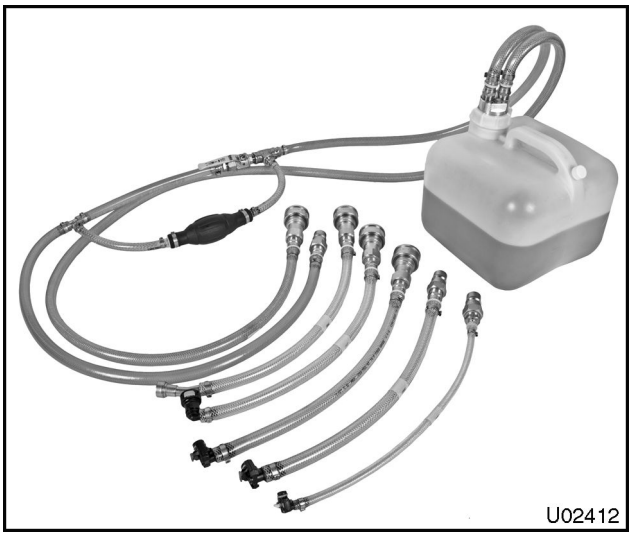


Figure 400 15-637-01

The Clean Fuel Source Tool is used to provide a clean, alternative fuel source to aid in the diagnosis of the fuel system.

Inlet Air Heater Solenoid Test Adapter Kit

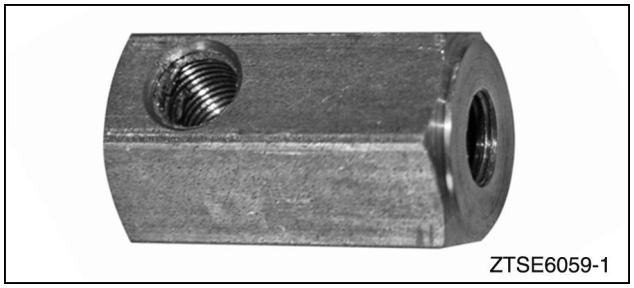


Figure 401 ZTSE6059-1

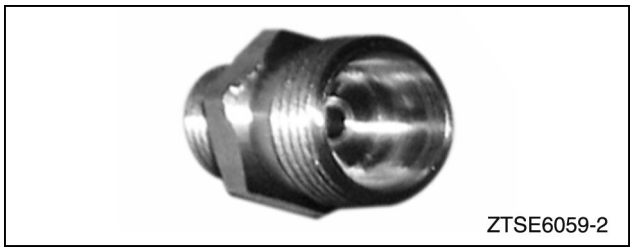


Figure 402 ZTSE6059-2

The Inlet Air Heater Solenoid Test Adapter Kit is used with the Fuel Pressure Gauge to test fuel pressure at the Inlet Air Heater Fuel Igniter (IAHFI) and Inlet Air Heater Fuel Solenoid (IAHFS).

Digital Manometer



Figure 403 Obtain locally

The Digital Manometer is used to measure low vacuum due to intake restriction or low crankcase pressure. A variety of digital manometers are available for purchase locally. The Water Manometer kit (ZTSE2217A) is an alternative to the Digital Manometer.

EGR Cooler Leak Detection Test Kit



Figure 404 12-892-02

The EGR Cooler Leak Detection Test Kit is used to pressure test the EGR cooler to check for leaks.

Lash Gauge (0.50mm)



Figure 405 ZTSE6076-5A

This tool is used to measure intake valve lash.

Lash Gauge (0.80mm)



Figure 406 ZTSE6076-7A

This tool is used to measure exhaust valve lash.

Fuel Block Off Tool

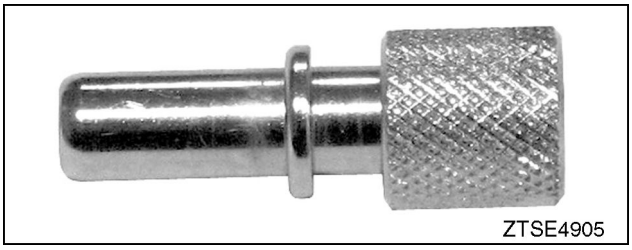


Figure 407 ZTSE4905

The Fuel Block Off Tool is used to block the T-connector fuel line at the high pressure pump in order to measure the low pressure pump output pressure.

Fuel Injector Cups



Figure 408 ZTSE4892

Fuel Injector Cups protects and prevents dirt and debris from damaging the injectors while out of the engine.

Fuel Inlet Restriction and Aeration Tool

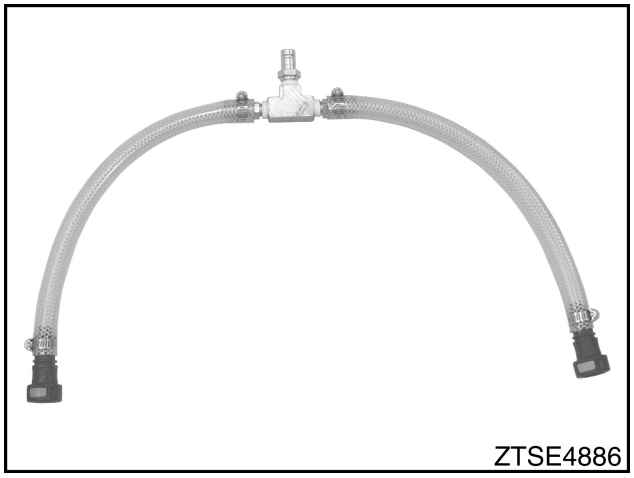


Figure 409 ZTSE4886

The Fuel Inlet Restriction and Aeration Tool is used to check for pressure and aerated fuel in the low fuel pressure system.

Fuel Line Coupler

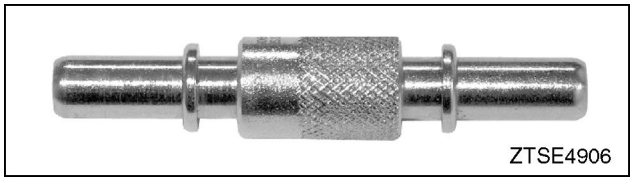


Figure 410 ZTSE4906

The Fuel Line Coupler is used in conjunction with the Fuel Inlet Restriction and Aeration Tool to measure the fuel pressure in the return line.

Fuel Line Disconnect Tool 11.8 mm

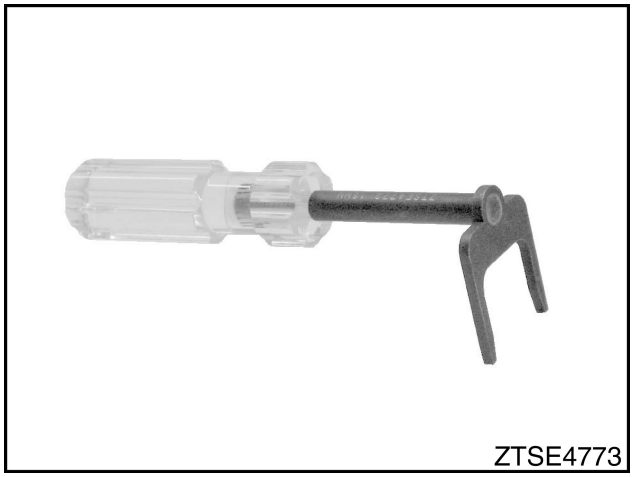


Figure 411 ZTSE4773

The Fuel Line Disconnect Tool 11.8 mm is used to release the locking mechanism on low pressure fuel line connectors.

Fuel Line Disconnect Tool 16 mm

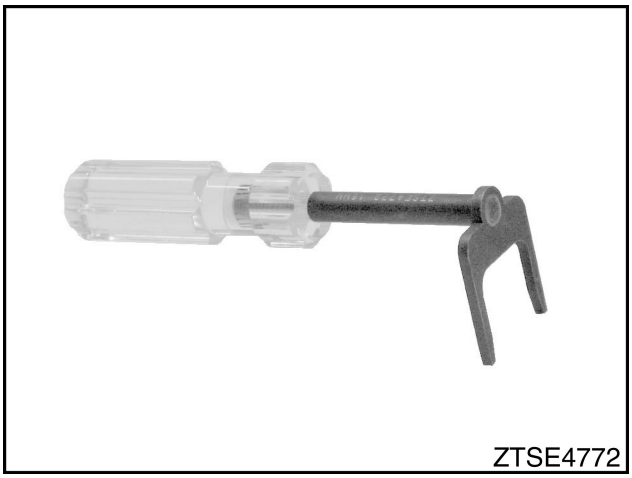


Figure 412 ZTSE4772

The Fuel Line Disconnect Tool 16 mm is used to release the locking mechanism on low pressure fuel line connectors.

Fuel Pressure Gauge

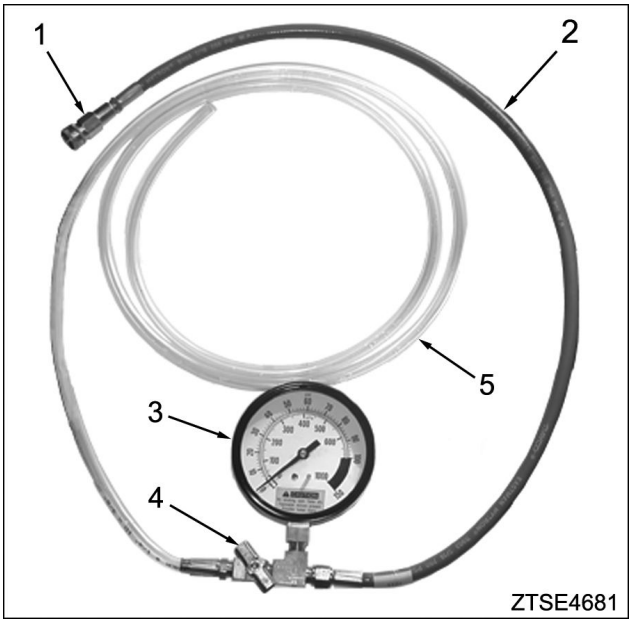


Figure 413 ZTSE4681

1. Quick disconnect check valve
2. Fuel test line
3. Fuel Pressure Gauge
4. Inline shut-off valve
5. Clear test line

The Fuel Pressure Gauge is used to check for fuel pressure and aerated fuel in the low fuel pressure system.

High Pressure Rail Plugs

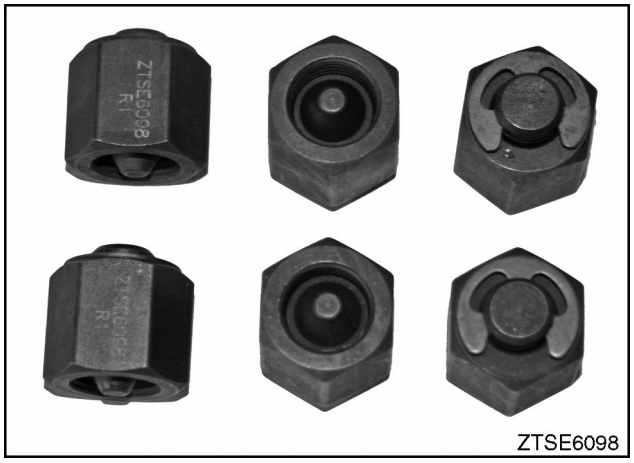


Figure 414 ZTSE6098

The High Pressure Rail Plugs are used to isolate individual injectors by blocking the pressure pipe rail output.

High Pressure Return Line Tester

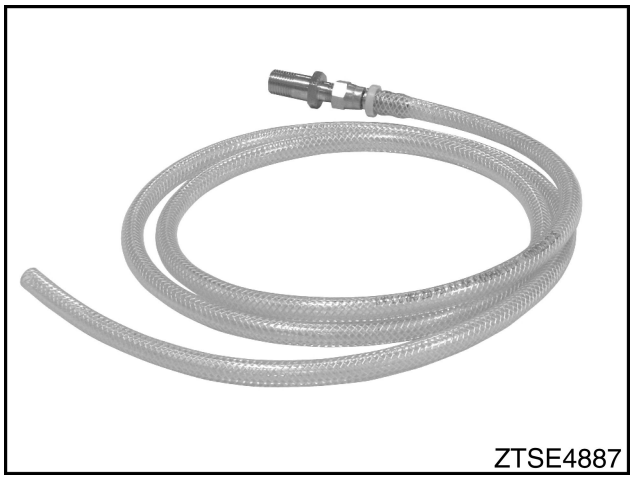


Figure 415 ZTSE4887

The High Pressure Return Line Tester is used to check for fuel returning from the pressure pipe rail or from the cylinder head fuel return port. Tool consists of two adapters, ZTSE4887-1 (17mm) and ZTSE4887-2 (19mm), and hose ZTSE4887-3.

Pressure Test Kit

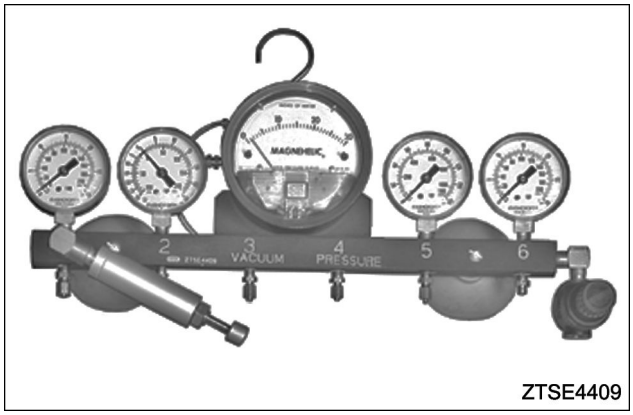


Figure 416 ZTSE4409

The Pressure Test Kit is used to measure intake manifold (boost) pressure, fuel system inlet restriction, fuel pressure, oil pressure, air cleaner intake restriction, and crankcase pressure.

- 0 to 200 kPa (0 to 30 psi) measures intake manifold pressure.
- 0-30 in Hg vacuum /0 to 200 kPa (0 to 30 psi) compound gauge measures fuel system inlet restriction and intake manifold pressure.

  0-30 in H2O 0 to 7.5 kPa (0 to 1 psi) maximum pressure magnehelic gauge measures crankcase pressure and air inlet restriction.
- 60 to 1100 kPa (0 to 160 psi) gauge may be used to check the fuel pressure and oil pressure.

Radiator Pressure Test Kit

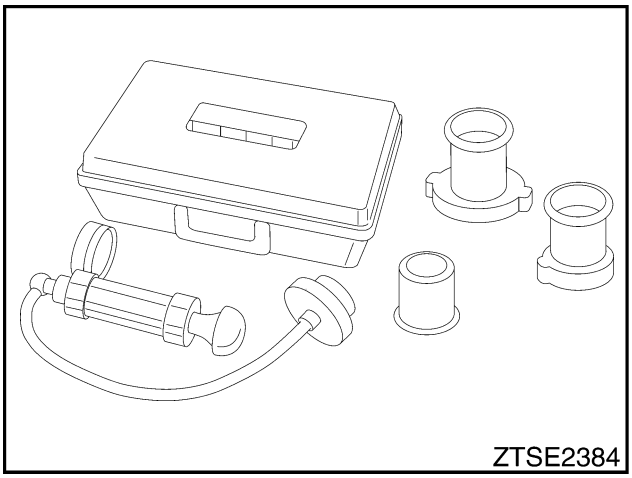


Figure 417 ZTSE2384

The Radiator Pressure Test Kit is used to check pressure caps and cooling systems. The pressure gauge indicates if the pressure cap holds the correct pressure and whether the cooling system has leaks or holds pressure.

Slack Tube® Manometer

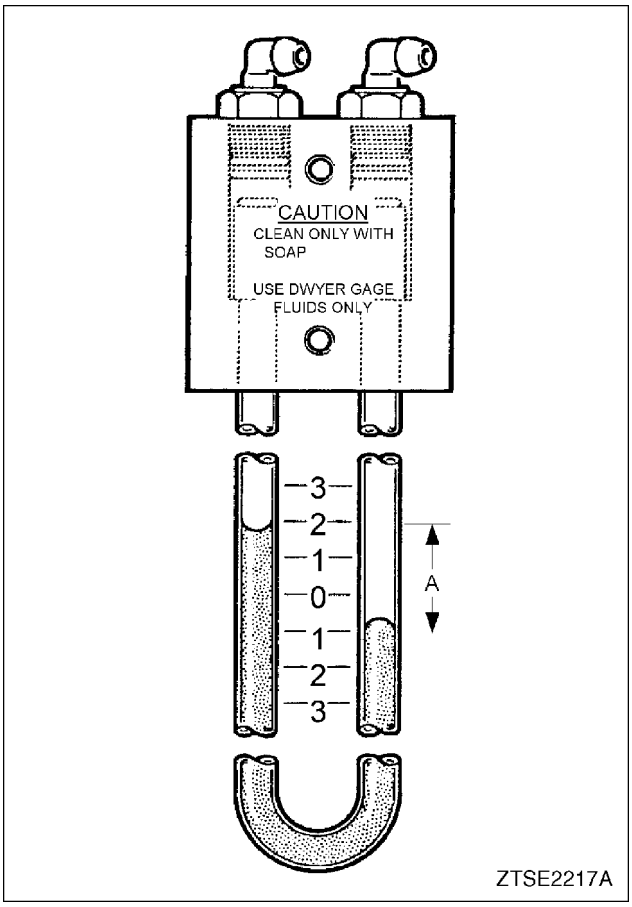


Figure 418 ZTSE2217A

The Slack Tube® Manometer is a U-shaped tube with a scale mounted between the legs of the tube. When the portability of the Pressure Test Kit is not required, this manometer is used to measure low vacuum for intake restriction, low pressure for crankcase, or exhaust back pressure.

Filling

Fill the manometer with water before checking pressure. Use only distilled water. Add some colored water vegetable dye so the scale can be read more easily. With both legs of the manometer open to the atmosphere, fill the tube until the top of the fluid column is near the zero mark on the scale. Shake the tube to eliminate any air bubbles.

Installing, Reading, and Cleaning

1. Support the manometer vertically. Make sure the fluid level is in line with the zero indicator on the graduated scale.
2. Connect one leg of the manometer to the source of the pressure or vacuum. Leave the other leg open to atmospheric pressure.
3. Start the engine and allow it to reach normal operating temperature. Then run the engine to high idle. The manometer can be read after 10 seconds.
4. Record the average position of the fluid level when it is above and below the zero indicator. Add the two figures together. The sum of the two is the total column of fluid (distance A). This represents the crankcase pressure in inches of water (in H_2O).

   At times, both columns of the manometer will not travel the same distance. This is no concern if the leg not connected to the pressure or vacuum source is open to the atmosphere.
5. Compare the manometer reading with engine specifications.
6. When the test is done, clean the tube thoroughly using soap and water. Avoid liquid soaps and solvents.

UV Leak Detection Kit



Figure 419 ZTSE4618

The UV Leak Detection Kit is used with fuel dye to quickly identify leaks. The fuel dye combines with fuel and migrates out at the leak. The ultraviolet lamp illuminates the leaking fuel dye, which appears fluorescent yellow-green in color.

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Abbreviations and Acronyms.....933

Abbreviations and Acronyms

A or amp – Ampere
AAT – Ambient Air Temperature
ABDC – After Bottom Dead Center
ABS – Antilock Brake System
AC – Alternating Current
A/C – Air Conditioner
ACC – Air Conditioner Control
ACCEL – Accelerator
ACD – Air Conditioner Demand
ACM – Aftertreatment Control Module
ACT PWR GND – Actuator Power Ground
ACV – Air Control Valve
A/F – Air to Fuel ratio
AFD – Aftertreatment Fuel Drain
AFI – Aftertreatment Fuel Injector
AFP – Aftertreatment Fuel Pressure
AFS – Aftertreatment Fuel Supply
AFT – Aftertreatment
AFTFD – Aftertreatment Fuel Doser
AFTFDH – Aftertreatment Fuel Doser High
AFTFDL – Aftertreatment Fuel Doser Low
AFTFIT – Aftertreatment Fuel Inlet Temperature
AFTFIS – Aftertreatment Fuel Inlet Sensor
AFTFP – Aftertreatment Fuel Pressure
AFTFP1 – Aftertreatment Fuel Pressure 1
AFTFP2 – Aftertreatment Fuel Pressure 2
AFTFSH – Aftertreatment Fuel Shutoff High
AFTFSL – Aftertreatment Fuel Shutoff Low
AFTFSV – Aftertreatment Fuel Shutoff Valve
Amb – Ambient
amp or A – Ampere
AMS – Air Management System
API – American Petroleum Institute
APP – Accelerator Pedal Position
APP1 – Accelerator Pedal Position 1
APP2 – Accelerator Pedal Position 2
APS – Accelerator Position Sensor
APS/IVS – Accelerator Position Sensor / Idle Validation Switch
ASTM – American Society for Testing and Materials
ATA – American Trucking Association
ATAH – American Trucking Association Link High
ATAL – American Trucking Association Link Low
ATDC – After Top Dead Center
AWG – American Wire Gauge
AWL – Amber Warning Lamp

B+ or VBAT – Battery Voltage
BAP or BARO – Barometric Absolute Pressure
BARO or BAP – Barometric Absolute Pressure
BBDC – Before Bottom Dead Center
BC – Body Controller
BCP – Brake Control Pressure
BCS – Boost Control Solenoid
BDC – Bottom Dead Center
bhp – Brake Horsepower
BNO – Brake Normally Open
BOO – Brake On / Off
BPP – Brake Pedal Position
BPS – Brake Pressure Switch
BSV – Brake Shut-off Valve
BTDC – Before Top Dead Center
BTU – British Thermal Unit

C – Celsius
CAC – Charge Air Cooler
CACOT – Charge Air Cooler Outlet Temperature
CAN – Controller Area Network
CAP – Cold Ambient Protection
CARB – California Air Resources Board
cc – Cubic centimeter
CCA – Cold Cranking Ampere
CCV – Coolant Control Valve
CCOSS – Crankcase Oil Separator Speed
CCPS – Crankcase Pressure Sensor
CCS – Cruise Control Switches
CDR – Crankcase Depression Regulator
cfm – Cubic feet per minute
cfs – Cubic feet per second
CFV – Coolant Flow Valve
CID – Cubic Inch Displacement
CKP – Crankshaft Position
CKPH – Crankshaft Position High
CKPL – Crankshaft Position Low
CKPO – Crankshaft Position Out
cm – Centimeter
CMP – Camshaft Position
CMPH – Camshaft Position High
CMPL – Camshaft Position Low
CMPO – Camshaft Position Out
CMV – Coolant Mixer Valve
CO – Carbon Monoxide
COO – Cruise On / Off switch
CPU – Central Processing Unit
CTC – Coolant Temperature Compensation
Cyl – Cylinder

DB – Decibel
DC – Direct Current
DCA – Diesel Coolant Additive
DDI – Digital Direct Fuel Injection

DDS – Driveline Disengagement Switch
DLC – Data Link Connector
DME – Dimethyl Ether
DMM – Digital Multimeter
DOC – Diesel Oxidation Catalyst
DOCIT – Diesel Oxidation Catalyst Inlet Temperature
DOCOT – Diesel Oxidation Catalyst Outlet Temperature
DPF – Diesel Particulate Filter
DPFDP – Diesel Particulate Filter Differential Pressure
DPFIT – Diesel Particulate Filter Inlet Temperature
DPFOT – Diesel Particulate Filter Outlet Temperature
DSI – Down Stream Injection
DT – Diesel Turbocharged
DTC – Diagnostic Trouble Code
DTCs – Diagnostic Trouble Codes
DTRM – Diesel Thermo Recirculation Module

EBC – Exhaust Brake Controller
EBP – Exhaust Back Pressure
EBPD – Exhaust Back Pressure Desired
EBPV – Exhaust Back Pressure Valve
ECB – Engine Compression Brake
ECB1 – Engine Compression Brake 1
ECB2 – Engine Compression Brake 2
ECB3 – Engine Compression Brake 3
ECBP – Engine Compression Brake Pressure
ECI – Engine Crank Inhibit
ECL – Engine Coolant Level
ECM – Engine Control Module
ECM GND – Engine Control Module Ground
ECM PWR – Engine Control Module Power
ECS – Engine Coolant System
ECSR – Engine Controlled Shutdown Request
ECT – Engine Coolant Temperature
ECT1 – Engine Coolant Temperature 1
ECT2 – Engine Coolant Temperature 2
EFAN – Engine Fan
EFANS – Engine Fan Speed
EFC – Engine Fan Control
EFP – Engine Fuel Pressure
EFRC – Engine Family Rating Code
EFS – Engine Fan Speed
EFT – Engine Fuel Temperature
EG – Ethylene Glycol
EGC – Electronic Gauge Cluster
EGBP – Exhaust Gas Back Pressure
EGDP – Exhaust Gas Differential Pressure
EGR – Exhaust Gas Recirculation
EGRC – Exhaust Gas Recirculation Control
EGRH – Exhaust Gas Recirculation High control
EGRL – Exhaust Gas Recirculation Low control
EGROT – Exhaust Gas Recirculation Outlet Temperature
EGRP – Exhaust Gas Recirculation Position
EGRT – Exhaust Gas Recirculation Temperature
EGT – Exhaust Gas Temperature
EGT1 – Exhaust Gas Temperature 1
EGT2 – Exhaust Gas Temperature 2
EGT3 – Exhaust Gas Temperature 3
EIM – Engine Interface Module
ELS – Exhaust Lambda Sensor
EMI – Electromagnetic Interference
EMP – Exhaust Manifold Pressure
EMT – Exhaust Manifold Temperature
EOP – Engine Oil Pressure
EOT – Engine Oil Temperature
EPA – Environmental Protection Agency
EPR – Engine Pressure Regulator
ESC – Electronic System Controller
ESN – Engine Serial Number
EST – Electronic Service Tool
ETC – Engine Throttle Control
ETCH – Engine Throttle Control High
ETCL – Engine Throttle Control Low
ETP – Engine Throttle Position
ETV – Engine Throttle Valve
EVB – Exhaust Valve Brake
EWPS – Engine Warning Protection System

F – Fahrenheit
FCV – Fuel Coolant Valve
FDP – Fuel Delivery Pressure
FEL – Family Emissions Limit
fhp – Friction horsepower
FMI – Failure Mode Indicator
FPC – Fuel Pump Control
FPCV – Fuel Pressure Control Valve
fpm – Feet per minute
FPM – Fuel Pump Monitor
fps – Feet per second
FRP – Fuel Rail Pressure
ft – Feet
FVCV – Fuel Volume Control Valve

GND – Ground (electrical)
gal – Gallon
gal/h – U.S. Gallons per hour
gal/min – U.S. Gallons per minute
GCW – Gross Combined Weight
GCWR – Gross Combined Weight Rating

GND – Ground
GPC – Glow Plug Control
GPD – Glow Plug Diagnostic
GPR – Glow Plug Relay
GVW – Gross Vehicle Weight

H_2O – Water
HC – Hydrocarbons
HCI – Hydrocarbon Injection
HEST – High Exhaust System Temperature
HFCM – Horizontal Fuel Conditioning Module
Hg – Mercury
hp – Horsepower
HPCAC – High-Pressure Charge Air Cooler
HPCR – High-Pressure Common Rail
HPFP – High-Pressure Fuel Pump
hr – Hour
HS – Humidity Sensor
Hyd – Hydraulic

IAH – Inlet Air Heater
IAHC – Inlet Air Heater Control
IAHD – Inlet Air Heater Diagnostic
IAHFI – Inlet Air Heater Fuel Igniter
IAHFS – Inlet Air Heater Fuel Solenoid
IAHR – Inlet Air Heater Relay
IAHS – Inlet Air Heater Solenoid
IAHR – Inlet Air Heater Relay
IAT – Inlet Air Temperature
IC – Integrated Circuit
ICP – Injection Control Pressure
ICPR – Injection Control Pressure Regulator
ICG1 – Injector Control Group 1
ICG2 – Injector Control Group 2
ID – Inside Diameter
IDM – Injector Driver Module
IGN – Ignition
ILO – Injector Leak Off
IMP – Intake Manifold Pressure
IMT – Intake Manifold Temperature
in – Inch
inHg – Inch of mercury
inH_2O – Inch of water
INJs – Injectors
IPR – Injection Pressure Regulator
IPR PWR – Injection Pressure Regulator Power
ISC – Interstage Cooler
ISIS® – International Service Information Solutions
IST – Idle Shutdown Timer
ITP – Internal Transfer Pump
ITV – Intake Throttle Valve
ITVH – Intake Throttle Valve High control
ITVL – Intake Throttle Valve Low control
ITVP – Intake Throttle Valve Position
IVS – Idle Validation Switch

J1939H – J1939 Data Link High
J1939L – J1939 Data Link Low
JCT – Junction (electrical)

kg – Kilogram
km – Kilometer
km/h – Kilometers per hour
km/l – Kilometers per liter
KOEO – Key-On Engine-Off
KOER – Key-On Engine-Running
kPa – Kilopascal

L – Liter
L/h – Liters per hour
L/m – Liters per minute
L/s – Liters per second
lb – Pound
lbf – Pounds of force
lb/s – Pounds per second
lbf ft – Pounds of force per foot
lb in – Pounds of force per inch
lbm – Pounds of mass
LPCAC – Low-pressure Charge Air Cooler
LSD – Low Sulfur Diesel

m – Meter
m/s – Meters per second
MAF – Mass Air Flow
MAF GND – Mass Air Flow Ground
MAG – Magnetic
MAP – Manifold Absolute Pressure
MAP/IAT – Manifold Absolute Pressure / Inlet Air Temperature
MAT – Manifold Air Temperature
mep – Mean effective pressure
mi – Mile
MIL – Malfunction Indicator Lamp
mm – Millimeter
mpg – Miles per gallon
mph – Miles per hour
MPR – Main Power Relay
MSDS – Material Safety Data Sheet
MSG – Micro Strain Gauge
MSM – Multiplex System Module
MY – Model Year

NC – Normally Closed (electrical)
NETS – Navistar Electronics Technical Support
Nm – Newton meter
NO – Normally Open (electrical)
NO_X – Nitrogen Oxides

O_2S – Oxygen Sensor
O_2SH – Oxygen Sensor Heater
OAT – Organic Acid Technology
OCC – Output Circuit Check
OCP – Overcrank Protection
OD – Outside Diameter
OL – Over Limit
ORH – Out-of-Range High
ORL – Out-of-Range Low
OSHA – Occupational Safety and Health Administration
OWL – Oil/Water Lamp

PID – Parameter Identifier
P/N – Part Number
PDOC – Pre-Diesel Oxidation Catalyst
ppm – Parts per million
PROM – Programmable Read Only Memory
psi – Pounds per square inch
psia – Pounds per square inch absolute
psig – Pounds per square inch gauge
pt – Pint
PTO – Power Takeoff
PWM – Pulse Width Modulate
PWR – Power (voltage)

qt – Quart

RAM – Random Access Memory
RAPP – Remote Accelerator Pedal Position
RAS – Resume / Accelerate Switch (speed control)
REPTO – Rear Engine Power Takeoff
RFI – Radio Frequency Interference
rev – Revolution
rpm – Revolutions per minute
RPRE – Remote Preset
RSE – Radiator Shutter Enable
RVAR – Remote Variable

SAE – Society of Automotive Engineers
SCA – Supplemental Cooling Additive
SCCS – Speed Control Command Switches
SCS – Speed Control Switch
SHD – Shield (electrical)
SID – Subsystem Identifier
SIG GND – Signal Ground
SIG GNDB – Signal Ground Body
SIG GNDC – Signal Ground Chassis
SIG GNDE – Signal Ground Engine
S/N – Serial Number
SPEEDO – Speedometer
SPN – Suspect Parameter Number
SW – Switch (electrical)
SWBAT – Switch Battery
SYNC – Synchronization

TACH – Tachometer output signal
TBD – To Be Determined
TC2CIS – Turbocharger 2 Compressor Inlet Sensor
TC1TOP – Turbocharger 1 Turbine Outlet Pressure
TC2TOP – Turbocharger 2 Turbine Outlet Pressure
TC1WC – Turbocharger 1 Wastegate Control
TC2WC – Turbocharger 2 Wastegate Control
TCAPE – Truck Computer Analysis of Performance and Economy
TCM – Transmission Control Module
TDC – Top Dead Center
TDE – Transmission Driving Engaged
TOP – Transmission Oil Pressure
TOSS – Transmission Output Shaft Speed
TOT – Transmission Oil Temperature
TTS – Transmission Tailshaft Speed

ULSD – Ultra-Low Sulfur Diesel
UVC – Under Valve Cover

V – Volt
VBAT or B+ – Battery Voltage
VC – Volume Control
VEPS – Vehicle Electronics Programming System
VGT – Variable Geometry Turbo
VIGN – Ignition Voltage
VIN – Vehicle Identification Number
VOP – Valve Opening Pressure
VRE – Vehicle Retarder Enable
VREF – Reference Voltage
VREFB – Reference Voltage Body
VREFC – Reference Voltage Chassis
VREFE – Reference Voltage Engine
VSO – Vehicle Speed Output
VSO or VSS_CAL – Vehicle Speed Output
VSS – Vehicle Speed Sensor
VSS_CAL or VSO – Vehicle Speed Output
VSSH – Vehicle Speed Sensor High
VSSL – Vehicle Speed Sensor Low

WTSL – Wait to Start Lamp
WEL – Warn Engine Lamp
WIF – Water In Fuel
WIFL – Water In Fuel Lamp
WTEC – World Transmission Electronically Controlled automatic transmissions (Allison)

XCS – Transfercase
XMSN – Transmission

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Terms

Accelerator Pedal Position (APP) sensor – A potentiometer sensor that indicates the position of the throttle pedal.

Accessory work – The work per cycle required to drive engine accessories (normally, only those essential to engine operation).

Actuator – A device that performs work in response to an input signal.

Actuator Control – The ECM controls the actuators by applying a low-level signal (low-side driver) or a high-level signal (high side driver). When switched on, both drivers complete a ground or power circuit to an actuator.

Aeration – The entrainment of air or combustion gas in coolant, lubricant, or fuel.

Aftercooler (Charge Air Cooler) – A heat exchanger mounted in the charge air path between the turbocharger and engine intake manifold. The aftercooler reduces the charge air temperature by transferring heat from the charge air to a cooling medium (usually air).

Aftertreatment Fuel Doser (AFTFD) – A part of the Down Stream Injection (DSI) unit that sends pressurized fuel to the Aftertreatment Fuel Injector (AFI) to inject fuel into the exhaust pipe.

Aftertreatment Fuel Injector (AFI) – Injects fuel into the exhaust system to increase temperature of the exhaust gases.

Aftertreatment (AFT) system – A part of the exhaust system that processes engine exhaust to meet emission requirements and traps particulate matter (soot) to prevent it from leaving the tailpipe.

Air Control Valve (ACV) – Contains the LP turbocharger wastegate control port, HP turbocharger wastegate control port, the EBPV control port, and the TC1TOP port. Although these components are integral to the ACV, each circuit is controlled by the ECM. The ACV controls compressed air for each control valve.

Ambient temperature – The environmental air temperature in which a unit is operating. In general, the temperature is measured in the shade (no solar radiation) and represents the air temperature for other engine cooling performance measurement purposes. Air entering the radiator may or may not be the same ambient due to possible heating from other sources or recirculation. (SAE J1004 SEP81)

Ampere (amp) – The standard unit for measuring the strength of an electrical current. The flow rate of a charge in a conductor or conducting medium of one coulomb per second. (SAE J1213 NOV82)

Analog – A continuously variable voltage.

Analog to digital converter (A/D) – A device in the ECM that converts an analog signal to a digital signal.

American Trucking Association (ATA) Datalink – A serial datalink specified by the American Trucking Association and the SAE.

Boost pressure – 1. The pressure of the charge air leaving the turbocharger.

2. Inlet manifold pressure that is greater than atmospheric pressure. Obtained by turbocharging.

Bottom Dead Center (BDC) – The lowest position of the piston during the stroke.

Brake Horsepower (bhp) – The power output from an engine, not the indicated horsepower. The power output of an engine, sometimes-called flywheel horsepower, is less than the indicated horsepower by the amount of friction horsepower consumed in the engine.

Brake Horsepower (bhp) net – Net brake horsepower is measured with all engine components. The power of an engine when configured as a fully equipped engine. (SAE J1349 JUN90)

Calibration – ECM programming strategy to solve engine performance equations and make decisions. Calibration values are stored in ROM and put into the processor during programming to allow the engine to operate within certain parameters.

Camshaft Position (CMP) sensor – A magnetic pickup sensor that provides the ECM with a camshaft speed and position signal.

Carbon Monoxide (CO) – A colorless, odorless, highly poisonous gas that is formed by the incomplete combustion of carbon burning diesel engine. It is present in the exhaust gases of diesel engines.

Catalyst – A substance that produces a chemical reaction without undergoing a chemical change itself.

Catalytic converter – An antipollution device in the exhaust system that contains a catalyst for chemically

converting some pollutants in the exhaust gases (carbon monoxide, unburned hydrocarbons, and oxides of nitrogen) into harmless compounds.

Cavitation – A dynamic condition in a fluid system that forms gas-filled bubbles (cavities) in the fluid.

Cetane number – 1. The auto-ignition quality of diesel fuel.

2. A rating applied to diesel fuel similar to octane rating for gasoline.

3. A measure of how readily diesel fuel starts to burn (self-ignites) at high compression temperature.

Diesel fuel with a high cetane number self-ignites shortly after injection into the combustion chamber. Therefore, it has a short ignition delay time. Diesel fuel with a low cetane number resists self-ignition. Therefore, it has a longer ignition delay time.

Charge air – Dense, pressurized, heated air discharged from the turbocharger.

Charge Air Cooler (CAC) – See **Aftercooler**.

Charge Air Outlet Temperature (CACOT) sensor – A thermistor sensor that monitors the temperature of charge air entering the intake air duct.

Closed crankcase – A crankcase ventilation that recycles crankcase gases through a breather, then back to the clean air intake.

Closed loop operation – A system that uses sensors to provide feedback to the ECM. The ECM uses the sensor input to continuously monitor variables and adjust actuators to match engine requirements.

Cloud point – The point when wax crystals occur in fuel, making fuel cloudy or hazy. Usually below -12°C (10°F).

Cold cranking ampere rating (battery rating) – The sustained constant current (in amperes) needed to produce a minimum terminal voltage under a load of 7.2 volts per battery after 30 seconds.

Controller Area Network (CAN) – A J1939 high-speed communication link.

Coolant – A fluid used to transport heat from one point to another.

Coolant level switch – A switch sensor used to monitor coolant level.

Coolant Flow Valve (CFV) – The CFV is ECM controlled and redirects coolant through the fuel cooler, based on EFT, when directed.

Coolant Mixer Valve (CMV) – Controls coolant flow through the low-temperature radiator.

Continuous Monitor Test – An ECM function that continuously monitors the inputs and outputs to ensure that readings are within set limits.

Crankcase – The housing that encloses the crankshaft, connecting rods, and allied parts.

Crankcase breather – A vent for the crankcase to release excess interior air pressure.

Crankcase Oil Separator Speed (CCOSS) sensor – The CCOSS sensor sends the ECM information about the speed of the crankcase oil separator internal components.

Crankcase pressure – The force of air inside the crankcase against the crankcase housing.

Crankshaft Position (CKP) sensor – A magnetic pickup sensor that determines crankshaft position and speed.

Current – The flow of electrons passing through a conductor. Measured in amperes.

Damper – A device that reduces the amplitude of torsional vibration. (SAE J1479 JAN85)

Deaeration – The removal or purging of gases (air or combustion gas) entrained in coolant or lubricating oil.

Deaeration tank – A separate tank in the coolant system used for one or more of the following functions:

- Deaeration
- Coolant reservoir (fluid expansion and afterboil)
- Coolant retention
- Filling
- Fluid level indication (visible)

Diagnostic Trouble Code (DTC) – 2010 model year vehicles no longer utilize DTC identification by number. DTCs are now identified using the Suspect Parameter Number (SPN) and Failure Mode Indicator (FMI) identifiers only.

Diesel Particulate Filter (DPF) – A diesel particulate filter, sometimes called a DPF, is a device designed to remove diesel particulate matter or soot from the exhaust gas of a diesel engine.

Diesel Oxidation Catalyst (DOC) – A DOC is part of the diesel exhaust Aftertreatment system. DOCs are devices that use a chemical process to break down pollutants in the exhaust stream into less harmful components. More specifically, DOCs utilize rare metals such as palladium and platinum to reduce hydrocarbon based Soluble Organic Fraction (SOF) and carbon monoxide content of diesel exhaust by simple oxidation. The DOC can be used during an active regeneration to create higher exhaust temperatures, thereby reducing soot in the DPF.

Digital Multimeter (DMM) – An electronic meter that uses a digital display to indicate a measured value. Preferred for use on microprocessor systems because it has a very high internal impedance and will not load down the circuit being measured.

Disable – A computer decision that deactivates a system and prevents operation of the system.

Displacement – The stroke of the piston multiplied by the area of the cylinder bore multiplied by the number of cylinders in the engine.

Down Stream Injection (DSI) – The DSI system injects fuel into the exhaust system to increase temperature of the exhaust gases, and is necessary for DPF regeneration.

Driver (high side) – A transistor within an electronic module that controls the power to an actuator circuit.

Driver (low side) – A transistor within an electronic module that controls the ground to an actuator circuit.

Dual Stage Turbocharger – An assembly of two turbochargers (low-pressure and high-pressure) in series to provide a wide range of charge air pressures efficiently.

Duty cycle – A control signal that has a controlled on/off time measurement from 0 to 100%. Normally used to control solenoids.

EGR Cooler – A cooler that allows heat to dissipate from the exhaust gasses before they enter the intake manifold.

Engine Back Pressure Valve (EBPV) – The ECM commands the EBPV to control the Exhaust Brake.

Engine Compression Brake (ECB) valve – The ECB valve controls pressure entering the brake oil gallery from the high-pressure oil rail gallery. This activates the brake actuator pistons and opens the exhaust valves.

Engine Compression Brake 1 (ECB1) solenoid – The ECB1 solenoid controls pressure entering the brake oil gallery from the high-pressure oil rail gallery.

Engine Compression Brake 2 (ECB2) solenoid – The ECB2 solenoid controls pressure entering the brake oil gallery from the high-pressure oil rail gallery.

Engine Compression Brake Pressure (ECBP) sensor – A high-pressure sensor that provides a feedback signal to the ECM indicating brake control pressure.

Engine Control Module (ECM) – An electronic processor that monitors and controls the engine.

Engine Coolant Level (ECL) sensor – A switch sensor that monitors coolant level.

Engine Coolant Temperature 1 (ECT1) sensor – A thermistor sensor that detects engine coolant temperature.

Engine Coolant Temperature 2 (ECT2) sensor – A thermistor sensor that detects engine coolant temperature.

Engine Fuel Temperature (EFT) sensor – A thermistor sensor that measures fuel temperature.

Engine lamp – An instrument panel lamp that comes on when DTCs are set. DTCs can be read as flash codes (red and amber instrument panel lamps).

Engine OFF tests – Tests that are done with the ignition switch ON and the engine OFF.

Engine Oil Pressure (EOP) sensor – A variable capacitance sensor that measures oil pressure.

Engine Oil Temperature (EOT) sensor – A thermistor sensor that measures oil temperature.

Engine rating – Engine rating includes **Rated hp** and **Rated rpm**.

Engine RUNNING tests – Tests done with the engine running.

Engine Throttle Valve (ETV) and Engine Throttle Position Sensor – The ETV valve is used to control airflow during a regeneration process of the aftertreatment system. The ETV valve is also used to ensure a smooth engine shut down by restricting airflow to the engine at shut down.

Engine Warning Protection System (EWPS) – Safeguards the engine from undesirable operating conditions to prevent engine damage and to prolong engine life.

Exhaust Back Pressure (EBP) – The pressure present in the exhaust system during the exhaust period.

Exhaust Back Pressure Valve (EBPV) – A valve that regulates the amount of air pressure applied to the EBPV pneumatic actuator.

Exhaust brake – A brake device using engine exhaust back pressure as a retarding medium.

Exhaust Gas Recirculation (EGR) – A system used to recirculate a portion of the exhaust gases into the power cylinder in order to reduce oxides of nitrogen.

Exhaust Gas Temperature (EGT) – The temperature of exhaust gases.

Exhaust Gas Recirculation Temperature (EGRT) sensor – A thermistor sensor that detects the exhaust gas temperature entering the EGR cooler.

Exhaust Gas Recirculation (EGR) valve – The EGRV controls the flow of exhaust gases to the intake manifold. The EGRV is integrated with an EGR Position (EGRP) sensor.

Exhaust manifold – Exhaust gases flow through the exhaust manifold to the turbocharger exhaust inlet and are directed to the EGR cooler.

Exhaust Manifold Pressure (EMP) sensor – A variable capacitance sensor used to indicate air pressure in the exhaust manifold.

Exhaust Manifold Temperature (EMT) sensor – A thermistor style sensor used to indicate air temperature in the exhaust manifold.

Fault detection/management – An alternate control strategy that reduces adverse effects that can be caused by a system failure. If a sensor fails, the ECM substitutes a good sensor signal or assumed sensor value in its place. A lit amber instrument panel lamp signals that the vehicle needs service.

Failure Mode Indicator (FMI) – Identifies the fault or condition effecting the individual component.

Filter restriction – A blockage, usually from contaminants, that prevents the flow of fluid through a filter.

Flash code – See **Diagnostic Trouble Code (DTC)**.

Fuel Delivery Pressure (FDP) sensor – A variable capacitance sensor that monitors fuel pressure coming from the fuel tank and sends a signal to the ECM.

Fuel inlet restriction – A blockage, usually from contaminants, that prevents the flow of fluid through the fuel inlet line.

Fuel pressure – The force fuel exerts on the fuel system as it is pumped through the fuel system.

Fuel Pressure Control Valve (FPCV) – The FPCV controls the fuel pressure to the fuel rails and is controlled by the ECM. FPCV control depends on fuel pressure and fuel temperature.

Fuel Rail Pressure (FRP) – The amount of pressure in the fuel rail.

Fuel Rail Pressure (FRP) sensor – A variable capacitance sensor that monitors fuel pressure in the fuel rail and sends a signal to the ECM.

Fuel strainer – A pre-filter in the fuel system that keeps larger contaminants from entering the fuel system.

Fuel Volume Control Valve (FVCV) – The FVCV regulates the volume of flow sent to the HPFP. The FVCV allows a sufficient quantity of fuel to be delivered to the HPFP depending on engine load, speed, injector quantity, fuel temperature, and number of injections per cycle.

Fully equipped engine – A fully equipped engine is an engine equipped with only those accessories necessary to perform its intended service. A fully equipped engine does not include components that are used to power auxiliary systems. If these components are integral with the engine or, for any reason are included on the test engine, the power absorbed may be determined and added to the net brake power. (SAE J1995 JUN90)

Fusible link (fuse link) – A fusible link is a special section of low tension cable designed to open the circuit when subjected to an extreme current overload. (SAE J1156 APR86)

Gradeability – The maximum percent grade, which the vehicle can transverse for a specified time at a specified speed. The gradeability limit is the grade upon which the vehicle can just move forward. (SAE J227a)

Gross Combined Weight Rating (GCWR) – Maximum combined weight of towing vehicle (including passengers and cargo) and the trailer. The GCWR indicates the maximum loaded weight that the vehicle is allowed to tow.

Gross brake horsepower – The power of a complete basic engine, with air cleaner, without fan, and alternator, and air compressor not charging.

H-Bridge Circuit – An H-Bridge (bipolar) circuit operates like putting a power source on one side of a motor and connecting the other side of the motor to a ground. This turns the motor. By shifting the leads on the motor, it will turn in the opposite direction.

Hall effect – The development of a transverse electric potential gradient in a current-carrying conductor or semiconductor when a magnetic field is applied.

Hall effect sensor – Transducer that varies its output voltage in response to changes in a magnetic field. Commonly used to time the speed of wheels and shafts.

High-pressure Fuel Pump (HPFP) assembly – The HPFP is a volumetric pump that supplies fuel at high-pressure. The HPFP is mounted in the rear valley on the top of the engine and is driven by the camshaft.

High-pressure Piezo Common Rail (HPCR) – The HPFP pumps fuel through separate tubes to each fuel rail. Each fuel rail has four fuel tubes, one for each injector, that maintain constant pressure from the high-pressure pump to each injector.

High-speed digital inputs – Inputs to the ECM from a sensor that generates varying frequencies (engine speed and vehicle speed sensors).

Horsepower (hp) – Horsepower is the unit of work done in a given period of time, equal to 33,000 pounds multiplied by one foot per minute. 1 hp = 33,000 lb x 1 ft. /1 min.

Humidity Sensor (HS) – A sensor that measures the moisture content of filtered air entering the intake system.

Hydrocarbons – Organic compounds consisting of hydrogen and carbon (fuel and oil).

Injection Pressure Regulator (IPR) valve – A valve that is used to maintain desired injection control pressure.

Injection Control Pressure (ICP) sensor – Provides a feedback signal to the ECM indicating injection control pressure.

Inlet Air Heater (IAH) – The IAH is primarily used to assist in starting the engine during cold weather. In addition, it helps to reduce white smoke emissions by heating the incoming air.

Inlet Air Heater Fuel Igniter (IAHFI) – The IAHFI heats the intake air by vaporizing and igniting fuel in the air inlet duct.

Inlet Air Heater Fuel Solenoid (IAHFS) – As the engine is cranked, the ECM energizes the IAHFS valve, introducing fuel into the IAHFI, which ignites and warms the air being drawn into the engine.

Inlet Air Heater Relay (IAHR) – The IAHR provides voltage to the IAHFI, and is controlled by the ECM.

Inlet Air Temperature (IAT) sensor – A thermistor sensor that monitors intake air temperature.

Intake manifold – Engine component that evenly supplies air to each intake port in the cylinder head(s).

Intake Manifold Pressure (IMP) sensor – A variable capacitance sensor used to indicate air pressure in the intake manifold.

Intake Manifold Temperature (IMT) sensor – A thermistor sensor used to indicate air temperature in the intake manifold.

Internal Transfer Pump (ITP) – The ITP is part of the HPFP assembly and driven off the same shaft as the HPFP assembly. The ITP supplies fuel at a slightly higher pressure and flow to the HPFP though the Fuel Volume Control Valve (FVCV). The ITP also provides fuel for cooling and lubrication of the HPFP. Fuel is rerouted as pump return flow through the HPFP cooling and lubrication valve. Pressure is maintained at the inlet of the HPFP piston pump by an ITP regulator.

International NGV Tool Utilized for Next Generation Electronics (INTUNE) – The diagnostics software for chassis related components and systems.

Interstage Cooler (ISC) – Uses cooled coolant to lower the charged air temperature that exits from the turbocharger low-pressure compressor and enters the turbocharger high-pressure compressor.

Low speed digital inputs – Switched sensor inputs that generate an on/off (high/low) signal to the ECM. The input to the ECM from the sensor could be from a high input source switch (usually 5 or 12 volts) or from a grounding switch that grounds the signal from a current limiting resistor in the ECM that creates a low signal (0 volts).

Low temperature radiator thermostat – Coolant flow to the low temperature radiator is regulated by the low temperature radiator thermostat.

Lubricity – Lubricity is the ability of a substance to reduce friction between solid surfaces in relative motion under loaded conditions.

Lug (engine) – A condition when the engine is run at an overly low RPM for the load being applied.

Manifold Absolute Pressure (MAP) – Boost pressure in the manifold that is a result of the turbocharger.

Manifold Absolute Pressure (MAP) sensor – A variable capacitance sensor that measures boost pressure.

Manometer – A double-leg liquid-column gauge, or a single inclined gauge, used to measure the difference between two fluid pressures. Typically, a manometer records in inches of water.

Mass Air Flow – The intake airflow in an engine.

Mass Air Flow (MAF) sensor – The MAF sensor is used for closed loop control of the EGR valve and ITV. The ECM monitors the MAF signal so that the ECM can control the EGR and intake throttle systems.

MasterDiagnostics® (MD) – Diagnostics software for engine related components and systems.

Magnehelic Gauge – A gauge that measures pressure in inches of water.

Magnetic Pickup Sensor – A magnetic pickup sensor generates an alternating frequency that indicates speed. Magnetic pickups have a two-wire connection for signal and ground. This sensor has a permanent magnetic core surrounded by a wire coil. The signal frequency is generated by the rotation of the gear teeth that disturb the magnetic field.

Metering unit valve assembly – The Metering unit valve assembly provides a metered amount of fuel to the Aftertreatment Fuel Injector (AFI).

Microprocessor – An integrated circuit in a microcomputer that controls information flow.

Micro Strain Gauge (MSG) Sensor – A MSG sensor measures pressure. Pressure exerts force on a pressure vessel that stretches and compresses to change resistance of strain gauges bonded to the surface of the pressure vessel. Internal sensor electronics convert the changes in resistance to a ratiometric voltage output.

Nitrogen Oxides (NO_x) – Nitrogen oxides form by a reaction between nitrogen and oxygen at high temperatures and pressures in the combustion chamber.

Normally closed – Refers to a switch that remains closed when no control force is acting on it.

Normally open – Refers to a switch that remains open when no control force is acting on it.

Ohm (Ω) – The unit of electrical resistance. One ohm is the value of resistance through which a potential of one volt will maintain a current of one ampere. (SAE J1213 NOV82)

On demand test – A self-test the technician initiates using the EST that is run from a program in the software.

Output Circuit Check (OCC) – An on-demand test done during an Engine OFF self-test to check the continuity of selected actuators.

Oxides of Nitrogen (NOx) – Nitrogen oxides formed by a reaction between nitrogen and oxygen at high temperatures.

Oxygen Sensor (O_2S) – A sensor that monitors oxygen levels in the exhaust.

pH – A measure of the acidity or alkalinity of a solution.

Particulate matter – Particulate matter includes mostly burned particles of fuel and engine oil.

Piezometer – An instrument for measuring fluid pressure.

Power – Power is a measure of the rate at which work (force x distance) is done during a specific time. Compare with Torque.

Power TakeOff (PTO) – Accessory output, usually from the transmission, used to power a hydraulic pump for a special auxiliary feature (garbage packing, lift equipment, etc).

Pulse Width Modulation (PWM) – Succession of digital electrical pulses, rather than an analog signal. Efficient method of providing power between fully on and fully off.

Random Access Memory (RAM) – Computer memory that stores information. Information can be written to and read from RAM. Input information (current engine speed or temperature) can be stored in RAM to be compared to values stored in Read Only Memory (ROM). All memory in RAM is lost when the ignition switch is turned off.

Rated gross horsepower – Engine gross horsepower at rated speed as declared by the manufacturer. (SAE J1995 JUN90)

Rated horsepower – Maximum brake horsepower output of an engine as certified by the engine manufacturer. The power of an engine when configured as a basic engine. (SAE J1995 JUN90)

Rated net horsepower – Engine net horsepower at rated speed as declared by the manufacturer. (SAE J1349 JUN90)

Rated speed – The speed, as determined by the manufacturer, at which the engine is rated. (SAE J1995 JUN90)

Rated torque – Maximum torque produced by an engine as certified by the manufacturer.

Ratiometric Voltage – In a Micro Strain Gauge (MSG) sensor, pressure to be measured exerts force on a pressure vessel that stretches and compresses to change resistance of strain gauges bonded to the surface of the pressure vessel. Internal sensor electronics convert the changes in resistance to a ratiometric voltage output.

Reference voltage (V_{REF}) – A 5 volt reference supplied by the ECM to operate the engine sensors.

Reserve capacity – Time in minutes that a fully charged battery can be discharged to 10.5 volts at 25 amperes.

Regeneration – Oxidation of accumulated soot (carbon-based particulates) in the Diesel Particulate Filter (DPF). The soot is reduced to ash and stored in the PDF.

Return Fuel System – The return fuel system moves unused fuel from the fuel injectors to the fuel cooler. Excess fuel out of the FVCV and the FPCV mix with fuel from the fuel injectors on the way to the fuel cooler.

ServiceMaxx™ software – Diagnostics software for engine related components and systems.

Signal Conditioner – The signal conditioner in the internal microprocessor converts analog signals to digital signals, squares up sine wave signals, or amplifies low-intensity signals to a level that the ECM microprocessor can process.

Signal ground – The common ground wire to the ECM for the sensors.

Speed Control Command Switches (SCCS) – A set of switches used for cruise control, Power Take Off (PTO), and remote hand throttle system.

Steady state condition – An engine operating at a constant speed and load and at stabilized temperatures and pressures. (SAE J215 JAN80)

Strategy – A plan or set of operating instructions that the microprocessor follows for a desired goal. Strategy is the computer program itself, including all equations and decision making logic. Strategy is

always stored in ROM and cannot be changed during calibration.

Stroke – The movement of the piston from Top Dead Center (TDC) to Bottom Dead Center (BDC).

Substrate – Material that supports the wash coating or catalytic materials.

Suspect Parameter Number (SPN) – A 19-bit number used to identify the item for which diagnostics are being reported. The SPN is used for multiple purposes, some that are specific to diagnostics are as follows;

- Identify the least repairable subsystem that has failed.
- Identify subsystems or assemblies that may not have hard failures but may be exhibiting abnormal operating performance.
- Identify a particular event or condition that will be reported.
- Report a component and non-standard failure mode.

System restriction (air) – The static pressure differential that occurs at a given airflow from air entrance through air exit in a system. Usually measured in inches (millimeters) of water. (SAE J1004 SEP81)

Tachometer output signal – Engine speed signal for remote tachometers.

Thermistor – A semiconductor device. A sensing element that changes resistance as the temperature changes.

Thermistor Sensor – Changes electrical resistance with changes in temperature. Resistance in the thermistor decreases as temperature increases, and increases as temperature decreases. Thermistors work with a resistor that limits current to form a voltage signal matched with a temperature value.

Thrust load – A thrust load pushes or reacts through a bearing in a direction parallel to the shaft.

Top Dead Center (TDC) – The uppermost position of the piston during the stroke.

Torque – A force having a twisting or turning effect. For a single force, the cross product of a vector from some reference point to the point of application of the force within the force itself. Also known as moment of force or rotation moment. Torque is a measure of the ability of an engine to do work.

Truck Computer Analysis of Performance and Economy (TCAPE) – A computer program that simulates the performance and fuel economy of trucks.

Turbocharger – A turbine driven compressor mounted on the exhaust manifold. The turbocharger increases the pressure, temperature and density of intake air to charge air.

Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor – A variable capacitance sensor that monitors exhaust back-pressure.

Turbocharger 2 Compressor Inlet (TC2CIS) sensor – The TC2CIS sensor includes a thermistor sensor that monitors the temperature of charge air entering the HP turbocharger. This sensor also monitors boost pressure for the LP turbocharger.

Turbocharger Wastegate Control (TCWC) solenoid – Controls the TCWC actuator by regulating the amount of charge air pressure supplied to the TCWC actuator. The TCWC solenoid is controlled by signals from the ECM in response to engine speed, required fuel quantity, boost, exhaust back-pressure, and altitude.

Turbocharger 1 Wastegate Control (TC1WC) solenoid – Controls the TC1WC actuator by regulating the amount of charge air pressure supplied to the TC1WC actuator. The TC1WC solenoid is controlled by signals from the ECM in response to engine speed, required fuel quantity, boost, exhaust back-pressure, and altitude. The TC1WC actuator is part of the turbocharger assembly.

NOTE: TC1WC does not affect engine performance and is removed from postproduction engines.

Turbocharger 2 Wastegate Control (TC2WC) solenoid – Controls the TC2WC actuator by regulating the amount of charge air pressure supplied to the wastegate actuator. The TC2WC solenoid is controlled by signals from the ECM in response to engine speed, required fuel quantity, boost, exhaust back-pressure, and altitude. The TC2WC actuator is part of the turbocharger assembly.

Variable capacitance sensor – A variable capacitance sensor measures pressure. The pressure forces a ceramic material closer to a thin

metal disc in the sensor, changing the capacitance of the sensor.

Vehicle Electronic System Programming System – The computer system used to program electronically controlled vehicles.

Vehicle Retarder Enable/Engage – Output from the ECM to a vehicle retarder.

Vehicle Speed Sensor (VSS) – Normally a magnetic pickup sensor mounted in the tailshaft housing of the transmission, used to indicate ground speed.

Viscosity – The internal resistance to the flow of any fluid.

Viscous fan – A fan drive that is activated when a thermostat, sensing high air temperature, forces fluid through a special coupling. The fluid activates the fan.

Volt (v) – A unit of electromotive force that will move a current of one ampere through a resistance of one Ohm.

Voltage – Electrical potential expressed in volts.

Voltage drop – Reduction in applied voltage from the current flowing through a circuit or portion of the circuit current multiplied by resistance.

Voltage ignition – Voltage supplied by the ignition switch when the key is ON.

Washcoat – A layer of alumina applied to the substrate in a monolith-type converter.

Water In Fuel (WIF) sensor – A switch sensor that measures the amount of water in the fuel.

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All Ratings

Key-On Engine-Off

Barometric pressure (500 ft. above sea level)	99.01 kPa (14.36 psi) / 3.91 V
Fuel rail pressure	0 kPa (0 psi) / 0.5 V
Turbocharger 1 turbine outlet pressure	0 kPa (0 psi) / 0.84 V
Fuel delivery pressure	0 kPa (0 psi) / 0.5 V
Intake manifold pressure	0 kPa (0 psi) / 1.06 V
Diesel particulate filter differential pressure	0 kPa (0 psi) / 0.5 V
Exhaust gas recirculation valve position	0.47 V / 0 %
Engine throttle valve position	4.5 %
Accelerator pedal position sensor (at idle)	0.7 V / 0 %
Accelerator pedal position sensor (depressed to floor)	3.75 V / 99.6 %
Engine oil pressure	0 kPa (0 psi) / 0.5 V

Engine Cranking

Battery voltage (min. based on ECM drop out)	10.5 V
Cranking rpm (min.)	130 rpm
20 seconds maximum crank time per attempt. Wait 2 to 3 minutes before repeating.	
Fuel delivery pressure (min.)	With Gauge: 207 kPa (30 psi) / 1.15 V With EST: 103 kPa (15 psi) / 1.15 V
Fuel rail pressure	20 MPa (3000 psi) / 1 V
Turbocharger 1 turbine outlet pressure	< 34 kPa (< 5 psi) / 0.84 V
Fuel dead head test pressure	> 448 kPa (> 65 psi)
Fuel inlet restriction	203 - 305 mmHg (8 - 12 inHg)
High-pressure pump inlet pressure	> 207 kPa (> 30 psi)
Inlet air heater fuel solenoid fuel supply pressure	55 - 82 kPa (8 - 12 psi)
Inlet air heater fuel igniter fuel supply pressure	55 - 82 kPa (8 - 12 psi)
Diesel particulate filter differential pressure	0 kPa (0 psi) / 0.66 V
Exhaust gas recirculation valve	0 %

Low Idle, no load, stabilized engine operating temperature

Fuel delivery pressure (min.)	413 kPa (60 psi) / 1.8 V
Fuel delivery pressure (max.)	827 kPa (120 psi) / 3.2 V
Fuel rail pressure	86700 kPa (12574 psi) / 1.945 V
Engine speed	600 - 650 rpm
Intake manifold pressure	< 21 kPa (< 3 psi) / 1.026 V
Turbocharger 1 turbine outlet pressure	< 34 kPa (< 5 psi) / 0.84 V
Fuel inlet restriction	330 - 432 mmHg (13 - 17 inHg)
High-pressure pump inlet pressure	482 - 896 kPa (70 - 130 psi)
High-pressure fuel return flow	20 - 22 ml
Crankcase oil separator speed	5720 rpm
Engine coolant temperature 1 (at thermostat opening)	86° C (186° F) / 0.571 V
Engine coolant temperature 1 (max. before DTC is set)	120 °C (248 °F) / 0.64 V
Engine coolant temperature 2 (at thermostat opening)	55 °C (131 °F) / 1.26 V
Engine coolant temperature 2 (max. before DTC is set)	120 °C (248 °F) / 0.64 V
Engine oil pressure (min. with gauge)	68 kPa (10 psi) / 1.5 V
Engine oil temperature	98 °C (208 °F) / 0.405 V
Intake air temperature 2 (boost)	48 °C (118 °F) / 1.06 V
Intake air temperature 2 (boost) (max. before DTC is set)	95 °C (203 °F) / 1.11 V
Intake manifold air temperature	53 °C (127 °F) / 1.329 V
Intake manifold air temperature (max. before DTC is set)	135 °C (275 °F) / 0.47 V
Actuator supply pressure (min.)	620 kPa (90 psi)
Turbocharger wastegate control supply pressure (min.)	358 kPa (52 psi)

High Idle, no load, stabilized engine operating temperature

Air cleaner restriction (max.)	3.7 kPa (15 in H_2O)
Fuel delivery pressure (min.)	413 kPa (60 psi) / 1.8 V
Fuel delivery pressure (max.)	827 kPa (120 psi) / 3.2 V
Fuel rail pressure	211 MPa (30542 psi) / 4.01 V
Engine speed	1550 - 2200 rpm
Intake manifold pressure	90 - 110 kPa (13 - 16 psi)
Turbocharger 1 turbine outlet pressure	< 34 kPa (< 5 psi) / 0.84 V
High-pressure pump fuel return pressure	90 kPa (13 psi)
Diesel particulate filter differential pressure (max. before DTC is set)	35 kPa (5 psi) / 1.9 V
Engine oil pressure (min. with gauge)	275 - 482 kPa (40 - 70 psi) / 4.7 V

Full load, rated speed on dynamometer, stabilized engine operating temperature

Air cleaner restriction (max.)	3.3 kPa (13.4 in H_2O)
Fuel rail pressure	220 MPa (31900 psi) / 4.1 V
Fuel delivery pressure (min.)	413 kPa (60 psi) / 1.3 V
Fuel delivery pressure (max.)	827 kPa (120 psi) / 3.2 V
Engine speed	1550 - 2200 rpm
Intake manifold pressure	> 206 kPa (30 psi) / 2.18 V
Turbocharger 1 turbine outlet pressure	< 34 kPa (< 5 psi) / 0.84 V
Engine oil pressure (min. with gauge)	500 kPa (72 psi) / 3.9 V
Engine oil temperature (max.)	98 °C (208 °F) / 0.41 V
Diesel particulate filter differential pressure (max. before DTC is set)	35 kPa (5 psi) / 1.9 V
Exhaust back pressure (max.)	35 kPa (5 psi)
Water temperature differential across radiator (top and bottom)	9 °C (16 °F)

Component Specifications

Temperature Sensors (Engine Coolant Temperature 1 [ECT1], Engine Coolant Temperature 2 [ECT2], Engine Oil Temperature [EOT], Intake Manifold Air Temperature [IMAT])	
Temperature at -18 °C (0 °F)	4.2 V / 14030 Ω
Temperature at 0 °C (32 °F)	3.6 V / 5876 Ω
Temperature at 21 °C (70 °F)	2.6 V / 2404 Ω
Temperature at 65 °C (150 °F)	0.94 V / 507 Ω
Temperature at 93 °C (200 °F)	0.47 V / 224 Ω
Temperature Sensors (Intake Air Temperature [IAT])	
Temperature at -18 °C (0 °F)	4.21 V / 13866 Ω
Temperature at 0 °C (32 °F)	3.59 V / 5988 Ω
Temperature at 21 °C (70 °F)	2.67 V / 2561 Ω
Temperature at 65 °C (150 °F)	1.05 V / 576 Ω
Temperature Sensors (Diesel Oxidation Catalyst Inlet Temperature [DOCIT], Diesel Oxidation Catalyst Outlet Temperature [DOCOT], Diesel Particulate Filter Outlet Temperature [DPFOT])	
Temperature at 21 °C (70 °F)	4.5 V / 19.4 Ω
Temperature at 65 °C (150 °F)	3.9 V / 7.1 Ω
Temperature at 93 °C (200 °F)	3.4 V / 4.3 Ω
Temperature at 204 °C (400 °F)	1.6 V / 0.96 Ω
Temperature at 482 °C (900 °F)	0.34 V / 0.146 Ω
Other Components	
Camshaft Position (CMP) sensor	860 Ω ± 10% @ 20 °C
Crankshaft Position (CKP) sensor	860 Ω ± 10% @ 20 °C
Coolant Mixer Valve (CMV)	5.45 - 6.00 Ω @ 24 °C
Coolant Flow Valve (CFV)	5.45 - 6.00 Ω @ 24 °C
Inlet Air Heater Fuel Solenoid (IAHFS)	8 Ω ± 1 Ω @ room temperature
Turbocharger Wastegate Control (TC1WC and TC2WC) solenoid	9.5 Ω ± 10%, -5% @ 20 °C

Actuator Output State

Exhaust Gas Recirculation (EGR) valve control	Output state low – 5 % Output state high – 95 %
Exhaust Gas Recirculation Position (EGRP)	Output state low – 5 % Output state high – 95 %
Exhaust Back Pressure (EBP) valve	Output state low – 0 % Output state high – 95%
Engine Throttle Valve (ETV) control	Output state low – 5 % Output state high – 95 %
Engine Throttle Valve (ETV) position	Output state low – 5 % Output state high – 95 %
Turbocharger Wastegate Control (TC1WC and TC2WC) solenoid	Output state low – 5 % Output state high – 95 %
Fuel Pressure Control Valve (FPCV)	Output state low – 5 % Output state high – 95 %
Coolant Flow Valve (CFV)	Output state low – 5 % Output state high – 95 %
Coolant Mixer Valve (CMV)	Output state low – 5 % Output state high – 95 %
Aftertreatment Fuel Doser Control (AFTFD)	Output state low – 5 % Output state high – 95 %
Inlet Air Heater Fuel Igniter (IAHFI)	Output state low – 5 % Output state high – 95 %
Engine Fan Control (EFC)	Output state low – 5 % Output state high – 95 %

Inlet Air Heater System

Inlet air heater fuel igniter current draw	15 A

Crankcase Pressure

High idle no load - crankcase blow by flow	< 8 in H_2O

EBPV Rod Extension

Full travel	42 mm

TC2WC Rod Extension

Full travel	13 mm

MaxxForce® 11 (10.5 L)

330 hp @ 1700 rpm

International® MaxxForce® 11 330 hp @ 1700 rpm / 1250 ft•lb @ 1000 rpm	
50 state 2010 Model Year (MY)	
Engine model	GDT330
Engine Family Rating Code (EFRC)	2232 and 1132
Injection timing	Nonadjustable
High idle speed - manual transmission	2200 rpm
High idle speed - automatic transmission	2200 rpm
Low idle speed	600 rpm
Full load on chassis dynamometer or highway, stabilized engine operating temperature	
Intake manifold pressure (gauge)	Peak torque – 203 kPa (30 psi) / 2.25 V
	Rated speed – 288 kPa (42 psi) / 3.22 V

370 hp @ 1700 rpm

International® MaxxForce® 11 370 hp @ 1700 rpm / 1350 ft•lb @ 1000 rpm	
50 state 2010 Model Year (MY)	
Engine model	GDT370
Engine Family Rating Code (EFRC)	2222 and 1122
Injection timing	Nonadjustable
High idle speed - manual transmission	2200 rpm
High idle speed - automatic transmission	2200 rpm
Low idle speed	600 rpm
Full load on chassis dynamometer or highway, stabilized engine operating temperature	
Intake manifold pressure (gauge)	Peak torque – 227 kPa (33 psi) / 2.52 V
	Rated speed – 288 kPa (42 psi) / 3.22 V

390 hp @ 1700 rpm

International® MaxxForce® 11 390 hp @ 1700 rpm / 1400 ft•lb @ 1000 rpm	
50 state 2010 Model Year (MY)	
Engine model	GDT390
Engine Family Rating Code (EFRC)	2212 and 1112
Injection timing	Nonadjustable
High idle speed - manual transmission	2200 rpm
High idle speed - automatic transmission	2200 rpm
Low idle speed	600 rpm
Full load on chassis dynamometer or highway, stabilized engine operating temperature	
Intake manifold pressure (gauge)	Peak torque – 257 kPa (37 psi) / 2.87 V
	Rated speed – 295 kPa (43 psi) / 3.30 V

MaxxForce® 13 (12.4 L)

410 hp @ 1700 rpm

International® MaxxForce® 13 410 hp @ 1700 rpm / 1450 ft•lb @ 1000 rpm	
50 state 2010 Model Year (MY)	
Engine model	GDT410
Engine Family Rating Code (EFRC)	2231 and 1131
Injection timing	Nonadjustable
High idle speed - manual transmission	2200 rpm
High idle speed - automatic transmission	2200 rpm
Low idle speed	600 rpm
Full load on chassis dynamometer or highway, stabilized engine operating temperature	
Intake manifold pressure (gauge)	Peak torque – 196 kPa (29 psi) / 2.17 V
	Rated speed – 295 kPa (43 psi) / 3.30 V

430 hp @ 1700 rpm

International® MaxxForce® 13 430 hp @ 1700 rpm / 1550 ft•lb @ 1000 rpm	
50 state 2010 Model Year (MY)	
Engine model	GDT430
Engine Family Rating Code (EFRC)	2221 and 1121
Injection timing	Nonadjustable
High idle speed - manual transmission	2200 rpm
High idle speed - automatic transmission	2200 rpm
Low idle speed	600 rpm
Full load on chassis dynamometer or highway, stabilized engine operating temperature	
Intake manifold pressure (gauge)	Peak torque – 213 kPa (31 psi) / 2.36 V
	Rated speed – 298 kPa (43 psi) / 3.33 V

450 hp @ 1700 rpm (Allison Automatic Transmission)

International® MaxxForce® 13 450 hp @ 1900 rpm / 1250 ft•lb @ 1000 rpm	
50 state 2010 Model Year (MY)	
Engine model	GDT450
Engine Family Rating Code (EFRC)	2221 and 1121
Injection timing	Nonadjustable
High idle speed - automatic transmission	2200 rpm
Low idle speed	600 rpm
Full load on chassis dynamometer or highway, stabilized engine operating temperature	
Intake manifold pressure (gauge)	Peak torque – 124kPa (18 psi) / 1.36 V
	Rated speed – 269 kPa (39 psi) / 3.15 V

450 hp @ 1700 rpm (Manual Transmission)

International® MaxxForce® 13 450 hp @ 1700 rpm / 1700 ft•lb @ 1000 rpm	
50 state 2010 Model Year (MY)	
Engine model	GDT450
Engine Family Rating Code (EFRC)	2211 and 1111
Injection timing	Nonadjustable
High idle speed - manual transmission	2200 rpm
Low idle speed	600 rpm
Full load on chassis dynamometer or highway, stabilized engine operating temperature	
Intake manifold pressure (gauge)	Peak torque – 214 kPa (31 psi) / 2.73 V
	Rated speed – 285 kPa (41 psi) / 3.33 V

475 hp @ 1700 rpm

International® MaxxForce® 13 475 hp @ 1700 rpm / 1700 ft•lb @ 1000 rpm	
50 state 2010 Model Year (MY)	
Engine model	GDT475
Engine Family Rating Code (EFRC)	2211 and 1111
Injection timing	Nonadjustable
High idle speed - manual transmission	2200 rpm
High idle speed - automatic transmission	2200 rpm
Low idle speed	600 rpm
Full load on chassis dynamometer or highway, stabilized engine operating temperature	
Intake manifold pressure (gauge)	Peak torque – 214 kPa (31 psi) / 2.73 V
	Rated speed – 285 kPa (41 psi) / 3.33 V

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Signal Values

NOTE: Voltage measurements were taken with the ignition Key ON, Engine OFF (KOEO) and with Breakout Harness 00-01467-00 connected between the Engine Control Module (ECM) and vehicle harness. See "APPENDIX A: PERFORMANCE SPECIFICATIONS" (page 953) for actuator output voltages, sensor values, and component specifications in a range of conditions.

ECM 58-pin C2 Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
C2-01	B+	Battery Power	B+
C2-02	GND	Ground	0 V
C2-07	AFTFS-H	AFT Fuel Shutoff Valve High	1.18 V
C2-08	VREF4	Voltage Reference 4	5.00 V
C2-09	TACH	Tachometer	11.35 V
C2-10	XCS	Transfercase	0.10 V
C2-13	AES	Auxiliary Engine Switch	N/A
C2-14	WIFL	Water in Fuel Lamp	3.62 V
C2-15	WTSL	Wait to Start Lamp	3.60 V
C2-16	EGRP	Exhaust Gas Recirculation Position	2.83 V
C2-17	WEL	Warn Engine Lamp	3.60 V
C2-20	AFTFS-L	AFT Fuel Shutoff Valve Low	1.18 V
C2-22	COO	Cruise On/Off Switch	0.10 V
C2-23	RAS	Resume Accel Switch	1.10 V
C2-26	TSA	Two-Speed Axle Switch	N/A
C2-27	ACD_Sw	A/C Demand Switch	N/A
C2-28	RSL	Red Stop Lamp	3.58 V
C2-30	VSS CAL	Vehicle Speed Sensor Calibration	B+
C2-34	SIG GND	Signal Ground	0 V
C2-35	RVAR	Remote Variable PTO	0.10 V
C2-36	CP_Sw	Clutch Position Switch	N/A
C2-37	WIF	Water in Fuel Sensor	3.85 V +/- 0.20 V
C2-39	PB_Sw	Parking Brake Switch	N/A
C2-40	EB_Sw1	Engine Brake Switch 1	N/A
C2-41	SIG GND	Signal Ground	0 V
C2-42	SIG GND	Signal Ground	0 V
C2-43	SIG GND	Signal Ground	0 V
C2-46	RPAS	Remote Pedal Activation Switch	0.10 V

ECM 58-pin C2 Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
C2-48	RPRE	Remote Preset PTO	0.10 V
C2-49	ECL	Engine Coolant Level	0.10 V +/- 0.10 V
C2-50	AFTFP2	AFT Fuel Pressure 2	0.40 V
C2-52	SCS	Speed Control Switch	0.10 V
C2-53	EB_Sw2	Engine Brake Switch 2	N/A
C2-54	APP1	Accelerator Pedal Position 1	1.16 V +/- 0.10 V
C2-55	APP2	Accelerator Pedal Position 2	0.66 V

NOTE: Voltage measurements were taken with the ignition Key ON, Engine OFF (KOEO) and with Breakout Harness 00-01467-00 connected between the Engine Control Module (ECM) and vehicle harness. See "APPENDIX A: PERFORMANCE SPECIFICATIONS" (page 953) for actuator output voltages, sensor values, and component specifications in a range of conditions.

ECM 58-pin C1 Connector

ECM Pin	Abbreviation	Circuit Name	KOEO
C1-01, 03, 05	B+	Battery Power	B+
C1-02, 04, 06	GND	Ground	0 V
C1-08	EF GND	Engine Fan Ground	0 V
C1-10	SIG GND	Signal Ground	0 V
C1-11	SIG GND	Signal Ground	0 V
C1-12	DPFDP	DPF Differential Pressure	0.78 V
C1-13	RPS	Remote Pedal Sensor	0.08 V
C1-16	DOCOT	DOC Outlet Temperature	4.47 V
C1-17	SWBAT	Switched Battery	B+
C1-18	EFC	Engine Fan Control	0.21 V - 6.25 V
C1-19	TIMER	Stand-Alone Real Timer	B+
C1-22	SIG GND	Signal Ground	0 V
C1-23	SIG GND	Signal Ground	0 V
C1-24	SIG GND	Signal Ground	0 V
C1-25	AFTFP1	AFT Fuel Pressure 1	1.20 V +/- 0.30 V
C1-26	AFTFT	AFT Fuel Temperature	3.24 V
C1-27	DPFOT	DPF Outlet Temperature	4.56 V
C1-28	DOCIT	DOC Inlet Temperature	4.55 V
C1-30	ECM PWR OUT 3	ECM Power Output 3	B+
C1-33	ECM PWR OUT 1	ECM Power Output 1	B+
C1-34	J1939-H	J1939 Datalink High	2.69 V
C1-36	VREF1	Voltage Reference 1	5.00 V
C1-37	VREF4	Voltage Reference 4	5.00 V
C1-39	NVOLT	Nernst Volt	3.02 V
C1-40	VIRGND	Virtual Ground	2.59 V
C1-41	SIG GND	Signal Ground	0V
C1-42	ECM PWR OUT 2	ECM Power Output 2	B+
C1-46	O2SH-L	Oxygen Sensor High and Low	B+

ECM 58-pin C1 Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
C1-47	J1939-L	J1939 Datalink Low	2.40 V
C1-49	VREF4	Voltage Reference 4	5.00 V
C1-50	VREF5	Voltage Reference 5	5.00 V
C1-52	PUMPCUR	Pumping Current	2.90 V
C1-53	TRIMRES	Trim Resistor	2.92 V
C1-54	ECM PWR OUT 1	ECM Power Output 1	B+
C1-55	SIG GND	Signal Ground	0 V
C1-56	ERO	Engine Running Output	0.10 V
C1-57	MIL	Malfunction Indicator Lamp	3.58 V +/- 0.10 V
C1-58	EFS	Engine Fan Speed	5.00 V

NOTE: Voltage measurements were taken with the ignition Key ON, Engine OFF (KOEO) and with Breakout Harness 00-01467-00 connected between the Engine Control Module (ECM) and vehicle harness. See "APPENDIX A: PERFORMANCE SPECIFICATIONS" (page 953) for actuator output voltages, sensor values, and component specifications in a range of conditions.

ECM 98-pin E1 Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
E1-02	TC2WC	Turbocharger 2 Wastegate Control	B+
E1-03	IAHFS	Inlet Air Heater Fuel Solenoid	B+
E1-04	EBPV	Exhaust Back Pressure Valve	B+
E1-05	ECM PWR OUT 2	ECM Power Output 2	B+
E1-07	CCOSS-L	Crankcase Oil Separator Speed Low	2.58 V
E1-10	EOP	Engine Oil Pressure	0.59 V
E1-12	TC2CIT	Turbocharger 2 Compressor Inlet Temperature	2.32 V
E1-13	CACOT	Charge Air Cooler Outlet Temperature	2.46 V +/- 0.50 V
E1-14	ECT1	Engine Coolant Temperature 1	2.21 V
E1-15	VSS-L	Vehicle Speed Sensor Low	2.46 V
E1-16	CKP-L	Crankshaft Position Low	2.50 V
E1-17	CMP-H	Camshaft Position High	2.64 V
E1-18	IMP	Intake Manifold Pressure	0.80 V
E1-19	SIG GND	Signal Ground	0 V
E1-20	SIG GND	Signal Ground	0 V
E1-21	SIG GND	Signal Ground	0 V
E1-22	SIG GND	Signal Ground	0 V
E1-23	SIG GND	Signal Ground	0 V
E1-24	ECM PWR OUT 3	ECM Power Output 3	B+
E1-25	FPCV 12V	Fuel Rail Pressure Control High	B+
E1-26	ECM PWR OUT 3	ECM Power Output 3	B+
E1-27	ECM PWR OUT 3	ECM Power Output 3	B+
E1-28	ECM PWR OUT 2	ECM Power Output 2	B+
E1-29	ECM PWR OUT 2	ECM Power Output 2	B+
E1-31	CCOSS-H	Crankcase Oil Separator Speed High	2.58 V
E1-34	FRP	Fuel Rail Pressure	0.54 V +/- 0.20 V
E1-35	FDP	Fuel Delivery Pressure	0.59 V
E1-36	EOT	Engine Oil Temperature	2.40 V
E1-37	IMT	Intake Manifold Temperature	2.36 V

ECM 98-pin E1 Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
E1-38	IAT	Inlet Air Temperature	2.49 V
E1-39	VSS-H	Vehicle Speed Sensor High	2.65 V
E1-40	CKP-H	Crankshaft Position High	2.61 V
E1-41	CMP-L	Camshaft Position Low	2.51 V
E1-42	AAT	Ambient Air Temperature	2.67 V at 70°
E1-43	SIG GND	Signal Ground	0 V
E1-44	SIG GND	Signal Ground	0 V
E1-45	SIG GND	Signal Ground	0 V
E1-46	SIG GND	Signal Ground	0 V
E1-47	ECB1	Engine Compression Brake 1	B+
E1-48	CMV	Coolant Mixer Valve	B+
E1-49	ECB2	Engine Compression Brake 2	B+
E1-50	ECB2 12V	Engine Compression Brake 2 High	B+
E1-52	TC1WC	Turbocharger 1 Wastegate Control	B+
E1-53	AFTFD-H	AFT Fuel Doser High	1.30 V
E1-54	ECM PWR OUT 2	ECM Power Output 2	B+
E1-55	SIG GND	Signal Ground	0 V
E1-57	ETP	Engine Throttle Position	2.82 V
E1-58	VREF4	Voltage Reference 4	5.00 V
E1-61	TC1TOP	Turbocharger 1 Turbine Outlet Pressure	0.94 V
E1-63	SIG GND	Signal Ground	0 V
E1-64	EOL	Engine Oil Level	0.10 V
E1-67	IAHRD	Inlet Air Heater Relay Diagnostic	6.10 V
E1-68	SIG GND	Signal Ground	0 V
E1-71	ECT2	Engine Coolant Temperature 2	2.29 V
E1-72	IAHRC	Inlet Air Heater Relay Control	0.95 V
E1-73	FRPCV	Fuel Rail Pressure Control Valve	8.75 V +/- 0.20 V
E1-74	CFV	Coolant Flow Valve	B+
E1-75	ETC	Engine Throttle Control	7.77 V
E1-76	AFTFD-L	AFT Fuel Doser Low	1.32 V
E1-77	EGR-C	Exhaust Gas Recirculation Control	7.78 V
E1-79	TC2CIP	Turbocharger 2 Compression Inlet Pressure	1.15 V
E1-81	VREF5	Voltage Reference 5	5.00 V

ECM 98-pin E1 Connector			
ECM Pin	**Abbreviation**	**Circuit Name**	**KOEO**
E1-82	VREF5	Voltage Reference 5	5.00 V
E1-83	SIG GND	Signal Ground	0 V
E1-85	VREF2	Voltage Reference 2	5.00 V
E1-86	VREF2	Voltage Reference 2	5.00 V
E1-88	VREF6	Voltage Reference 6	5.00 V
E1-89	VREF3	Voltage Reference 3	5.00 V
E1-94	SIG GND	Signal Ground	0 V
E1-95	EGRT	EGR Temperature	4.66 V
E1-96	IAHRE	Inlet Air Heater Relay Enable	B+

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Technical Service Information (TSI) letters are periodically published to inform service technicians of product enhancements and field service issues. File TSIs in this section for supplemental reference.